

# Linux Device Drivers

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# **Chapter 1. Driver Basics**

## **Driver Entry and Exit points**

## Name

`module_init` — driver initialization entry point

## Synopsis

```
module_init ( x );
```

## Arguments

`x` function to be run at kernel boot time or module insertion

## Description

`module_init` will either be called during `do_initcalls` (if builtin) or at module insertion time (if a module). There can only be one per module.

## Name

`module_exit` — driver exit entry point

## Synopsis

```
module_exit ( x );
```

## Arguments

`x` function to be run when driver is removed

## Description

`module_exit` will wrap the driver clean-up code with `cleanup_module` when used with `rmmod` when the driver is a module. If the driver is statically compiled into the kernel, `module_exit` has no effect. There can only be one per module.

# Atomic and pointer manipulation

## Name

`atomic_read` — read atomic variable

## Synopsis

```
int atomic_read (const atomic_t * v);
```

## Arguments

`v` pointer of type `atomic_t`

## Description

Atomically reads the value of `v`.

## Name

`atomic_set` — set atomic variable

## Synopsis

```
void atomic_set (atomic_t * v, int i);
```

## Arguments

*v* pointer of type `atomic_t`

*i* required value

## Description

Atomically sets the value of *v* to *i*.

## Name

`atomic_add` — add integer to atomic variable

## Synopsis

```
void atomic_add (int i, atomic_t * v);
```

## Arguments

*i* integer value to add

*v* pointer of type `atomic_t`

## Description

Atomically adds *i* to *v*.

## Name

`atomic_sub` — subtract integer from atomic variable

## Synopsis

```
void atomic_sub (int i, atomic_t * v);
```

## Arguments

*i* integer value to subtract

*v* pointer of type `atomic_t`

## Description

Atomically subtracts *i* from *v*.

## Name

`atomic_sub_and_test` — subtract value from variable and test result

## Synopsis

```
int atomic_sub_and_test (int i, atomic_t * v);
```

## Arguments

*i* integer value to subtract

*v* pointer of type `atomic_t`

## Description

Atomically subtracts *i* from *v* and returns true if the result is zero, or false for all other cases.

## Name

`atomic_inc` — increment atomic variable

## Synopsis

```
void atomic_inc (atomic_t * v);
```

## Arguments

`v` pointer of type `atomic_t`

## Description

Atomically increments `v` by 1.

## Name

`atomic_dec` — decrement atomic variable

## Synopsis

```
void atomic_dec (atomic_t * v);
```

## Arguments

`v` pointer of type `atomic_t`

## Description

Atomically decrements `v` by 1.

## Name

`atomic_dec_and_test` — decrement and test

## Synopsis

```
int atomic_dec_and_test (atomic_t * v);
```

## Arguments

`v` pointer of type `atomic_t`

## Description

Atomically decrements `v` by 1 and returns true if the result is 0, or false for all other cases.

## Name

`atomic_inc_and_test` — increment and test

## Synopsis

```
int atomic_inc_and_test (atomic_t * v);
```

## Arguments

`v` pointer of type `atomic_t`

## Description

Atomically increments `v` by 1 and returns true if the result is zero, or false for all other cases.

## Name

`atomic_add_negative` — add and test if negative

## Synopsis

```
int atomic_add_negative (int i, atomic_t * v);
```

## Arguments

*i* integer value to add

*v* pointer of type `atomic_t`

## Description

Atomically adds *i* to *v* and returns true if the result is negative, or false when result is greater than or equal to zero.

## Name

`atomic_add_return` — add integer and return

## Synopsis

```
int atomic_add_return (int i, atomic_t * v);
```

## Arguments

*i* integer value to add

*v* pointer of type `atomic_t`

## Description

Atomically adds *i* to *v* and returns *i + v*

## Name

`atomic_sub_return` — subtract integer and return

## Synopsis

```
int atomic_sub_return (int i, atomic_t * v);
```

## Arguments

*i* integer value to subtract

*v* pointer of type `atomic_t`

## Description

Atomically subtracts *i* from *v* and returns  $v - i$

## Name

`__atomic_add_unless` — add unless the number is already a given value

## Synopsis

```
int __atomic_add_unless (atomic_t * v, int a, int u);
```

## Arguments

*v* pointer of type `atomic_t`

*a* the amount to add to *v*...

*u* ...unless *v* is equal to *u*.

## Description

Atomically adds *a* to *v*, so long as *v* was not already *u*. Returns the old value of *v*.

## Name

`atomic_inc_short` — increment of a short integer

## Synopsis

```
short int atomic_inc_short (short int * v);
```

## Arguments

`v` pointer to type int

## Description

Atomically adds 1 to `v` Returns the new value of `u`

# Delaying, scheduling, and timer routines

## Name

struct cputime — snaphsot of system and user cputime

## Synopsis

```
struct cputime {  
    cputime_t utime;  
    cputime_t stime;  
};
```

## Members

utime time spent in user mode

stime time spent in system mode

## Description

Gathers a generic snapshot of user and system time.

## Name

struct task\_cputime — collected CPU time counts

## Synopsis

```
struct task_cputime {
    cputime_t utime;
    cputime_t stime;
    unsigned long long sum_exec_runtime;
};
```

## Members

|                  |   |
|------------------|---|
| utime            | time spent in user mode, in cputime_t units   |
| stime            | time spent in kernel mode, in cputime_t units |
| sum_exec_runtime | total time spent on the CPU, in nanoseconds   |

## Description

This is an extension of struct cputime that includes the total runtime spent by the task from the scheduler point of view.

As a result, this structure groups together three kinds of CPU time that are tracked for threads and thread groups. Most things considering CPU time want to group these counts together and treat all three of them in parallel.

## Name

struct thread\_group\_cputimer — thread group interval timer counts

## Synopsis

```
struct thread_group_cputimer {
    struct task_cputime cputime;
    int running;
    raw_spinlock_t lock;
};
```

## Members

`cputime` thread group interval timers.

`running` non-zero when there are timers running and *cputime* receives updates.

`lock` lock for fields in this struct.

## Description

This structure contains the version of `task_cputime`, above, that is used for thread group CPU timer calculations.

## Name

`pid_alive` — check that a task structure is not stale

## Synopsis

```
int pid_alive (const struct task_struct * p);
```

## Arguments

*p* Task structure to be checked.

## Description

Test if a process is not yet dead (at most zombie state) If `pid_alive` fails, then pointers within the task structure can be stale and must not be dereferenced.

## Return

1 if the process is alive. 0 otherwise.

## Name

`is_global_init` — check if a task structure is init

## Synopsis

```
int is_global_init (struct task_struct * tsk);
```

## Arguments

*tsk* Task structure to be checked.

## Description

Check if a task structure is the first user space task the kernel created.

## Return

1 if the task structure is init. 0 otherwise.

## Name

`task_nice` — return the nice value of a given task.

## Synopsis

```
int task_nice (const struct task_struct * p);
```

## Arguments

*p* the task in question.

## Return

The nice value [ -20 ... 0 ... 19 ].

## Name

`is_idle_task` — is the specified task an idle task?

## Synopsis

```
bool is_idle_task (const struct task_struct * p);
```

## Arguments

*p* the task in question.

## Return

1 if *p* is an idle task. 0 otherwise.

## Name

`threadgroup_lock` — lock threadgroup

## Synopsis

```
void threadgroup_lock (struct task_struct * tsk);
```

## Arguments

*tsk* member task of the threadgroup to lock

## Description

Lock the threadgroup *tsk* belongs to. No new task is allowed to enter and member tasks aren't allowed to exit (as indicated by `PF_EXITING`) or change `->group_leader/pid`. This is useful for cases where the threadgroup needs to stay stable across blockable operations.

fork and exit paths explicitly call `threadgroup_change_{begin|end}()` for synchronization. While held, no new task will be added to threadgroup and no existing live task will have its `PF_EXITING` set.

`de_thread` does `threadgroup_change_{begin|end}()` when a non-leader sub-thread becomes a new leader.

## Name

threadgroup\_unlock — unlock threadgroup

## Synopsis

```
void threadgroup_unlock (struct task_struct * tsk);
```

## Arguments

*tsk* member task of the threadgroup to unlock

## Description

Reverse threadgroup\_lock.

## Name

wake\_up\_process — Wake up a specific process

## Synopsis

```
int wake_up_process (struct task_struct * p);
```

## Arguments

*p* The process to be woken up.

## Description

Attempt to wake up the nominated process and move it to the set of runnable processes.

## Return

1 if the process was woken up, 0 if it was already running.

It may be assumed that this function implies a write memory barrier before changing the task state if and only if any tasks are woken up.

## Name

`preempt_notifier_register` — tell me when current is being preempted & rescheduled

## Synopsis

```
void preempt_notifier_register (struct preempt_notifier * notifier);
```

## Arguments

*notifier* notifier struct to register

## Name

`preempt_notifier_unregister` — no longer interested in preemption notifications

## Synopsis

```
void preempt_notifier_unregister (struct preempt_notifier * notifier);
```

## Arguments

*notifier* notifier struct to unregister

## Description

This is safe to call from within a preemption notifier.

## Name

`preempt_schedule_context` — `preempt_schedule` called by tracing

## Synopsis

```
__visible void __sched notrace preempt_schedule_context ( void );
```

## Arguments

*void* no arguments

## Description

The tracing infrastructure uses `preempt_enable_notrace` to prevent recursion and tracing preempt enabling caused by the tracing infrastructure itself. But as tracing can happen in areas coming from userspace or just about to enter userspace, a preempt enable can occur before `user_exit` is called. This will cause the scheduler to be called when the system is still in usermode.

To prevent this, the `preempt_enable_notrace` will use this function instead of `preempt_schedule` to exit user context if needed before calling the scheduler.

## Name

`sched_setscheduler` — change the scheduling policy and/or RT priority of a thread.

## Synopsis

```
int sched_setscheduler (struct task_struct * p, int policy, const struct  
sched_param * param);
```

## Arguments

*p* the task in question.

*policy* new policy.

*param* structure containing the new RT priority.

## Return

0 on success. An error code otherwise.

NOTE that the task may be already dead.

## Name

`yield` — yield the current processor to other threads.

## Synopsis

```
void __sched yield ( void );
```

## Arguments

*void* no arguments

## Description

Do not ever use this function, there's a 99% chance you're doing it wrong.

The scheduler is at all times free to pick the calling task as the most eligible task to run, if removing the `yield` call from your code breaks it, its already broken.

## Typical broken usage is

```
while (!event) yield;
```

where one assumes that `yield` will let 'the other' process run that will make event true. If the current task is a `SCHED_FIFO` task that will never happen. Never use `yield` as a progress guarantee!!

If you want to use `yield` to wait for something, use `wait_event`. If you want to use `yield` to be 'nice' for others, use `cond_resched`. If you still want to use `yield`, do not!

## Name

`yield_to` — yield the current processor to another thread in your thread group, or accelerate that thread toward the processor it's on.

## Synopsis

```
int __sched yield_to (struct task_struct * p, bool preempt);
```

## Arguments

*p*            target task

*preempt*    whether task preemption is allowed or not

## Description

It's the caller's job to ensure that the target task struct can't go away on us before we can do any checks.

## Return

true (>0) if we indeed boosted the target task. false (0) if we failed to boost the target. -ESRCH if there's no task to yield to.

## Name

`cpupri_find` — find the best (lowest-pri) CPU in the system

## Synopsis

```
int cpupri_find (struct cpupri * cp, struct task_struct * p, struct
cpumask * lowest_mask);
```

## Arguments

*cp*                    The cpupri context

*p*                     The task

*lowest\_mask*        A mask to fill in with selected CPUs (or NULL)

## Note

This function returns the recommended CPUs as calculated during the current invocation. By the time the call returns, the CPUs may have in fact changed priorities any number of times. While not ideal, it is not an issue of correctness since the normal rebalancer logic will correct any discrepancies created by racing against the uncertainty of the current priority configuration.

## Return

(int)bool - CPUs were found

## Name

`cpupri_set` — update the cpu priority setting

## Synopsis

```
void cpupri_set (struct cpupri * cp, int cpu, int newpri);
```

## Arguments

*cp*        The cpupri context

*cpu*       The target cpu

*newpri*   The priority (INVALID-RT99) to assign to this CPU

## Note

Assumes `cpu_rq(cpu)->lock` is locked

## Returns

(void)

## Name

`cpupri_init` — initialize the `cpupri` structure

## Synopsis

```
int cpupri_init (struct cpupri * cp);
```

## Arguments

*cp* The `cpupri` context

## Return

-ENOMEM on memory allocation failure.

## Name

`cpupri_cleanup` — clean up the `cpupri` structure

## Synopsis

```
void cpupri_cleanup (struct cpupri * cp);
```

## Arguments

*cp* The `cpupri` context

## Name

`get_sd_load_idx` — Obtain the load index for a given sched domain.

## Synopsis

```
int get_sd_load_idx (struct sched_domain * sd, enum cpu_idle_type idle);
```

## Arguments

*sd*     The sched\_domain whose load\_idx is to be obtained.

*idle*   The idle status of the CPU for whose sd load\_idx is obtained.

## Return

The load index.

## Name

`update_sg_lb_stats` — Update `sched_group`'s statistics for load balancing.

## Synopsis

```
void update_sg_lb_stats (struct lb_env * env, struct sched_group *  
group, int load_idx, int local_group, struct sg_lb_stats * sgs, bool  
* overload);
```

## Arguments

|                    |   |
|--------------------|---|
| <i>env</i>         | The load balancing environment.   |
| <i>group</i>       | <code>sched_group</code> whose statistics are to be updated.                    |
| <i>load_idx</i>    | Load index of <code>sched_domain</code> of <code>this_cpu</code> for load calc. |
| <i>local_group</i> | Does group contain <code>this_cpu</code> .                                      |
| <i>sgs</i>         | variable to hold the statistics for this group.                                 |
| <i>overload</i>    | Indicate more than one runnable task for any CPU.                               |

## Name

`update_sd_pick_busiest` — return 1 on busiest group

## Synopsis

```
bool update_sd_pick_busiest (struct lb_env * env, struct sd_lb_stats *  
sds, struct sched_group * sg, struct sg_lb_stats * sgs);
```

## Arguments

*env* The load balancing environment.

*sds* sched\_domain statistics

*sg* sched\_group candidate to be checked for being the busiest

*sgs* sched\_group statistics

## Description

Determine if *sg* is a busier group than the previously selected busiest group.

## Return

true if *sg* is a busier group than the previously selected busiest group. false otherwise.

## Name

`update_sd_lb_stats` — Update `sched_domain`'s statistics for load balancing.

## Synopsis

```
void update_sd_lb_stats (struct lb_env * env, struct sd_lb_stats * sds);
```

## Arguments

*env* The load balancing environment.

*sds* variable to hold the statistics for this `sched_domain`.

## Name

`check_asym_packing` — Check to see if the group is packed into the sched domain.

## Synopsis

```
int check_asym_packing (struct lb_env * env, struct sd_lb_stats * sds);
```

## Arguments

*env* The load balancing environment.

*sds* Statistics of the sched\_domain which is to be packed

## Description

This is primarily intended to be used at the sibling level. Some cores like POWER7 prefer to use lower numbered SMT threads. In the case of POWER7, it can move to lower SMT modes only when higher threads are idle. When in lower SMT modes, the threads will perform better since they share less core resources. Hence when we have idle threads, we want them to be the higher ones.

This packing function is run on idle threads. It checks to see if the busiest CPU in this domain (core in the P7 case) has a higher CPU number than the packing function is being run on. Here we are assuming lower CPU number will be equivalent to lower a SMT thread number.

## Return

1 when packing is required and a task should be moved to this CPU. The amount of the imbalance is returned in *\*imbalance*.

## Name

`fix_small_imbalance` — Calculate the minor imbalance that exists amongst the groups of a `sched_domain`, during load balancing.

## Synopsis

```
void fix_small_imbalance (struct lb_env * env, struct sd_lb_stats *  
sds);
```

## Arguments

*env* The load balancing environment.

*sds* Statistics of the `sched_domain` whose imbalance is to be calculated.

## Name

`calculate_imbalance` — Calculate the amount of imbalance present within the groups of a given `sched_domain` during load balance.

## Synopsis

```
void calculate_imbalance (struct lb_env * env, struct sd_lb_stats *  
sds);
```

## Arguments

*env* load balance environment

*sds* statistics of the `sched_domain` whose imbalance is to be calculated.

## Name

`find_busiest_group` — Returns the busiest group within the `sched_domain` if there is an imbalance. If there isn't an imbalance, and the user has opted for power-savings, it returns a group whose CPUs can be put to idle by rebalancing those tasks elsewhere, if such a group exists.

## Synopsis

```
struct sched_group * find_busiest_group (struct lb_env * env);
```

## Arguments

*env* The load balancing environment.

## Description

Also calculates the amount of weighted load which should be moved to restore balance.

## Return

- The busiest group if imbalance exists. - If no imbalance and user has opted for power-savings balance, return the least loaded group whose CPUs can be put to idle by rebalancing its tasks onto our group.

## Name

DECLARE\_COMPLETION — declare and initialize a completion structure

## Synopsis

```
DECLARE_COMPLETION ( work );
```

## Arguments

*work* identifier for the completion structure

## Description

This macro declares and initializes a completion structure. Generally used for static declarations. You should use the `_ONSTACK` variant for automatic variables.

## Name

`DECLARE_COMPLETION_ONSTACK` — declare and initialize a completion structure

## Synopsis

```
DECLARE_COMPLETION_ONSTACK ( work );
```

## Arguments

*work* identifier for the completion structure

## Description

This macro declares and initializes a completion structure on the kernel stack.

## Name

`init_completion` — Initialize a dynamically allocated completion

## Synopsis

```
void init_completion (struct completion * x);
```

## Arguments

*x* pointer to completion structure that is to be initialized

## Description

This inline function will initialize a dynamically created completion structure.

## Name

`reinit_completion` — reinitialize a completion structure

## Synopsis

```
void reinit_completion (struct completion * x);
```

## Arguments

*x* pointer to completion structure that is to be reinitialized

## Description

This inline function should be used to reinitialize a completion structure so it can be reused. This is especially important after `complete_all` is used.

## Name

`__round_jiffies` — function to round jiffies to a full second

## Synopsis

```
unsigned long __round_jiffies (unsigned long j, int cpu);
```

## Arguments

*j* the time in (absolute) jiffies that should be rounded

*cpu* the processor number on which the timeout will happen

## Description

`__round_jiffies` rounds an absolute time in the future (in jiffies) up or down to (approximately) full seconds. This is useful for timers for which the exact time they fire does not matter too much, as long as they fire approximately every X seconds.

By rounding these timers to whole seconds, all such timers will fire at the same time, rather than at various times spread out. The goal of this is to have the CPU wake up less, which saves power.

The exact rounding is skewed for each processor to avoid all processors firing at the exact same time, which could lead to lock contention or spurious cache line bouncing.

The return value is the rounded version of the *j* parameter.

## Name

`__round_jiffies_relative` — function to round jiffies to a full second

## Synopsis

```
unsigned long __round_jiffies_relative (unsigned long j, int cpu);
```

## Arguments

*j* the time in (relative) jiffies that should be rounded

*cpu* the processor number on which the timeout will happen

## Description

`__round_jiffies_relative` rounds a time delta in the future (in jiffies) up or down to (approximately) full seconds. This is useful for timers for which the exact time they fire does not matter too much, as long as they fire approximately every X seconds.

By rounding these timers to whole seconds, all such timers will fire at the same time, rather than at various times spread out. The goal of this is to have the CPU wake up less, which saves power.

The exact rounding is skewed for each processor to avoid all processors firing at the exact same time, which could lead to lock contention or spurious cache line bouncing.

The return value is the rounded version of the *j* parameter.

## Name

`round_jiffies` — function to round jiffies to a full second

## Synopsis

```
unsigned long round_jiffies (unsigned long j);
```

## Arguments

*j* the time in (absolute) jiffies that should be rounded

## Description

`round_jiffies` rounds an absolute time in the future (in jiffies) up or down to (approximately) full seconds. This is useful for timers for which the exact time they fire does not matter too much, as long as they fire approximately every X seconds.

By rounding these timers to whole seconds, all such timers will fire at the same time, rather than at various times spread out. The goal of this is to have the CPU wake up less, which saves power.

The return value is the rounded version of the *j* parameter.

## Name

`round_jiffies_relative` — function to round jiffies to a full second

## Synopsis

```
unsigned long round_jiffies_relative (unsigned long j);
```

## Arguments

*j* the time in (relative) jiffies that should be rounded

## Description

`round_jiffies_relative` rounds a time delta in the future (in jiffies) up or down to (approximately) full seconds. This is useful for timers for which the exact time they fire does not matter too much, as long as they fire approximately every X seconds.

By rounding these timers to whole seconds, all such timers will fire at the same time, rather than at various times spread out. The goal of this is to have the CPU wake up less, which saves power.

The return value is the rounded version of the *j* parameter.

## Name

`__round_jiffies_up` — function to round jiffies up to a full second

## Synopsis

```
unsigned long __round_jiffies_up (unsigned long j, int cpu);
```

## Arguments

*j* the time in (absolute) jiffies that should be rounded

*cpu* the processor number on which the timeout will happen

## Description

This is the same as `__round_jiffies` except that it will never round down. This is useful for timeouts for which the exact time of firing does not matter too much, as long as they don't fire too early.

## Name

`__round_jiffies_up_relative` — function to round jiffies up to a full second

## Synopsis

```
unsigned long __round_jiffies_up_relative (unsigned long j, int cpu);
```

## Arguments

*j* the time in (relative) jiffies that should be rounded

*cpu* the processor number on which the timeout will happen

## Description

This is the same as `__round_jiffies_relative` except that it will never round down. This is useful for timeouts for which the exact time of firing does not matter too much, as long as they don't fire too early.

## Name

`round_jiffies_up` — function to round jiffies up to a full second

## Synopsis

```
unsigned long round_jiffies_up (unsigned long j);
```

## Arguments

*j* the time in (absolute) jiffies that should be rounded

## Description

This is the same as `round_jiffies` except that it will never round down. This is useful for timeouts for which the exact time of firing does not matter too much, as long as they don't fire too early.

## Name

`round_jiffies_up_relative` — function to round jiffies up to a full second

## Synopsis

```
unsigned long round_jiffies_up_relative (unsigned long j);
```

## Arguments

*j* the time in (relative) jiffies that should be rounded

## Description

This is the same as `round_jiffies_relative` except that it will never round down. This is useful for timeouts for which the exact time of firing does not matter too much, as long as they don't fire too early.

## Name

`set_timer_slack` — set the allowed slack for a timer

## Synopsis

```
void set_timer_slack (struct timer_list * timer, int slack_hz);
```

## Arguments

*timer*        the timer to be modified

*slack\_hz*    the amount of time (in jiffies) allowed for rounding

## Description

Set the amount of time, in jiffies, that a certain timer has in terms of slack. By setting this value, the timer subsystem will schedule the actual timer somewhere between the time `mod_timer` asks for, and that time plus the slack.

By setting the slack to -1, a percentage of the delay is used instead.

## Name

`init_timer_key` — initialize a timer

## Synopsis

```
void init_timer_key (struct timer_list * timer, unsigned int flags,  
const char * name, struct lock_class_key * key);
```

## Arguments

*timer* the timer to be initialized

*flags* timer flags

*name* name of the timer

*key* lockdep class key of the fake lock used for tracking timer sync lock dependencies

## Description

`init_timer_key` must be done to a timer prior calling *any* of the other timer functions.

## Name

`mod_timer_pending` — modify a pending timer's timeout

## Synopsis

```
int mod_timer_pending (struct timer_list * timer, unsigned long expires);
```

## Arguments

*timer*     the pending timer to be modified

*expires*   new timeout in jiffies

## Description

`mod_timer_pending` is the same for pending timers as `mod_timer`, but will not re-activate and modify already deleted timers.

It is useful for unserialized use of timers.

## Name

`mod_timer` — modify a timer's timeout

## Synopsis

```
int mod_timer (struct timer_list * timer, unsigned long expires);
```

## Arguments

*timer*      the timer to be modified

*expires*    new timeout in jiffies

## Description

`mod_timer` is a more efficient way to update the `expire` field of an active timer (if the timer is inactive it will be activated)

`mod_timer(timer, expires)` is equivalent to:

```
del_timer(timer); timer->expires = expires; add_timer(timer);
```

Note that if there are multiple unserialized concurrent users of the same timer, then `mod_timer` is the only safe way to modify the timeout, since `add_timer` cannot modify an already running timer.

The function returns whether it has modified a pending timer or not. (ie. `mod_timer` of an inactive timer returns 0, `mod_timer` of an active timer returns 1.)

## Name

`mod_timer_pinned` — modify a timer's timeout

## Synopsis

```
int mod_timer_pinned (struct timer_list * timer, unsigned long expires);
```

## Arguments

*timer*      the timer to be modified

*expires*    new timeout in jiffies

## Description

`mod_timer_pinned` is a way to update the `expire` field of an active timer (if the timer is inactive it will be activated) and to ensure that the timer is scheduled on the current CPU.

Note that this does not prevent the timer from being migrated when the current CPU goes offline. If this is a problem for you, use CPU-hotplug notifiers to handle it correctly, for example, cancelling the timer when the corresponding CPU goes offline.

`mod_timer_pinned(timer, expires)` is equivalent to:

```
del_timer(timer); timer->expires = expires; add_timer(timer);
```

## Name

`add_timer` — start a timer

## Synopsis

```
void add_timer (struct timer_list * timer);
```

## Arguments

*timer* the timer to be added

## Description

The kernel will do a `->function(->data)` callback from the timer interrupt at the `->expires` point in the future. The current time is 'jiffies'.

The timer's `->expires`, `->function` (and if the handler uses it, `->data`) fields must be set prior calling this function.

Timers with an `->expires` field in the past will be executed in the next timer tick.

## Name

`add_timer_on` — start a timer on a particular CPU

## Synopsis

```
void add_timer_on (struct timer_list * timer, int cpu);
```

## Arguments

*timer* the timer to be added

*cpu* the CPU to start it on

## Description

This is not very scalable on SMP. Double adds are not possible.

## Name

`del_timer` — deactivate a timer.

## Synopsis

```
int del_timer (struct timer_list * timer);
```

## Arguments

*timer* the timer to be deactivated

## Description

`del_timer` deactivates a timer - this works on both active and inactive timers.

The function returns whether it has deactivated a pending timer or not. (ie. `del_timer` of an inactive timer returns 0, `del_timer` of an active timer returns 1.)

## Name

`try_to_del_timer_sync` — Try to deactivate a timer

## Synopsis

```
int try_to_del_timer_sync (struct timer_list * timer);
```

## Arguments

*timer* timer to del

## Description

This function tries to deactivate a timer. Upon successful (ret >= 0) exit the timer is not queued and the handler is not running on any CPU.

## Name

`del_timer_sync` — deactivate a timer and wait for the handler to finish.

## Synopsis

```
int del_timer_sync (struct timer_list * timer);
```

## Arguments

*timer* the timer to be deactivated

## Description

This function only differs from `del_timer` on SMP: besides deactivating the timer it also makes sure the handler has finished executing on other CPUs.

## Synchronization rules

Callers must prevent restarting of the timer, otherwise this function is meaningless. It must not be called from interrupt contexts unless the timer is an irqsafe one. The caller must not hold locks which would prevent completion of the timer's handler. The timer's handler must not call `add_timer_on`. Upon exit the timer is not queued and the handler is not running on any CPU.

## Note

For irqsafe timers, you must not hold locks that are held in interrupt context while calling this function. Even if the lock has nothing to do with the timer in question. Here's why:

```
CPU0 CPU1 ---- ---- <SOFTIRQ> call_timer_fn; base->running_timer = mytimer;
spin_lock_irq(somelock); <IRQ> spin_lock(somelock); del_timer_sync(mytimer); while (base-
>running_timer == mytimer);
```

Now `del_timer_sync` will never return and never release `somelock`. The interrupt on the other CPU is waiting to grab `somelock` but it has interrupted the softirq that CPU0 is waiting to finish.

The function returns whether it has deactivated a pending timer or not.

## Name

`schedule_timeout` — sleep until timeout

## Synopsis

```
signed long __sched schedule_timeout (signed long timeout);
```

## Arguments

*timeout* timeout value in jiffies

## Description

Make the current task sleep until *timeout* jiffies have elapsed. The routine will return immediately unless the current task state has been set (see `set_current_state`).

You can set the task state as follows -

`TASK_UNINTERRUPTIBLE` - at least *timeout* jiffies are guaranteed to pass before the routine returns. The routine will return 0

`TASK_INTERRUPTIBLE` - the routine may return early if a signal is delivered to the current task. In this case the remaining time in jiffies will be returned, or 0 if the timer expired in time

The current task state is guaranteed to be `TASK_RUNNING` when this routine returns.

Specifying a *timeout* value of `MAX_SCHEDULE_TIMEOUT` will schedule the CPU away without a bound on the timeout. In this case the return value will be `MAX_SCHEDULE_TIMEOUT`.

In all cases the return value is guaranteed to be non-negative.

## Name

`msleep` — sleep safely even with waitqueue interruptions

## Synopsis

```
void msleep (unsigned int msecs);
```

## Arguments

*msecs* Time in milliseconds to sleep for

## Name

`msleep_interruptible` — sleep waiting for signals

## Synopsis

```
unsigned long msleep_interruptible (unsigned int msecs);
```

## Arguments

*msecs* Time in milliseconds to sleep for

## Name

`usleep_range` — Drop in replacement for `udelay` where wakeup is flexible

## Synopsis

```
void usleep_range (unsigned long min, unsigned long max);
```

## Arguments

*min* Minimum time in usecs to sleep

*max* Maximum time in usecs to sleep

## Wait queues and Wake events

## Name

`wait_event` — sleep until a condition gets true

## Synopsis

```
wait_event ( wq, condition);
```

## Arguments

`wq`            the waitqueue to wait on

`condition`   a C expression for the event to wait for

## Description

The process is put to sleep (TASK\_UNINTERRUPTIBLE) until the `condition` evaluates to true. The `condition` is checked each time the waitqueue `wq` is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

## Name

`wait_event_freezable` — sleep (or freeze) until a condition gets true

## Synopsis

```
wait_event_freezable ( wq, condition );
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

## Description

The process is put to sleep (`TASK_INTERRUPTIBLE` -- so as not to contribute to system load) until the *condition* evaluates to true. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

## Name

`wait_event_timeout` — sleep until a condition gets true or a timeout elapses

## Synopsis

```
wait_event_timeout ( wq, condition, timeout );
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

*timeout*      timeout, in jiffies

## Description

The process is put to sleep (TASK\_UNINTERRUPTIBLE) until the *condition* evaluates to true. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

## Returns

0 if the *condition* evaluated to false after the *timeout* elapsed, 1 if the *condition* evaluated to true after the *timeout* elapsed, or the remaining jiffies (at least 1) if the *condition* evaluated to true before the *timeout* elapsed.

## Name

`wait_event_cmd` — sleep until a condition gets true

## Synopsis

```
wait_event_cmd ( wq, condition, cmd1, cmd2);
```

## Arguments

|                        |   |
|------------------------|---|
| <code>wq</code>        | the waitqueue to wait on                  |
| <code>condition</code> | a C expression for the event to wait for  |
| <code>cmd1</code>      | the command will be executed before sleep |
| <code>cmd2</code>      | the command will be executed after sleep  |

## Description

The process is put to sleep (TASK\_UNINTERRUPTIBLE) until the `condition` evaluates to true. The `condition` is checked each time the waitqueue `wq` is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

## Name

`wait_event_interruptible` — sleep until a condition gets true

## Synopsis

```
wait_event_interruptible ( wq, condition);
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

## Description

The process is put to sleep (`TASK_INTERRUPTIBLE`) until the *condition* evaluates to true or a signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

The function will return `-ERESTARTSYS` if it was interrupted by a signal and 0 if *condition* evaluated to true.

## Name

`wait_event_interruptible_timeout` — sleep until a condition gets true or a timeout elapses

## Synopsis

```
wait_event_interruptible_timeout ( wq, condition, timeout);
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

*timeout*      timeout, in jiffies

## Description

The process is put to sleep (`TASK_INTERRUPTIBLE`) until the *condition* evaluates to true or a signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

## Returns

0 if the *condition* evaluated to false after the *timeout* elapsed, 1 if the *condition* evaluated to true after the *timeout* elapsed, the remaining jiffies (at least 1) if the *condition* evaluated to true before the *timeout* elapsed, or `-ERESTARTSYS` if it was interrupted by a signal.

## Name

`wait_event_hrtimeout` — sleep until a condition gets true or a timeout elapses

## Synopsis

```
wait_event_hrtimeout ( wq, condition, timeout );
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

*timeout*      timeout, as a `ktime_t`

## Description

The process is put to sleep (`TASK_UNINTERRUPTIBLE`) until the *condition* evaluates to true or a signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

The function returns 0 if *condition* became true, or `-ETIME` if the timeout elapsed.

## Name

`wait_event_interruptible_hrtimeout` — sleep until a condition gets true or a timeout elapses

## Synopsis

```
wait_event_interruptible_hrtimeout ( wq, condition, timeout );
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

*timeout*      timeout, as a `ktime_t`

## Description

The process is put to sleep (`TASK_INTERRUPTIBLE`) until the *condition* evaluates to true or a signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

The function returns 0 if *condition* became true, `-ERESTARTSYS` if it was interrupted by a signal, or `-ETIME` if the timeout elapsed.

## Name

`wait_event_interruptible_locked` — sleep until a condition gets true

## Synopsis

```
wait_event_interruptible_locked ( wq, condition);
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

## Description

The process is put to sleep (`TASK_INTERRUPTIBLE`) until the *condition* evaluates to true or a signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

It must be called with `wq.lock` being held. This spinlock is unlocked while sleeping but *condition* testing is done while lock is held and when this macro exits the lock is held.

The lock is locked/unlocked using `spin_lock/spin_unlock` functions which must match the way they are locked/unlocked outside of this macro.

`wake_up_locked` has to be called after changing any variable that could change the result of the wait condition.

The function will return `-ERESTARTSYS` if it was interrupted by a signal and 0 if *condition* evaluated to true.

## Name

`wait_event_interruptible_locked_irq` — sleep until a condition gets true

## Synopsis

```
wait_event_interruptible_locked_irq ( wq, condition);
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

## Description

The process is put to sleep (TASK\_INTERRUPTIBLE) until the *condition* evaluates to true or a signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

It must be called with `wq.lock` being held. This spinlock is unlocked while sleeping but *condition* testing is done while lock is held and when this macro exits the lock is held.

The lock is locked/unlocked using `spin_lock_irq/spin_unlock_irq` functions which must match the way they are locked/unlocked outside of this macro.

`wake_up_locked` has to be called after changing any variable that could change the result of the wait condition.

The function will return `-ERESTARTSYS` if it was interrupted by a signal and 0 if *condition* evaluated to true.

## Name

`wait_event_interruptible_exclusive_locked` — sleep exclusively until a condition gets true

## Synopsis

```
wait_event_interruptible_exclusive_locked ( wq, condition);
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

## Description

The process is put to sleep (TASK\_INTERRUPTIBLE) until the *condition* evaluates to true or a signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

It must be called with `wq.lock` being held. This spinlock is unlocked while sleeping but *condition* testing is done while lock is held and when this macro exits the lock is held.

The lock is locked/unlocked using `spin_lock/spin_unlock` functions which must match the way they are locked/unlocked outside of this macro.

The process is put on the wait queue with an `WQ_FLAG_EXCLUSIVE` flag set thus when other process waits process on the list if this process is awoken further processes are not considered.

`wake_up_locked` has to be called after changing any variable that could change the result of the wait condition.

The function will return `-ERESTARTSYS` if it was interrupted by a signal and 0 if *condition* evaluated to true.

## Name

`wait_event_interruptible_exclusive_locked_irq` — sleep until a condition gets true

## Synopsis

```
wait_event_interruptible_exclusive_locked_irq ( wq, condition);
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

## Description

The process is put to sleep (TASK\_INTERRUPTIBLE) until the *condition* evaluates to true or a signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

It must be called with *wq.lock* being held. This spinlock is unlocked while sleeping but *condition* testing is done while lock is held and when this macro exits the lock is held.

The lock is locked/unlocked using `spin_lock_irq/spin_unlock_irq` functions which must match the way they are locked/unlocked outside of this macro.

The process is put on the wait queue with an WQ\_FLAG\_EXCLUSIVE flag set thus when other process waits process on the list if this process is awoken further processes are not considered.

`wake_up_locked` has to be called after changing any variable that could change the result of the wait condition.

The function will return `-ERESTARTSYS` if it was interrupted by a signal and 0 if *condition* evaluated to true.

## Name

`wait_event_killable` — sleep until a condition gets true

## Synopsis

```
wait_event_killable ( wq, condition );
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

## Description

The process is put to sleep (TASK\_KILLABLE) until the *condition* evaluates to true or a signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

The function will return `-ERESTARTSYS` if it was interrupted by a signal and 0 if *condition* evaluated to true.

## Name

`wait_event_lock_irq_cmd` — sleep until a condition gets true. The condition is checked under the lock. This is expected to be called with the lock taken.

## Synopsis

```
wait_event_lock_irq_cmd ( wq, condition, lock, cmd);
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

*lock*           a locked `spinlock_t`, which will be released before `cmd` and `schedule` and reacquired afterwards.

*cmd*           a command which is invoked outside the critical section before sleep

## Description

The process is put to sleep (`TASK_UNINTERRUPTIBLE`) until the *condition* evaluates to true. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

This is supposed to be called while holding the lock. The lock is dropped before invoking the `cmd` and going to sleep and is reacquired afterwards.

## Name

`wait_event_lock_irq` — sleep until a condition gets true. The condition is checked under the lock. This is expected to be called with the lock taken.

## Synopsis

```
wait_event_lock_irq ( wq, condition, lock);
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

*lock*           a locked `spinlock_t`, which will be released before `schedule` and reacquired afterwards.

## Description

The process is put to sleep (`TASK_UNINTERRUPTIBLE`) until the *condition* evaluates to true. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

This is supposed to be called while holding the lock. The lock is dropped before going to sleep and is reacquired afterwards.

## Name

`wait_event_interruptible_lock_irq_cmd` — sleep until a condition gets true. The condition is checked under the lock. This is expected to be called with the lock taken.

## Synopsis

```
wait_event_interruptible_lock_irq_cmd ( wq, condition, lock, cmd);
```

## Arguments

|                  |  |
|------------------|--|
| <i>wq</i>        | the waitqueue to wait on   |
| <i>condition</i> | a C expression for the event to wait for   |
| <i>lock</i>      | a locked <code>spinlock_t</code> , which will be released before <code>cmd</code> and <code>schedule</code> and reacquired afterwards. |
| <i>cmd</i>       | a command which is invoked outside the critical section before sleep   |

## Description

The process is put to sleep (`TASK_INTERRUPTIBLE`) until the *condition* evaluates to true or a signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

This is supposed to be called while holding the lock. The lock is dropped before invoking the `cmd` and going to sleep and is reacquired afterwards.

The macro will return `-ERESTARTSYS` if it was interrupted by a signal and `0` if *condition* evaluated to true.

## Name

`wait_event_interruptible_lock_irq` — sleep until a condition gets true. The condition is checked under the lock. This is expected to be called with the lock taken.

## Synopsis

```
wait_event_interruptible_lock_irq ( wq, condition, lock);
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

*lock*           a locked `spinlock_t`, which will be released before `schedule` and reacquired afterwards.

## Description

The process is put to sleep (`TASK_INTERRUPTIBLE`) until the *condition* evaluates to true or signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

This is supposed to be called while holding the lock. The lock is dropped before going to sleep and is reacquired afterwards.

The macro will return `-ERESTARTSYS` if it was interrupted by a signal and `0` if *condition* evaluated to true.

## Name

`wait_event_interruptible_lock_irq_timeout` — sleep until a condition gets true or a timeout elapses. The condition is checked under the lock. This is expected to be called with the lock taken.

## Synopsis

```
wait_event_interruptible_lock_irq_timeout ( wq, condition, lock, time-  
out );
```

## Arguments

*wq*            the waitqueue to wait on

*condition*   a C expression for the event to wait for

*lock*           a locked `spinlock_t`, which will be released before `schedule` and reacquired afterwards.

*timeout*       timeout, in jiffies

## Description

The process is put to sleep (`TASK_INTERRUPTIBLE`) until the *condition* evaluates to true or signal is received. The *condition* is checked each time the waitqueue *wq* is woken up.

`wake_up` has to be called after changing any variable that could change the result of the wait condition.

This is supposed to be called while holding the lock. The lock is dropped before going to sleep and is reacquired afterwards.

The function returns 0 if the *timeout* elapsed, `-ERESTARTSYS` if it was interrupted by a signal, and the remaining jiffies otherwise if the condition evaluated to true before the timeout elapsed.

## Name

`wait_on_bit` — wait for a bit to be cleared

## Synopsis

```
int wait_on_bit (void * word, int bit, unsigned mode);
```

## Arguments

*word* the word being waited on, a kernel virtual address

*bit* the bit of the word being waited on

*mode* the task state to sleep in

## Description

There is a standard hashed waitqueue table for generic use. This is the part of the hashtable's accessor API that waits on a bit. For instance, if one were to have waiters on a bitflag, one would call `wait_on_bit` in threads waiting for the bit to clear. One uses `wait_on_bit` where one is waiting for the bit to clear, but has no intention of setting it. Returned value will be zero if the bit was cleared, or non-zero if the process received a signal and the mode permitted wakeup on that signal.

## Name

`wait_on_bit_io` — wait for a bit to be cleared

## Synopsis

```
int wait_on_bit_io (void * word, int bit, unsigned mode);
```

## Arguments

*word* the word being waited on, a kernel virtual address

*bit* the bit of the word being waited on

*mode* the task state to sleep in

## Description

Use the standard hashed waitqueue table to wait for a bit to be cleared. This is similar to `wait_on_bit`, but calls `io_schedule` instead of `schedule` for the actual waiting.

Returned value will be zero if the bit was cleared, or non-zero if the process received a signal and the mode permitted wakeup on that signal.

## Name

`wait_on_bit_timeout` — wait for a bit to be cleared or a timeout elapses

## Synopsis

```
int wait_on_bit_timeout (void * word, int bit, unsigned mode, unsigned  
long timeout);
```

## Arguments

*word*        the word being waited on, a kernel virtual address

*bit*         the bit of the word being waited on

*mode*        the task state to sleep in

*timeout*    timeout, in jiffies

## Description

Use the standard hashed waitqueue table to wait for a bit to be cleared. This is similar to `wait_on_bit`, except also takes a timeout parameter.

Returned value will be zero if the bit was cleared before the *timeout* elapsed, or non-zero if the *timeout* elapsed or process received a signal and the mode permitted wakeup on that signal.

## Name

`wait_on_bit_action` — wait for a bit to be cleared

## Synopsis

```
int wait_on_bit_action (void * word, int bit, wait_bit_action_f * action,  
unsigned mode);
```

## Arguments

*word*     the word being waited on, a kernel virtual address

*bit*     the bit of the word being waited on

*action*   the function used to sleep, which may take special actions

*mode*     the task state to sleep in

## Description

Use the standard hashed waitqueue table to wait for a bit to be cleared, and allow the waiting action to be specified. This is like `wait_on_bit` but allows fine control of how the waiting is done.

Returned value will be zero if the bit was cleared, or non-zero if the process received a signal and the mode permitted wakeup on that signal.

## Name

`wait_on_bit_lock` — wait for a bit to be cleared, when wanting to set it

## Synopsis

```
int wait_on_bit_lock (void * word, int bit, unsigned mode);
```

## Arguments

*word* the word being waited on, a kernel virtual address

*bit* the bit of the word being waited on

*mode* the task state to sleep in

## Description

There is a standard hashed waitqueue table for generic use. This is the part of the hashtable's accessor API that waits on a bit when one intends to set it, for instance, trying to lock bitflags. For instance, if one were to have waiters trying to set bitflag and waiting for it to clear before setting it, one would call `wait_on_bit` in threads waiting to be able to set the bit. One uses `wait_on_bit_lock` where one is waiting for the bit to clear with the intention of setting it, and when done, clearing it.

Returns zero if the bit was (eventually) found to be clear and was set. Returns non-zero if a signal was delivered to the process and the *mode* allows that signal to wake the process.

## Name

`wait_on_bit_lock_io` — wait for a bit to be cleared, when wanting to set it

## Synopsis

```
int wait_on_bit_lock_io (void * word, int bit, unsigned mode);
```

## Arguments

*word* the word being waited on, a kernel virtual address

*bit* the bit of the word being waited on

*mode* the task state to sleep in

## Description

Use the standard hashed waitqueue table to wait for a bit to be cleared and then to atomically set it. This is similar to `wait_on_bit`, but calls `io_schedule` instead of `schedule` for the actual waiting.

Returns zero if the bit was (eventually) found to be clear and was set. Returns non-zero if a signal was delivered to the process and the *mode* allows that signal to wake the process.

## Name

`wait_on_bit_lock_action` — wait for a bit to be cleared, when wanting to set it

## Synopsis

```
int wait_on_bit_lock_action (void * word, int bit, wait_bit_action_f *  
action, unsigned mode);
```

## Arguments

*word*     the word being waited on, a kernel virtual address

*bit*       the bit of the word being waited on

*action*    the function used to sleep, which may take special actions

*mode*      the task state to sleep in

## Description

Use the standard hashed waitqueue table to wait for a bit to be cleared and then to set it, and allow the waiting action to be specified. This is like `wait_on_bit` but allows fine control of how the waiting is done.

Returns zero if the bit was (eventually) found to be clear and was set. Returns non-zero if a signal was delivered to the process and the *mode* allows that signal to wake the process.

## Name

`wait_on_atomic_t` — Wait for an `atomic_t` to become 0

## Synopsis

```
int wait_on_atomic_t (atomic_t * val, int (*action) (atomic_t *), unsigned mode);
```

## Arguments

*val*        The atomic value being waited on, a kernel virtual address

*action*    the function used to sleep, which may take special actions

*mode*      the task state to sleep in

## Description

Wait for an `atomic_t` to become 0. We abuse the bit-wait waitqueue table for the purpose of getting a waitqueue, but we set the key to a bit number outside of the target 'word'.

## Name

`__wake_up` — wake up threads blocked on a waitqueue.

## Synopsis

```
void __wake_up (wait_queue_head_t * q, unsigned int mode, int
nr_exclusive, void * key);
```

## Arguments

|                     |   |
|---------------------|---|
| <i>q</i>            | the waitqueue                                     |
| <i>mode</i>         | which threads                                     |
| <i>nr_exclusive</i> | how many wake-one or wake-many threads to wake up |
| <i>key</i>          | is directly passed to the wakeup function         |

## Description

It may be assumed that this function implies a write memory barrier before changing the task state if and only if any tasks are woken up.

## Name

`__wake_up_sync_key` — wake up threads blocked on a waitqueue.

## Synopsis

```
void __wake_up_sync_key (wait_queue_head_t * q, unsigned int mode, int
nr_exclusive, void * key);
```

## Arguments

|                     |   |
|---------------------|---|
| <i>q</i>            | the waitqueue                                     |
| <i>mode</i>         | which threads                                     |
| <i>nr_exclusive</i> | how many wake-one or wake-many threads to wake up |
| <i>key</i>          | opaque value to be passed to wakeup targets       |

## Description

The sync wakeup differs that the waker knows that it will schedule away soon, so while the target thread will be woken up, it will not be migrated to another CPU - ie. the two threads are 'synchronized' with each other. This can prevent needless bouncing between CPUs.

On UP it can prevent extra preemption.

It may be assumed that this function implies a write memory barrier before changing the task state if and only if any tasks are woken up.

## Name

`finish_wait` — clean up after waiting in a queue

## Synopsis

```
void finish_wait (wait_queue_head_t * q, wait_queue_t * wait);
```

## Arguments

*q*       waitqueue waited on

*wait*    wait descriptor

## Description

Sets current thread back to running state and removes the wait descriptor from the given waitqueue if still queued.

## Name

`abort_exclusive_wait` — abort exclusive waiting in a queue

## Synopsis

```
void abort_exclusive_wait (wait_queue_head_t * q, wait_queue_t * wait,  
unsigned int mode, void * key);
```

## Arguments

*q*       waitqueue waited on

*wait*    wait descriptor

*mode*    runstate of the waiter to be woken

*key*     key to identify a wait bit queue or NULL

## Description

Sets current thread back to running state and removes the wait descriptor from the given waitqueue if still queued.

Wakes up the next waiter if the caller is concurrently woken up through the queue.

This prevents waiter starvation where an exclusive waiter aborts and is woken up concurrently and no one wakes up the next waiter.

## Name

`wake_up_bit` — wake up a waiter on a bit

## Synopsis

```
void wake_up_bit (void * word, int bit);
```

## Arguments

*word* the word being waited on, a kernel virtual address

*bit* the bit of the word being waited on

## Description

There is a standard hashed waitqueue table for generic use. This is the part of the hashtable's accessor API that wakes up waiters on a bit. For instance, if one were to have waiters on a bitflag, one would call `wake_up_bit` after clearing the bit.

In order for this to function properly, as it uses `waitqueue_active` internally, some kind of memory barrier must be done prior to calling this. Typically, this will be `smp_mb__after_atomic`, but in some cases where bitflags are manipulated non-atomically under a lock, one may need to use a less regular barrier, such as `fs/inode.c`'s `smp_mb`, because `spin_unlock` does not guarantee a memory barrier.

## Name

`wake_up_atomic_t` — Wake up a waiter on a `atomic_t`

## Synopsis

```
void wake_up_atomic_t (atomic_t * p);
```

## Arguments

*p* The `atomic_t` being waited on, a kernel virtual address

## Description

Wake up anyone waiting for the `atomic_t` to go to zero.

Abuse the bit-waker function and its waitqueue hash table set (the `atomic_t` check is done by the waiter's wake function, not the by the waker itself).

## High-resolution timers

## Name

`ktime_set` — Set a `ktime_t` variable from a seconds/nanoseconds value

## Synopsis

```
ktime_t ktime_set (const s64 secs, const unsigned long nsecs);
```

## Arguments

*secs* seconds to set

*nsecs* nanoseconds to set

## Return

The `ktime_t` representation of the value.

## Name

`ktime_equal` — Compares two `ktime_t` variables to see if they are equal

## Synopsis

```
int ktime_equal (const ktime_t cmp1, const ktime_t cmp2);
```

## Arguments

*cmp1* comparable1

*cmp2* comparable2

## Description

Compare two `ktime_t` variables.

## Return

1 if equal.

## Name

`ktime_compare` — Compares two `ktime_t` variables for less, greater or equal

## Synopsis

```
int ktime_compare (const ktime_t cmp1, const ktime_t cmp2);
```

## Arguments

*cmp1* comparable1

*cmp2* comparable2

## Return

... `cmp1 < cmp2`: return `<0` `cmp1 == cmp2`: return `0` `cmp1 > cmp2`: return `>0`

## Name

`ktime_after` — Compare if a `ktime_t` value is bigger than another one.

## Synopsis

```
bool ktime_after (const ktime_t cmp1, const ktime_t cmp2);
```

## Arguments

*cmp1* comparable1

*cmp2* comparable2

## Return

true if `cmp1` happened after `cmp2`.

## Name

`ktime_before` — Compare if a `ktime_t` value is smaller than another one.

## Synopsis

```
bool ktime_before (const ktime_t cmp1, const ktime_t cmp2);
```

## Arguments

*cmp1* comparable1

*cmp2* comparable2

## Return

true if *cmp1* happened before *cmp2*.

## Name

`ktime_to_timespec_cond` — convert a `ktime_t` variable to `timespec` format only if the variable contains data

## Synopsis

```
bool ktime_to_timespec_cond (const ktime_t kt, struct timespec * ts);
```

## Arguments

*kt* the `ktime_t` variable to convert

*ts* the `timespec` variable to store the result in

## Return

true if there was a successful conversion, false if `kt` was 0.

## Name

`ktime_to_timespec64_cond` — convert a `ktime_t` variable to `timespec64` format only if the variable contains data

## Synopsis

```
bool ktime_to_timespec64_cond (const ktime_t kt, struct timespec64 *  
ts);
```

## Arguments

*kt* the `ktime_t` variable to convert

*ts* the `timespec` variable to store the result in

## Return

`true` if there was a successful conversion, `false` if `kt` was 0.

## Name

struct hrtimer — the basic hrtimer structure

## Synopsis

```
struct hrtimer {
    struct timerqueue_node node;
    ktime_t _softexpires;
    enum hrtimer_restart (* function) (struct hrtimer *);
    struct hrtimer_clock_base * base;
    unsigned long state;
#ifdef CONFIG_TIMER_STATS
    int start_pid;
    void * start_site;
    char start_comm[16];
#endif
};
```

## Members

|                |   |
|----------------|---|
| node           | timerqueue node, which also manages node.expires, the absolute expiry time in the hrtimers internal representation. The time is related to the clock on which the timer is based. Is setup by adding slack to the _softexpires value. For non range timers identical to _softexpires. |
| _softexpires   | the absolute earliest expiry time of the hrtimer. The time which was given as expiry time when the timer was armed.   |
| function       | timer expiry callback function  |
| base           | pointer to the timer base (per cpu and per clock)   |
| state          | state information (See bit values above)  |
| start_pid      | timer statistics field to store the pid of the task which started the timer   |
| start_site     | timer statistics field to store the site where the timer was started  |
| start_comm[16] | timer statistics field to store the name of the process which started the timer   |

## Description

The hrtimer structure must be initialized by `hrtimer_init`

## Name

struct hrtimer\_sleeper — simple sleeper structure

## Synopsis

```
struct hrtimer_sleeper {  
    struct hrtimer timer;  
    struct task_struct * task;  
};
```

## Members

timer embedded timer structure

task task to wake up

## Description

task is set to NULL, when the timer expires.

## Name

struct hrtimer\_clock\_base — the timer base for a specific clock

## Synopsis

```
struct hrtimer_clock_base {
    struct hrtimer_cpu_base * cpu_base;
    int index;
    clockid_t clockid;
    struct timerqueue_head active;
    ktime_t resolution;
    ktime_t (* get_time) (void);
    ktime_t softirq_time;
    ktime_t offset;
};
```

## Members

|              |  |
|--------------|--|
| cpu_base     | per cpu clock base   |
| index        | clock type index for per_cpu support when moving a timer to a base on another cpu. |
| clockid      | clock id for per_cpu support   |
| active       | red black tree root node for the active timers                                     |
| resolution   | the resolution of the clock, in nanoseconds  |
| get_time     | function to retrieve the current time of the clock                                 |
| softirq_time | the time when running the hrtimer queue in the softirq                             |
| offset       | offset of this clock to the monotonic base   |

## Name

`hrtimer_forward` — forward the timer expiry

## Synopsis

```
u64 hrtimer_forward (struct hrtimer * timer, ktime_t now, ktime_t interval);
```

## Arguments

*timer*        hrtimer to forward

*now*         forward past this time

*interval*    the interval to forward

## Description

Forward the timer expiry so it will expire in the future. Returns the number of overruns.

## Name

`hrtimer_start_range_ns` — (re)start an hrtimer on the current CPU

## Synopsis

```
int hrtimer_start_range_ns (struct hrtimer * timer, ktime_t tim, unsigned long delta_ns, const enum hrtimer_mode mode);
```

## Arguments

*timer*      the timer to be added

*tim*        expiry time

*delta\_ns*   "slack" range for the timer

*mode*       expiry mode: absolute (HRTIMER\_MODE\_ABS) or relative (HRTIMER\_MODE\_REL)

## Returns

0 on success 1 when the timer was active

## Name

`hrtimer_start` — (re)start an hrtimer on the current CPU

## Synopsis

```
int hrtimer_start (struct hrtimer * timer, ktime_t tim, const enum  
hrtimer_mode mode);
```

## Arguments

*timer* the timer to be added

*tim* expiry time

*mode* expiry mode: absolute (`HRTIMER_MODE_ABS`) or relative (`HRTIMER_MODE_REL`)

## Returns

0 on success 1 when the timer was active

## Name

`hrtimer_try_to_cancel` — try to deactivate a timer

## Synopsis

```
int hrtimer_try_to_cancel (struct hrtimer * timer);
```

## Arguments

*timer* hrtimer to stop

## Returns

0 when the timer was not active 1 when the timer was active -1 when the timer is currently executing the callback function and cannot be stopped

## Name

`hrtimer_cancel` — cancel a timer and wait for the handler to finish.

## Synopsis

```
int hrtimer_cancel (struct hrtimer * timer);
```

## Arguments

*timer* the timer to be cancelled

## Returns

0 when the timer was not active 1 when the timer was active

## Name

`hrtimer_get_remaining` — get remaining time for the timer

## Synopsis

```
ktime_t hrtimer_get_remaining (const struct hrtimer * timer);
```

## Arguments

*timer* the timer to read

## Name

`hrtimer_init` — initialize a timer to the given clock

## Synopsis

```
void hrtimer_init (struct hrtimer * timer, clockid_t clock_id, enum  
hrtimer_mode mode);
```

## Arguments

*timer*        the timer to be initialized

*clock\_id*    the clock to be used

*mode*        timer mode abs/rel

## Name

`hrtimer_get_res` — get the timer resolution for a clock

## Synopsis

```
int hrtimer_get_res (const clockid_t which_clock, struct timespec * tp);
```

## Arguments

*which\_clock*    which clock to query

*tp*             pointer to timespec variable to store the resolution

## Description

Store the resolution of the clock selected by *which\_clock* in the variable pointed to by *tp*.

## Name

`schedule_hrtimeout_range` — sleep until timeout

## Synopsis

```
int __sched schedule_hrtimeout_range (ktime_t * expires, unsigned long delta, const enum hrtimer_mode mode);
```

## Arguments

*expires* timeout value (ktime\_t)

*delta* slack in expires timeout (ktime\_t)

*mode* timer mode, HRTIMER\_MODE\_ABS or HRTIMER\_MODE\_REL

## Description

Make the current task sleep until the given expiry time has elapsed. The routine will return immediately unless the current task state has been set (see `set_current_state`).

The *delta* argument gives the kernel the freedom to schedule the actual wakeup to a time that is both power and performance friendly. The kernel give the normal best effort behavior for "*expires+delta*", but may decide to fire the timer earlier, but no earlier than *expires*.

You can set the task state as follows -

`TASK_UNINTERRUPTIBLE` - at least *timeout* time is guaranteed to pass before the routine returns.

`TASK_INTERRUPTIBLE` - the routine may return early if a signal is delivered to the current task.

The current task state is guaranteed to be `TASK_RUNNING` when this routine returns.

Returns 0 when the timer has expired otherwise `-EINTR`

## Name

`schedule_hrtimeout` — sleep until timeout

## Synopsis

```
int __sched schedule_hrtimeout (ktime_t * expires, const enum
hrtimer_mode mode);
```

## Arguments

*expires* timeout value (ktime\_t)

*mode* timer mode, HRTIMER\_MODE\_ABS or HRTIMER\_MODE\_REL

## Description

Make the current task sleep until the given expiry time has elapsed. The routine will return immediately unless the current task state has been set (see `set_current_state`).

You can set the task state as follows -

`TASK_UNINTERRUPTIBLE` - at least *timeout* time is guaranteed to pass before the routine returns.

`TASK_INTERRUPTIBLE` - the routine may return early if a signal is delivered to the current task.

The current task state is guaranteed to be `TASK_RUNNING` when this routine returns.

Returns 0 when the timer has expired otherwise `-EINTR`

## Workqueues and Kevents

## Name

`queue_work_on` — queue work on specific cpu

## Synopsis

```
bool queue_work_on (int cpu, struct workqueue_struct * wq, struct work_struct * work);
```

## Arguments

*cpu* CPU number to execute work on

*wq* workqueue to use

*work* work to queue

## Description

We queue the work to a specific CPU, the caller must ensure it can't go away.

## Return

false if *work* was already on a queue, true otherwise.

## Name

`queue_delayed_work_on` — queue work on specific CPU after delay

## Synopsis

```
bool queue_delayed_work_on (int cpu, struct workqueue_struct * wq,
struct delayed_work * dwork, unsigned long delay);
```

## Arguments

*cpu* CPU number to execute work on

*wq* workqueue to use

*dwork* work to queue

*delay* number of jiffies to wait before queueing

## Return

false if *work* was already on a queue, true otherwise. If *delay* is zero and *dwork* is idle, it will be scheduled for immediate execution.

## Name

`mod_delayed_work_on` — modify delay of or queue a delayed work on specific CPU

## Synopsis

```
bool mod_delayed_work_on (int cpu, struct workqueue_struct * wq, struct
delayed_work * dwork, unsigned long delay);
```

## Arguments

*cpu* CPU number to execute work on

*wq* workqueue to use

*dwork* work to queue

*delay* number of jiffies to wait before queueing

## Description

If *dwork* is idle, equivalent to `queue_delayed_work_on`; otherwise, modify *dwork*'s timer so that it expires after *delay*. If *delay* is zero, *work* is guaranteed to be scheduled immediately regardless of its current state.

## Return

`false` if *dwork* was idle and queued, `true` if *dwork* was pending and its timer was modified.

This function is safe to call from any context including IRQ handler. See `try_to_grab_pending` for details.

## Name

`flush_workqueue` — ensure that any scheduled work has run to completion.

## Synopsis

```
void flush_workqueue (struct workqueue_struct * wq);
```

## Arguments

*wq* workqueue to flush

## Description

This function sleeps until all work items which were queued on entry have finished execution, but it is not livelocked by new incoming ones.

## Name

`drain_workqueue` — drain a workqueue

## Synopsis

```
void drain_workqueue (struct workqueue_struct * wq);
```

## Arguments

*wq* workqueue to drain

## Description

Wait until the workqueue becomes empty. While draining is in progress, only chain queueing is allowed. IOW, only currently pending or running work items on *wq* can queue further work items on it. *wq* is flushed repeatedly until it becomes empty. The number of flushing is determined by the depth of chaining and should be relatively short. Whine if it takes too long.

## Name

`flush_work` — wait for a work to finish executing the last queueing instance

## Synopsis

```
bool flush_work (struct work_struct * work);
```

## Arguments

*work* the work to flush

## Description

Wait until *work* has finished execution. *work* is guaranteed to be idle on return if it hasn't been requeued since flush started.

## Return

true if `flush_work` waited for the work to finish execution, false if it was already idle.

## Name

`cancel_work_sync` — cancel a work and wait for it to finish

## Synopsis

```
bool cancel_work_sync (struct work_struct * work);
```

## Arguments

*work* the work to cancel

## Description

Cancel *work* and wait for its execution to finish. This function can be used even if the work re-queues itself or migrates to another workqueue. On return from this function, *work* is guaranteed to be not pending or executing on any CPU.

`cancel_work_sync(delayed_work->work)` must not be used for `delayed_work`'s. Use `cancel_delayed_work_sync` instead.

The caller must ensure that the workqueue on which *work* was last queued can't be destroyed before this function returns.

## Return

true if *work* was pending, false otherwise.

## Name

`flush_delayed_work` — wait for a `dwork` to finish executing the last queueing

## Synopsis

```
bool flush_delayed_work (struct delayed_work * dwork);
```

## Arguments

*dwork* the delayed work to flush

## Description

Delayed timer is cancelled and the pending work is queued for immediate execution. Like `flush_work`, this function only considers the last queueing instance of *dwork*.

## Return

true if `flush_work` waited for the work to finish execution, false if it was already idle.

## Name

`cancel_delayed_work` — cancel a delayed work

## Synopsis

```
bool cancel_delayed_work (struct delayed_work * dwork);
```

## Arguments

*dwork* delayed\_work to cancel

## Description

Kill off a pending `delayed_work`.

## Return

`true` if *dwork* was pending and canceled; `false` if it wasn't pending.

## Note

The work callback function may still be running on return, unless it returns `true` and the work doesn't re-arm itself. Explicitly flush or use `cancel_delayed_work_sync` to wait on it.

This function is safe to call from any context including IRQ handler.

## Name

`cancel_delayed_work_sync` — cancel a delayed work and wait for it to finish

## Synopsis

```
bool cancel_delayed_work_sync (struct delayed_work * dwork);
```

## Arguments

*dwork* the delayed work cancel

## Description

This is `cancel_work_sync` for delayed works.

## Return

true if *dwork* was pending, false otherwise.

## Name

`flush_scheduled_work` — ensure that any scheduled work has run to completion.

## Synopsis

```
void flush_scheduled_work ( void );
```

## Arguments

*void* no arguments

## Description

Forces execution of the kernel-global workqueue and blocks until its completion.

Think twice before calling this function! It's very easy to get into trouble if you don't take great care. Either of the following situations

### will lead to deadlock

One of the work items currently on the workqueue needs to acquire a lock held by your code or its caller.

Your code is running in the context of a work routine.

They will be detected by lockdep when they occur, but the first might not occur very often. It depends on what work items are on the workqueue and what locks they need, which you have no control over.

In most situations flushing the entire workqueue is overkill; you merely need to know that a particular work item isn't queued and isn't running. In such cases you should use `cancel_delayed_work_sync` or `cancel_work_sync` instead.

## Name

`execute_in_process_context` — reliably execute the routine with user context

## Synopsis

```
int execute_in_process_context (work_func_t fn, struct execute_work *  
ew);
```

## Arguments

*fn* the function to execute

*ew* guaranteed storage for the execute work structure (must be available when the work executes)

## Description

Executes the function immediately if process context is available, otherwise schedules the function for delayed execution.

## Return

0 - function was executed 1 - function was scheduled for execution

## Name

`destroy_workqueue` — safely terminate a workqueue

## Synopsis

```
void destroy_workqueue (struct workqueue_struct * wq);
```

## Arguments

*wq* target workqueue

## Description

Safely destroy a workqueue. All work currently pending will be done first.

## Name

`workqueue_set_max_active` — adjust `max_active` of a workqueue

## Synopsis

```
void workqueue_set_max_active (struct workqueue_struct * wq, int  
max_active);
```

## Arguments

*wq*                    target workqueue  
*max\_active*          new `max_active` value.

## Description

Set `max_active` of *wq* to *max\_active*.

## CONTEXT

Don't call from IRQ context.

## Name

`workqueue_congested` — test whether a workqueue is congested

## Synopsis

```
bool workqueue_congested (int cpu, struct workqueue_struct * wq);
```

## Arguments

*cpu* CPU in question

*wq* target workqueue

## Description

Test whether *wq*'s cpu workqueue for *cpu* is congested. There is no synchronization around this function and the test result is unreliable and only useful as advisory hints or for debugging.

If *cpu* is `WORK_CPU_UNBOUND`, the test is performed on the local CPU. Note that both per-cpu and unbound workqueues may be associated with multiple `pool_workqueues` which have separate congested states. A workqueue being congested on one CPU doesn't mean the workqueue is also congested on other CPUs / NUMA nodes.

## Return

true if congested, false otherwise.

## Name

`work_busy` — test whether a work is currently pending or running

## Synopsis

```
unsigned int work_busy (struct work_struct * work);
```

## Arguments

*work* the work to be tested

## Description

Test whether *work* is currently pending or running. There is no synchronization around this function and the test result is unreliable and only useful as advisory hints or for debugging.

## Return

OR'd bitmask of `WORK_BUSY_*` bits.

## Name

`work_on_cpu` — run a function in user context on a particular cpu

## Synopsis

```
long work_on_cpu (int cpu, long (*fn) (void *), void * arg);
```

## Arguments

*cpu* the cpu to run on

*fn* the function to run

*arg* the function arg

## Description

It is up to the caller to ensure that the cpu doesn't go offline. The caller must not hold any locks which would prevent *fn* from completing.

## Return

The value *fn* returns.

## Internal Functions

## Name

`wait_task_stopped` — Wait for `TASK_STOPPED` or `TASK_TRACED`

## Synopsis

```
int wait_task_stopped (struct wait_opts * wo, int ptrace, struct
task_struct * p);
```

## Arguments

*wo*        wait options

*ptrace*    is the wait for ptrace

*p*         task to wait for

## Description

Handle `sys_wait4` work for `p` in state `TASK_STOPPED` or `TASK_TRACED`.

## CONTEXT

`read_lock(tasklist_lock)`, which is released if return value is non-zero. Also, grabs and releases `p->sig-hand->siglock`.

## RETURNS

0 if wait condition didn't exist and search for other wait conditions should continue. Non-zero return, -`errno` on failure and `p`'s pid on success, implies that `tasklist_lock` is released and wait condition search should terminate.

## Name

`task_set_jobctl_pending` — set jobctl pending bits

## Synopsis

```
bool task_set_jobctl_pending (struct task_struct * task, unsigned int  
mask);
```

## Arguments

*task* target task

*mask* pending bits to set

## Description

Clear *mask* from *task->jobctl*. *mask* must be subset of `JOBCTL_PENDING_MASK | JOBCTL_STOP_CONSUME | JOBCTL_STOP_SIGMASK | JOBCTL_TRAPPING`. If stop signo is being set, the existing signo is cleared. If *task* is already being killed or exiting, this function becomes noop.

## CONTEXT

Must be called with *task->sigand->siglock* held.

## RETURNS

true if *mask* is set, false if made noop because *task* was dying.

## Name

`task_clear_jobctl_trapping` — clear jobctl trapping bit

## Synopsis

```
void task_clear_jobctl_trapping (struct task_struct * task);
```

## Arguments

*task* target task

## Description

If `JOBCTL_TRAPPING` is set, a ptracer is waiting for us to enter `TRACED`. Clear it and wake up the ptracer. Note that we don't need any further locking. `task->siglock` guarantees that `task->parent` points to the ptracer.

## CONTEXT

Must be called with `task->sigand->siglock` held.

## Name

`task_clear_jobctl_pending` — clear jobctl pending bits

## Synopsis

```
void task_clear_jobctl_pending (struct task_struct * task, unsigned int  
mask);
```

## Arguments

*task* target task

*mask* pending bits to clear

## Description

Clear *mask* from *task->jobctl*. *mask* must be subset of `JOBCTL_PENDING_MASK`. If `JOBCTL_STOP_PENDING` is being cleared, other `STOP` bits are cleared together.

If clearing of *mask* leaves no stop or trap pending, this function calls `task_clear_jobctl_trapping`.

## CONTEXT

Must be called with *task->sigband->siglock* held.

## Name

`task_participate_group_stop` — participate in a group stop

## Synopsis

```
bool task_participate_group_stop (struct task_struct * task);
```

## Arguments

*task* task participating in a group stop

## Description

*task* has `JOBCTL_STOP_PENDING` set and is participating in a group stop. Group stop states are cleared and the group stop count is consumed if `JOBCTL_STOP_CONSUME` was set. If the consumption completes the group stop, the appropriate `SIGNAL_*` flags are set.

## CONTEXT

Must be called with `task->sigand->siglock` held.

## RETURNS

`true` if group stop completion should be notified to the parent, `false` otherwise.

## Name

`ptrace_trap_notify` — schedule trap to notify ptracer

## Synopsis

```
void ptrace_trap_notify (struct task_struct * t);
```

## Arguments

`t` tracee wanting to notify tracer

## Description

This function schedules sticky ptrace trap which is cleared on the next TRAP\_STOP to notify ptracer of an event. `t` must have been seized by ptracer.

If `t` is running, STOP trap will be taken. If trapped for STOP and ptracer is listening for events, tracee is woken up so that it can re-trap for the new event. If trapped otherwise, STOP trap will be eventually taken without returning to userland after the existing traps are finished by PTRACE\_CONT.

## CONTEXT

Must be called with `task->sigband->siglock` held.

## Name

`do_notify_parent_cldstop` — notify parent of stopped/continued state change

## Synopsis

```
void do_notify_parent_cldstop (struct task_struct * tsk, bool
for_ptracer, int why);
```

## Arguments

*tsk*                    task reporting the state change

*for\_ptracer*        the notification is for ptracer

*why*                    CLD\_{CONTINUED|STOPPED|TRAPPED} to report

## Description

Notify *tsk*'s parent that the stopped/continued state has changed. If *for\_ptracer* is false, *tsk*'s group leader notifies to its real parent. If true, *tsk* reports to *tsk->parent* which should be the ptracer.

## CONTEXT

Must be called with `tasklist_lock` at least read locked.

## Name

`do_signal_stop` — handle group stop for SIGSTOP and other stop signals

## Synopsis

```
bool do_signal_stop (int signr);
```

## Arguments

*signr* signr causing group stop if initiating

## Description

If `JOBCTL_STOP_PENDING` is not set yet, initiate group stop with *signr* and participate in it. If already set, participate in the existing group stop. If participated in a group stop (and thus slept), `true` is returned with siglock released.

If ptraced, this function doesn't handle stop itself. Instead, `JOBCTL_TRAP_STOP` is scheduled and `false` is returned with siglock untouched. The caller must ensure that `INTERRUPT` trap handling takes places afterwards.

## CONTEXT

Must be called with `current->sigand->siglock` held, which is released on `true` return.

## RETURNS

`false` if group stop is already cancelled or ptrace trap is scheduled. `true` if participated in group stop.

## Name

`do_jobctl_trap` — take care of ptrace jobctl traps

## Synopsis

```
void do_jobctl_trap ( void );
```

## Arguments

*void* no arguments

## Description

When `PT_SEIZED`, it's used for both group stop and explicit `SEIZE/INTERRUPT` traps. Both generate `PTRACE_EVENT_STOP` trap with accompanying `siginfo`. If stopped, lower eight bits of `exit_code` contain the stop signal; otherwise, `SIGTRAP`.

When `!PT_SEIZED`, it's used only for group stop trap with stop signal number as `exit_code` and no `siginfo`.

## CONTEXT

Must be called with `current->sigand->siglock` held, which may be released and re-acquired before returning with intervening sleep.

## Name

signal\_delivered —

## Synopsis

```
void signal_delivered (struct ksignal * ksig, int stepping);
```

## Arguments

*ksig*        kernel signal struct

*stepping*   nonzero if debugger single-step or block-step in use

## Description

This function should be called when a signal has successfully been delivered. It updates the blocked signals accordingly (*ksig*->ka.sa.sa\_mask is always blocked, and the signal itself is blocked unless SA\_NODEFER is set in *ksig*->ka.sa.sa\_flags. Tracing is notified.

## Name

`sys_restart_syscall` — restart a system call

## Synopsis

```
long sys_restart_syscall ( void );
```

## Arguments

*void* no arguments

## Name

`set_current_blocked` — change `current->blocked` mask

## Synopsis

```
void set_current_blocked (sigset_t * newset);
```

## Arguments

*newset* new mask

## Description

It is wrong to change `->blocked` directly, this helper should be used to ensure the process can't miss a shared signal we are going to block.

## Name

`sys_rt_sigprocmask` — change the list of currently blocked signals

## Synopsis

```
long sys_rt_sigprocmask (int how, sigset_t __user * nset, sigset_t  
__user * oset, size_t sigsetsize);
```

## Arguments

|                   |   |
|-------------------|---|
| <i>how</i>        | whether to add, remove, or set signals    |
| <i>nset</i>       | stores pending signals                    |
| <i>oset</i>       | previous value of signal mask if non-null |
| <i>sigsetsize</i> | size of sigset_t type                     |

## Name

`sys_rt_sigpending` — examine a pending signal that has been raised while blocked

## Synopsis

```
long sys_rt_sigpending (sigset_t __user * uset, size_t sigsetsize);
```

## Arguments

*uset*            stores pending signals

*sigsetsize*    size of `sigset_t` type or larger

## Name

`do_sigtimedwait` — wait for queued signals specified in *which*

## Synopsis

```
int do_sigtimedwait (const sigset_t * which, siginfo_t * info, const
struct timespec * ts);
```

## Arguments

*which* queued signals to wait for

*info* if non-null, the signal's siginfo is returned here

*ts* upper bound on process time suspension

## Name

`sys_rt_sigtimedwait` — synchronously wait for queued signals specified in *uthese*

## Synopsis

```
long sys_rt_sigtimedwait (const sigset_t __user * uthese, siginfo_t  
__user * uinfo, const struct timespec __user * uts, size_t sigsetsize);
```

## Arguments

|                   |  |
|-------------------|--|
| <i>uthese</i>     | queued signals to wait for                         |
| <i>uinfo</i>      | if non-null, the signal's siginfo is returned here |
| <i>uts</i>        | upper bound on process time suspension             |
| <i>sigsetsize</i> | size of sigset_t type                              |

## Name

`sys_kill` — send a signal to a process

## Synopsis

```
long sys_kill (pid_t pid, int sig);
```

## Arguments

*pid* the PID of the process

*sig* signal to be sent

## Name

`sys_tgkill` — send signal to one specific thread

## Synopsis

```
long sys_tgkill (pid_t tgid, pid_t pid, int sig);
```

## Arguments

*tgid* the thread group ID of the thread

*pid* the PID of the thread

*sig* signal to be sent

## Description

This syscall also checks the *tgid* and returns `-ESRCH` even if the PID exists but it's not belonging to the target process anymore. This method solves the problem of threads exiting and PIDs getting reused.

## Name

`sys_kill` — send signal to one specific task

## Synopsis

```
long sys_kill (pid_t pid, int sig);
```

## Arguments

*pid* the PID of the task

*sig* signal to be sent

## Description

Send a signal to only one task, even if it's a CLONE\_THREAD task.

## Name

`sys_rt_sigqueueinfo` — send signal information to a signal

## Synopsis

```
long sys_rt_sigqueueinfo (pid_t pid, int sig, siginfo_t __user * uinfo);
```

## Arguments

*pid*     the PID of the thread

*sig*     signal to be sent

*uinfo*   signal info to be sent

## Name

`sys_sigpending` — examine pending signals

## Synopsis

```
long sys_sigpending (old_sigset_t __user * set);
```

## Arguments

*set* where mask of pending signal is returned

## Name

`sys_sigprocmask` — examine and change blocked signals

## Synopsis

```
long sys_sigprocmask (int how, old_sigset_t __user * nset, old_sigset_t  
__user * oset);
```

## Arguments

*how* whether to add, remove, or set signals

*nset* signals to add or remove (if non-null)

*oset* previous value of signal mask if non-null

## Description

Some platforms have their own version with special arguments; others support only `sys_rt_sigprocmask`.

## Name

`sys_rt_sigaction` — alter an action taken by a process

## Synopsis

```
long sys_rt_sigaction (int sig, const struct sigaction __user * act,  
struct sigaction __user * oact, size_t sigsetsize);
```

## Arguments

|                   |                                     |
|-------------------|-------------------------------------|
| <i>sig</i>        | signal to be sent                   |
| <i>act</i>        | new sigaction                       |
| <i>oact</i>       | used to save the previous sigaction |
| <i>sigsetsize</i> | size of sigset_t type               |

## Name

`sys_rt_sigsuspend` — replace the signal mask for a value with the *unewset* value until a signal is received

## Synopsis

```
long sys_rt_sigsuspend (sigset_t __user * unewset, size_t sigsetsize);
```

## Arguments

*unewset*      new signal mask value

*sigsetsize*   size of `sigset_t` type

## Name

`kthread_run` — create and wake a thread.

## Synopsis

```
kthread_run ( threadfn, data, namefmt, ... );
```

## Arguments

*threadfn* the function to run until `signal_pending(current)`.

*data* data ptr for *threadfn*.

*namefmt* printf-style name for the thread.

*...* variable arguments

## Description

Convenient wrapper for `kthread_create` followed by `wake_up_process`. Returns the `kthread` or `ERR_PTR(-ENOMEM)`.

## Name

`kthread_should_stop` — should this kthread return now?

## Synopsis

```
bool kthread_should_stop ( void );
```

## Arguments

*void* no arguments

## Description

When someone calls `kthread_stop` on your kthread, it will be woken and this will return true. You should then return, and your return value will be passed through to `kthread_stop`.

## Name

`kthread_freezable_should_stop` — should this freezable kthread return now?

## Synopsis

```
bool kthread_freezable_should_stop (bool * was_frozen);
```

## Arguments

*was\_frozen* optional out parameter, indicates whether current was frozen

## Description

`kthread_should_stop` for freezable kthreads, which will enter refrigerator if necessary. This function is safe from `kthread_stop` / freezer deadlock and freezable kthreads should use this function instead of calling `try_to_freeze` directly.

## Name

`kthread_create_on_node` — create a kthread.

## Synopsis

```
struct task_struct * kthread_create_on_node (int (*threadfn) (void *data), void * data, int node, const char namefmt[], ...);
```

## Arguments

*threadfn*    the function to run until `signal_pending(current)`.

*data*        data ptr for *threadfn*.

*node*        memory node number.

*namefmt*[ ]   printf-style name for the thread.

...         variable arguments

## Description

This helper function creates and names a kernel thread. The thread will be stopped: use `wake_up_process` to start it. See also `kthread_run`.

If thread is going to be bound on a particular cpu, give its node in *node*, to get NUMA affinity for kthread stack, or else give -1. When woken, the thread will run `@threadfn` with *data* as its argument. `@threadfn` can either call `do_exit` directly if it is a standalone thread for which no one will call `kthread_stop`, or return when `'kthread_should_stop'` is true (which means `kthread_stop` has been called). The return value should be zero or a negative error number; it will be passed to `kthread_stop`.

Returns a `task_struct` or `ERR_PTR(-ENOMEM)` or `ERR_PTR(-EINTR)`.

## Name

`kthread_bind` — bind a just-created kthread to a cpu.

## Synopsis

```
void kthread_bind (struct task_struct * p, unsigned int cpu);
```

## Arguments

*p* thread created by `kthread_create`.

*cpu* cpu (might not be online, must be possible) for *k* to run on.

## Description

This function is equivalent to `set_cpus_allowed`, except that *cpu* doesn't need to be online, and the thread must be stopped (i.e., just returned from `kthread_create`).

## Name

`kthread_stop` — stop a thread created by `kthread_create`.

## Synopsis

```
int kthread_stop (struct task_struct * k);
```

## Arguments

*k* thread created by `kthread_create`.

## Description

Sets `kthread_should_stop` for *k* to return true, wakes it, and waits for it to exit. This can also be called after `kthread_create` instead of calling `wake_up_process`: the thread will exit without calling `threadfn`.

If `threadfn` may call `do_exit` itself, the caller must ensure `task_struct` can't go away.

Returns the result of `threadfn`, or `-EINTR` if `wake_up_process` was never called.

## Name

`kthread_worker_fn` — kthread function to process `kthread_worker`

## Synopsis

```
int kthread_worker_fn (void * worker_ptr);
```

## Arguments

*worker\_ptr* pointer to initialized `kthread_worker`

## Description

This function can be used as *threadfn* to `kthread_create` or `kthread_run` with *worker\_ptr* argument pointing to an initialized `kthread_worker`. The started kthread will process `work_list` until the it is stopped with `kthread_stop`. A kthread can also call this function directly after extra initialization.

Different kthreads can be used for the same `kthread_worker` as long as there's only one kthread attached to it at any given time. A `kthread_worker` without an attached kthread simply collects queued `kthread_works`.

## Name

`queue_kthread_work` — queue a `kthread_work`

## Synopsis

```
bool queue_kthread_work (struct kthread_worker * worker, struct
kthread_work * work);
```

## Arguments

*worker* target `kthread_worker`

*work* `kthread_work` to queue

## Description

Queue *work* to work processor *task* for async execution. *task* must have been created with `kthread_worker_create`. Returns `true` if *work* was successfully queued, `false` if it was already pending.

## Name

`flush_kthread_work` — flush a `kthread_work`

## Synopsis

```
void flush_kthread_work (struct kthread_work * work);
```

## Arguments

*work* work to flush

## Description

If *work* is queued or executing, wait for it to finish execution.

## Name

`flush_kthread_worker` — flush all current works on a `kthread_worker`

## Synopsis

```
void flush_kthread_worker (struct kthread_worker * worker);
```

## Arguments

*worker* worker to flush

## Description

Wait until all currently executing or pending works on *worker* are finished.

## Kernel objects manipulation

## Name

`kobject_get_path` — generate and return the path associated with a given `kobj` and `kset` pair.

## Synopsis

```
char * kobject_get_path (struct kobject * kobj, gfp_t gfp_mask);
```

## Arguments

*kobj*            `kobject` in question, with which to build the path

*gfp\_mask*      the allocation type used to allocate the path

## Description

The result must be freed by the caller with `kfree`.

## Name

`kobject_set_name` — Set the name of a `kobject`

## Synopsis

```
int kobject_set_name (struct kobject * kobj, const char * fmt, ...);
```

## Arguments

*kobj* struct `kobject` to set the name of

*fmt* format string used to build the name

... variable arguments

## Description

This sets the name of the `kobject`. If you have already added the `kobject` to the system, you must call `kobject_rename` in order to change the name of the `kobject`.

## Name

`kobject_init` — initialize a `kobject` structure

## Synopsis

```
void kobject_init (struct kobject * kobj, struct kobj_type * ktype);
```

## Arguments

*kobj* pointer to the `kobject` to initialize

*ktype* pointer to the `ktype` for this `kobject`.

## Description

This function will properly initialize a `kobject` such that it can then be passed to the `kobject_add` call.

After this function is called, the `kobject` **MUST** be cleaned up by a call to `kobject_put`, not by a call to `kfree` directly to ensure that all of the memory is cleaned up properly.

## Name

`kobject_add` — the main kobject add function

## Synopsis

```
int kobject_add (struct kobject * kobj, struct kobject * parent, const
char * fmt, ...);
```

## Arguments

*kobj*     the kobject to add

*parent*   pointer to the parent of the kobject.

*fmt*     format to name the kobject with.

...     variable arguments

## Description

The kobject name is set and added to the kobject hierarchy in this function.

If *parent* is set, then the parent of the *kobj* will be set to it. If *parent* is NULL, then the parent of the *kobj* will be set to the kobject associated with the kset assigned to this kobject. If no kset is assigned to the kobject, then the kobject will be located in the root of the sysfs tree.

If this function returns an error, `kobject_put` must be called to properly clean up the memory associated with the object. Under no instance should the kobject that is passed to this function be directly freed with a call to `kfree`, that can leak memory.

Note, no “add” uevent will be created with this call, the caller should set up all of the necessary sysfs files for the object and then call `kobject_uevent` with the `UEVENT_ADD` parameter to ensure that userspace is properly notified of this kobject's creation.

## Name

`kobject_init_and_add` — initialize a `kobject` structure and add it to the `kobject` hierarchy

## Synopsis

```
int kobject_init_and_add (struct kobject * kobj, struct kobj_type *  
ktype, struct kobject * parent, const char * fmt, ...);
```

## Arguments

*kobj*     pointer to the `kobject` to initialize

*ktype*    pointer to the `ktype` for this `kobject`.

*parent*   pointer to the parent of this `kobject`.

*fmt*     the name of the `kobject`.

...      variable arguments

## Description

This function combines the call to `kobject_init` and `kobject_add`. The same type of error handling after a call to `kobject_add` and `kobject` lifetime rules are the same here.

## Name

`kobject_rename` — change the name of an object

## Synopsis

```
int kobject_rename (struct kobject * kobj, const char * new_name);
```

## Arguments

*kobj*        object in question.

*new\_name*   object's new name

## Description

It is the responsibility of the caller to provide mutual exclusion between two different calls of `kobject_rename` on the same `kobject` and to ensure that `new_name` is valid and won't conflict with other `kobjects`.

## Name

`kobject_del` — unlink `kobject` from hierarchy.

## Synopsis

```
void kobject_del (struct kobject * kobj);
```

## Arguments

*kobj* object.

## Name

`kobject_get` — increment refcount for object.

## Synopsis

```
struct kobject * kobject_get (struct kobject * kobj);
```

## Arguments

*kobj* object.

## Name

`kobject_put` — decrement refcount for object.

## Synopsis

```
void kobject_put (struct kobject * kobj);
```

## Arguments

*kobj* object.

## Description

Decrement the refcount, and if 0, call `kobject_cleanup`.

## Name

`kobject_create_and_add` — create a struct `kobject` dynamically and register it with `sysfs`

## Synopsis

```
struct kobject * kobject_create_and_add (const char * name, struct  
kobject * parent);
```

## Arguments

*name*     the name for the `kobject`

*parent*   the parent `kobject` of this `kobject`, if any.

## Description

This function creates a `kobject` structure dynamically and registers it with `sysfs`. When you are finished with this structure, call `kobject_put` and the structure will be dynamically freed when it is no longer being used.

If the `kobject` was not able to be created, `NULL` will be returned.

## Name

`kset_register` — initialize and add a kset.

## Synopsis

```
int kset_register (struct kset * k);
```

## Arguments

*k* kset.

## Name

`kset_unregister` — remove a kset.

## Synopsis

```
void kset_unregister (struct kset * k);
```

## Arguments

*k* kset.

## Name

`kset_create_and_add` — create a struct `kset` dynamically and add it to `sysfs`

## Synopsis

```
struct kset * kset_create_and_add (const char * name, const struct  
kset_uevent_ops * uevent_ops, struct kobject * parent_kobj);
```

## Arguments

*name*            the name for the `kset`

*uevent\_ops*    a struct `kset_uevent_ops` for the `kset`

*parent\_kobj*    the parent `kobject` of this `kset`, if any.

## Description

This function creates a `kset` structure dynamically and registers it with `sysfs`. When you are finished with this structure, call `kset_unregister` and the structure will be dynamically freed when it is no longer being used.

If the `kset` was not able to be created, `NULL` will be returned.

## Kernel utility functions

## Name

`upper_32_bits` — return bits 32-63 of a number

## Synopsis

```
upper_32_bits ( n );
```

## Arguments

`n` the number we're accessing

## Description

A basic shift-right of a 64- or 32-bit quantity. Use this to suppress the “right shift count  $\geq$  width of type” warning when that quantity is 32-bits.

## Name

`lower_32_bits` — return bits 0-31 of a number

## Synopsis

```
lower_32_bits ( n );
```

## Arguments

*n* the number we're accessing

## Name

`might_sleep` — annotation for functions that can sleep

## Synopsis

```
might_sleep (void);
```

## Arguments

None

## Description

this macro will print a stack trace if it is executed in an atomic context (spinlock, irq-handler, ...).

This is a useful debugging help to be able to catch problems early and not be bitten later when the calling function happens to sleep when it is not supposed to.

## Name

`reciprocal_scale` — "scale" a value into range  $[0, ep\_ro)$

## Synopsis

```
u32 reciprocal_scale (u32 val, u32 ep_ro);
```

## Arguments

*val* value

*ep\_ro* right open interval endpoint

## Description

Perform a “reciprocal multiplication” in order to “scale” a value into range  $[0, ep\_ro)$ , where the upper interval endpoint is right-open. This is useful, e.g. for accessing a index of an array containing `ep_ro` elements, for example. Think of it as sort of modulus, only that the result isn't that of modulo. ;) Note that if initial input is a small value, then result will return 0.

## Return

a result based on `val` in interval  $[0, ep\_ro)$ .

## Name

`kstrtoul` — convert a string to an unsigned long

## Synopsis

```
int kstrtoul (const char * s, unsigned int base, unsigned long * res);
```

## Arguments

*s*        The start of the string. The string must be null-terminated, and may also include a single newline before its terminating null. The first character may also be a plus sign, but not a minus sign.

*base*    The number base to use. The maximum supported base is 16. If *base* is given as 0, then the base of the string is automatically detected with the conventional semantics - If it begins with 0x the number will be parsed as a hexadecimal (case insensitive), if it otherwise begins with 0, it will be parsed as an octal number. Otherwise it will be parsed as a decimal.

*res*     Where to write the result of the conversion on success.

## Description

Returns 0 on success, -ERANGE on overflow and -EINVAL on parsing error. Used as a replacement for the obsolete `simple_strtoul`. Return code must be checked.

## Name

`kstrtol` — convert a string to a long

## Synopsis

```
int kstrtol (const char * s, unsigned int base, long * res);
```

## Arguments

*s*        The start of the string. The string must be null-terminated, and may also include a single newline before its terminating null. The first character may also be a plus sign or a minus sign.

*base*    The number base to use. The maximum supported base is 16. If *base* is given as 0, then the base of the string is automatically detected with the conventional semantics - If it begins with 0x the number will be parsed as a hexadecimal (case insensitive), if it otherwise begins with 0, it will be parsed as an octal number. Otherwise it will be parsed as a decimal.

*res*     Where to write the result of the conversion on success.

## Description

Returns 0 on success, -ERANGE on overflow and -EINVAL on parsing error. Used as a replacement for the obsolete `simple_strtoll`. Return code must be checked.

## Name

`trace_printk` — printf formatting in the ftrace buffer

## Synopsis

```
trace_printk ( fmt, ... );
```

## Arguments

*fmt* the printf format for printing

*...* variable arguments

## Note

`__trace_printk` is an internal function for `trace_printk` and the *ip* is passed in via the `trace_printk` macro.

This function allows a kernel developer to debug fast path sections that `printk` is not appropriate for. By scattering in various `printk` like tracing in the code, a developer can quickly see where problems are occurring.

This is intended as a debugging tool for the developer only. Please refrain from leaving `trace_printks` scattered around in your code. (Extra memory is used for special buffers that are allocated when `trace_printk` is used)

A little optimization trick is done here. If there's only one argument, there's no need to scan the string for printf formats. The `trace_puts` will suffice. But how can we take advantage of using `trace_puts` when `trace_printk` has only one argument? By stringifying the args and checking the size we can tell whether or not there are args. `__stringify((__VA_ARGS__))` will turn into “()`\0`” with a size of 3 when there are no args, anything else will be bigger. All we need to do is define a string to this, and then take its size and compare to 3. If it's bigger, use `do_trace_printk` otherwise, optimize it to `trace_puts`. Then just let gcc optimize the rest.

## Name

`trace_puts` — write a string into the ftrace buffer

## Synopsis

```
trace_puts ( str );
```

## Arguments

*str* the string to record

## Note

`__trace_bputs` is an internal function for `trace_puts` and the *ip* is passed in via the `trace_puts` macro.

This is similar to `trace_printk` but is made for those really fast paths that a developer wants the least amount of “Heisenbug” affects, where the processing of the print format is still too much.

This function allows a kernel developer to debug fast path sections that `printk` is not appropriate for. By scattering in various `printk` like tracing in the code, a developer can quickly see where problems are occurring.

This is intended as a debugging tool for the developer only. Please refrain from leaving `trace_puts` scattered around in your code. (Extra memory is used for special buffers that are allocated when `trace_puts` is used)

## Returns

0 if nothing was written, positive # if string was. (1 when `__trace_bputs` is used, `strlen(str)` when `__trace_puts` is used)

## Name

`min_not_zero` — return the minimum that is `_not_zero`, unless both are zero

## Synopsis

```
min_not_zero ( x, y );
```

## Arguments

`x` value1

`y` value2

## Name

`clamp` — return a value clamped to a given range with strict typechecking

## Synopsis

```
clamp ( val, lo, hi );
```

## Arguments

*val* current value

*lo* lowest allowable value

*hi* highest allowable value

## Description

This macro does strict typechecking of *lo*/*hi* to make sure they are of the same type as *val*. See the unnecessary pointer comparisons.

## Name

`clamp_t` — return a value clamped to a given range using a given type

## Synopsis

```
clamp_t ( type, val, lo, hi );
```

## Arguments

*type* the type of variable to use

*val* current value

*lo* minimum allowable value

*hi* maximum allowable value

## Description

This macro does no typechecking and uses temporary variables of type 'type' to make all the comparisons.

## Name

`clamp_val` — return a value clamped to a given range using `val`'s type

## Synopsis

```
clamp_val ( val, lo, hi );
```

## Arguments

*val* current value

*lo* minimum allowable value

*hi* maximum allowable value

## Description

This macro does no typechecking and uses temporary variables of whatever type the input argument '`val`' is. This is useful when `val` is an unsigned type and `min` and `max` are literals that will otherwise be assigned a signed integer type.

## Name

`container_of` — cast a member of a structure out to the containing structure

## Synopsis

```
container_of ( ptr, type, member );
```

## Arguments

*ptr*        the pointer to the member.

*type*      the type of the container struct this is embedded in.

*member*    the name of the member within the struct.

## Name

`printk` — print a kernel message

## Synopsis

```
__visible int printk (const char * fmt, ...);
```

## Arguments

*fmt* format string

... variable arguments

## Description

This is `printk`. It can be called from any context. We want it to work.

We try to grab the `console_lock`. If we succeed, it's easy - we log the output and call the console drivers. If we fail to get the semaphore, we place the output into the log buffer and return. The current holder of the `console_sem` will notice the new output in `console_unlock`; and will send it to the consoles before releasing the lock.

One effect of this deferred printing is that code which calls `printk` and then changes `console_loglevel` may break. This is because `console_loglevel` is inspected when the actual printing occurs.

## See also

`printf(3)`

See the `vsnprintf` documentation for format string extensions over C99.

## Name

`console_lock` — lock the console system for exclusive use.

## Synopsis

```
void console_lock ( void );
```

## Arguments

*void* no arguments

## Description

Acquires a lock which guarantees that the caller has exclusive access to the console system and the `console_drivers` list.

Can sleep, returns nothing.

## Name

`console_trylock` — try to lock the console system for exclusive use.

## Synopsis

```
int console_trylock ( void );
```

## Arguments

*void* no arguments

## Description

Try to acquire a lock which guarantees that the caller has exclusive access to the console system and the `console_drivers` list.

returns 1 on success, and 0 on failure to acquire the lock.

## Name

`console_unlock` — unlock the console system

## Synopsis

```
void console_unlock ( void );
```

## Arguments

*void* no arguments

## Description

Releases the `console_lock` which the caller holds on the console system and the console driver list.

While the `console_lock` was held, console output may have been buffered by `printk`. If this is the case, `console_unlock`; emits the output prior to releasing the lock.

If there is output waiting, we wake `/dev/kmsg` and `syslog` users.

`console_unlock`; may be called from any context.

## Name

`console_conditional_schedule` — yield the CPU if required

## Synopsis

```
void __sched console_conditional_schedule ( void );
```

## Arguments

*void* no arguments

## Description

If the console code is currently allowed to sleep, and if this CPU should yield the CPU to another task, do so here.

Must be called within `console_lock`;

## Name

`printk_timed_ratelimit` — caller-controlled printk ratelimiting

## Synopsis

```
bool printk_timed_ratelimit (unsigned long * caller_jiffies, unsigned
int interval_msecs);
```

## Arguments

*caller\_jiffies* pointer to caller's state

*interval\_msecs* minimum interval between prints

## Description

`printk_timed_ratelimit` returns true if more than *interval\_msecs* milliseconds have elapsed since the last time `printk_timed_ratelimit` returned true.

## Name

`kmsg_dump_register` — register a kernel log dumper.

## Synopsis

```
int kmsg_dump_register (struct kmsg_dumper * dumper);
```

## Arguments

*dumper* pointer to the `kmsg_dumper` structure

## Description

Adds a kernel log dumper to the system. The dump callback in the structure will be called when the kernel oopses or panics and must be set. Returns zero on success and `-EINVAL` or `-EBUSY` otherwise.

## Name

`kmsg_dump_unregister` — unregister a kmsg dumper.

## Synopsis

```
int kmsg_dump_unregister (struct kmsg_dumper * dumper);
```

## Arguments

*dumper* pointer to the kmsg\_dumper structure

## Description

Removes a dump device from the system. Returns zero on success and `-EINVAL` otherwise.

## Name

`kmsg_dump_get_line` — retrieve one kmsg log line

## Synopsis

```
bool kmsg_dump_get_line (struct kmsg_dumper * dumper, bool syslog, char  
* line, size_t size, size_t * len);
```

## Arguments

*dumper* registered kmsg dumper

*syslog* include the “<4>” prefixes

*line* buffer to copy the line to

*size* maximum size of the buffer

*len* length of line placed into buffer

## Description

Start at the beginning of the kmsg buffer, with the oldest kmsg record, and copy one record into the provided buffer.

Consecutive calls will return the next available record moving towards the end of the buffer with the youngest messages.

A return value of FALSE indicates that there are no more records to read.

## Name

`kmsg_dump_get_buffer` — copy kmsg log lines

## Synopsis

```
bool kmsg_dump_get_buffer (struct kmsg_dumper * dumper, bool syslog,  
char * buf, size_t size, size_t * len);
```

## Arguments

*dumper* registered kmsg dumper

*syslog* include the “<4>” prefixes

*buf* buffer to copy the line to

*size* maximum size of the buffer

*len* length of line placed into buffer

## Description

Start at the end of the kmsg buffer and fill the provided buffer with as many of the the \*youngest\* kmsg records that fit into it. If the buffer is large enough, all available kmsg records will be copied with a single call.

Consecutive calls will fill the buffer with the next block of available older records, not including the earlier retrieved ones.

A return value of FALSE indicates that there are no more records to read.

## Name

`kmsg_dump_rewind` — reset the iterator

## Synopsis

```
void kmsg_dump_rewind (struct kmsg_dumper * dumper);
```

## Arguments

*dumper* registered kmsg dumper

## Description

Reset the dumper's iterator so that `kmsg_dump_get_line` and `kmsg_dump_get_buffer` can be called again and used multiple times within the same `dumper.dump` callback.

## Name

`printk_hash` — print a kernel message include a hash over the message

## Synopsis

```
int printk_hash (const char * prefix, const char * fmt, ...);
```

## Arguments

*prefix* message prefix including the ".06x" for the hash

*fmt* format string

... variable arguments

## Name

`printk_dev_hash` — print a kernel message include a hash over the message

## Synopsis

```
int printk_dev_hash (const char * prefix, const char * driver_name,  
const char * fmt, ...);
```

## Arguments

*prefix*            message prefix including the ".06x" for the hash

*driver\_name*    -- undescribed --

*fmt*             format string

*...*            variable arguments

## Name

`panic` — halt the system

## Synopsis

```
void panic (const char * fmt, ...);
```

## Arguments

*fmt* The text string to print

... variable arguments

## Description

Display a message, then perform cleanups.

This function never returns.

## Name

`add_taint` —

## Synopsis

```
void add_taint (unsigned flag, enum lockdep_ok lockdep_ok);
```

## Arguments

*flag*            one of the TAIN\*\_\* constants.

*lockdep\_ok*    whether lock debugging is still OK.

## Description

If something bad has gone wrong, you'll want `lockdebug_ok = false`, but for some noteworthy-but-not-corrupting cases, it can be set to true.

## Name

/usr/src/linux-4.1.27-24//kernel/sys.c — Document generation inconsistency

## Oops

### Warning

The template for this document tried to insert the structured comment from the file `/usr/src/linux-4.1.27-24//kernel/sys.c` at this point, but none was found. This dummy section is inserted to allow generation to continue.

## Name

`init_srcu_struct` — initialize a sleep-RCU structure

## Synopsis

```
int init_srcu_struct (struct srcu_struct * sp);
```

## Arguments

*sp* structure to initialize.

## Description

Must invoke this on a given `srcu_struct` before passing that `srcu_struct` to any other function. Each `srcu_struct` represents a separate domain of SRCU protection.

## Name

`cleanup_srcu_struct` — deconstruct a sleep-RCU structure

## Synopsis

```
void cleanup_srcu_struct (struct srcu_struct * sp);
```

## Arguments

*sp* structure to clean up.

## Description

Must invoke this after you are finished using a given `srcu_struct` that was initialized via `init_srcu_struct`, else you leak memory.

## Name

`synchronize_srcu` — wait for prior SRCU read-side critical-section completion

## Synopsis

```
void synchronize_srcu (struct srcu_struct * sp);
```

## Arguments

*sp* `srcu_struct` with which to synchronize.

## Description

Wait for the count to drain to zero of both indexes. To avoid the possible starvation of `synchronize_srcu`, it waits for the count of the index=`((->completed & 1) ^ 1)` to drain to zero at first, and then flip the completed and wait for the count of the other index.

Can block; must be called from process context.

Note that it is illegal to call `synchronize_srcu` from the corresponding SRCU read-side critical section; doing so will result in deadlock. However, it is perfectly legal to call `synchronize_srcu` on one `srcu_struct` from some other `srcu_struct`'s read-side critical section, as long as the resulting graph of `srcu_structs` is acyclic.

There are memory-ordering constraints implied by `synchronize_srcu`. On systems with more than one CPU, when `synchronize_srcu` returns, each CPU is guaranteed to have executed a full memory barrier since the end of its last corresponding SRCU-sched read-side critical section whose beginning preceded the call to `synchronize_srcu`. In addition, each CPU having an SRCU read-side critical section that extends beyond the return from `synchronize_srcu` is guaranteed to have executed a full memory barrier after the beginning of `synchronize_srcu` and before the beginning of that SRCU read-side critical section. Note that these guarantees include CPUs that are offline, idle, or executing in user mode, as well as CPUs that are executing in the kernel.

Furthermore, if CPU A invoked `synchronize_srcu`, which returned to its caller on CPU B, then both CPU A and CPU B are guaranteed to have executed a full memory barrier during the execution of `synchronize_srcu`. This guarantee applies even if CPU A and CPU B are the same CPU, but again only if the system has more than one CPU.

Of course, these memory-ordering guarantees apply only when `synchronize_srcu`, `srcu_read_lock`, and `srcu_read_unlock` are passed the same `srcu_struct` structure.

## Name

`synchronize_srcu_expedited` — Brute-force SRCU grace period

## Synopsis

```
void synchronize_srcu_expedited (struct srcu_struct * sp);
```

## Arguments

*sp* srcu\_struct with which to synchronize.

## Description

Wait for an SRCU grace period to elapse, but be more aggressive about spinning rather than blocking when waiting.

Note that `synchronize_srcu_expedited` has the same deadlock and memory-ordering properties as does `synchronize_srcu`.

## Name

`srcu_barrier` — Wait until all in-flight `call_srcu` callbacks complete.

## Synopsis

```
void srcu_barrier (struct srcu_struct * sp);
```

## Arguments

*sp* `srcu_struct` on which to wait for in-flight callbacks.

## Name

`srcu_batches_completed` — return batches completed.

## Synopsis

```
unsigned long srcu_batches_completed (struct srcu_struct * sp);
```

## Arguments

*sp* `srcu_struct` on which to report batch completion.

## Description

Report the number of batches, correlated with, but not necessarily precisely the same as, the number of grace periods that have elapsed.

## Name

`rcu_idle_enter` — inform RCU that current CPU is entering idle

## Synopsis

```
void rcu_idle_enter ( void );
```

## Arguments

*void* no arguments

## Description

Enter idle mode, in other words, -leave- the mode in which RCU read-side critical sections can occur. (Though RCU read-side critical sections can occur in irq handlers in idle, a possibility handled by `irq_enter` and `irq_exit`.)

We crowbar the `->dynticks_nesting` field to zero to allow for the possibility of usermode upcalls having messed up our count of interrupt nesting level during the prior busy period.

## Name

`rcu_idle_exit` — inform RCU that current CPU is leaving idle

## Synopsis

```
void rcu_idle_exit ( void );
```

## Arguments

*void* no arguments

## Description

Exit idle mode, in other words, -enter- the mode in which RCU read-side critical sections can occur.

We crowbar the `->dynticks_nesting` field to `DYNTICK_TASK_NEST` to allow for the possibility of user-mode upcalls messing up our count of interrupt nesting level during the busy period that is just now starting.

## Name

`rcu_is_watching` — see if RCU thinks that the current CPU is idle

## Synopsis

```
bool notrace rcu_is_watching ( void );
```

## Arguments

*void* no arguments

## Description

If the current CPU is in its idle loop and is neither in an interrupt or NMI handler, return true.

## Name

`synchronize_sched` — wait until an rcu-sched grace period has elapsed.

## Synopsis

```
void synchronize_sched ( void );
```

## Arguments

*void* no arguments

## Description

Control will return to the caller some time after a full rcu-sched grace period has elapsed, in other words after all currently executing rcu-sched read-side critical sections have completed. These read-side critical sections are delimited by `rcu_read_lock_sched` and `rcu_read_unlock_sched`, and may be nested. Note that `preempt_disable`, `local_irq_disable`, and so on may be used in place of `rcu_read_lock_sched`.

This means that all `preempt_disable` code sequences, including NMI and non-threaded hardware-interrupt handlers, in progress on entry will have completed before this primitive returns. However, this does not guarantee that softirq handlers will have completed, since in some kernels, these handlers can run in process context, and can block.

Note that this guarantee implies further memory-ordering guarantees. On systems with more than one CPU, when `synchronize_sched` returns, each CPU is guaranteed to have executed a full memory barrier since the end of its last RCU-sched read-side critical section whose beginning preceded the call to `synchronize_sched`. In addition, each CPU having an RCU read-side critical section that extends beyond the return from `synchronize_sched` is guaranteed to have executed a full memory barrier after the beginning of `synchronize_sched` and before the beginning of that RCU read-side critical section. Note that these guarantees include CPUs that are offline, idle, or executing in user mode, as well as CPUs that are executing in the kernel.

Furthermore, if CPU A invoked `synchronize_sched`, which returned to its caller on CPU B, then both CPU A and CPU B are guaranteed to have executed a full memory barrier during the execution of `synchronize_sched` -- even if CPU A and CPU B are the same CPU (but again only if the system has more than one CPU).

This primitive provides the guarantees made by the (now removed) `synchronize_kernel` API. In contrast, `synchronize_rcu` only guarantees that `rcu_read_lock` sections will have completed. In “classic RCU”, these two guarantees happen to be one and the same, but can differ in realtime RCU implementations.

## Name

`synchronize_rcu_bh` — wait until an `rcu_bh` grace period has elapsed.

## Synopsis

```
void synchronize_rcu_bh ( void );
```

## Arguments

*void* no arguments

## Description

Control will return to the caller some time after a full `rcu_bh` grace period has elapsed, in other words after all currently executing `rcu_bh` read-side critical sections have completed. RCU read-side critical sections are delimited by `rcu_read_lock_bh` and `rcu_read_unlock_bh`, and may be nested.

See the description of `synchronize_sched` for more detailed information on memory ordering guarantees.

## Name

`get_state_synchronize_rcu` — Snapshot current RCU state

## Synopsis

```
unsigned long get_state_synchronize_rcu ( void );
```

## Arguments

*void* no arguments

## Description

Returns a cookie that is used by a later call to `cond_synchronize_rcu` to determine whether or not a full grace period has elapsed in the meantime.

## Name

`cond_synchronize_rcu` — Conditionally wait for an RCU grace period

## Synopsis

```
void cond_synchronize_rcu (unsigned long oldstate);
```

## Arguments

*oldstate* return value from earlier call to `get_state_synchronize_rcu`

## Description

If a full RCU grace period has elapsed since the earlier call to `get_state_synchronize_rcu`, just return. Otherwise, invoke `synchronize_rcu` to wait for a full grace period.

Yes, this function does not take counter wrap into account. But counter wrap is harmless. If the counter wraps, we have waited for more than 2 billion grace periods (and way more on a 64-bit system!), so waiting for one additional grace period should be just fine.

## Name

`synchronize_sched_expedited` — Brute-force RCU-sched grace period

## Synopsis

```
void synchronize_sched_expedited ( void );
```

## Arguments

*void* no arguments

## Description

Wait for an RCU-sched grace period to elapse, but use a “big hammer” approach to force the grace period to end quickly. This consumes significant time on all CPUs and is unfriendly to real-time workloads, so is thus not recommended for any sort of common-case code. In fact, if you are using `synchronize_sched_expedited` in a loop, please restructure your code to batch your updates, and then use a single `synchronize_sched` instead.

This implementation can be thought of as an application of ticket locking to RCU, with `sync_sched_expedited_started` and `sync_sched_expedited_done` taking on the roles of the halves of the ticket-lock word. Each task atomically increments `sync_sched_expedited_started` upon entry, snapshotting the old value, then attempts to stop all the CPUs. If this succeeds, then each CPU will have executed a context switch, resulting in an RCU-sched grace period. We are then done, so we use `atomic_cmpxchg` to update `sync_sched_expedited_done` to match our snapshot -- but only if someone else has not already advanced past our snapshot.

On the other hand, if `try_stop_cpus` fails, we check the value of `sync_sched_expedited_done`. If it has advanced past our initial snapshot, then someone else must have forced a grace period some time after we took our snapshot. In this case, our work is done for us, and we can simply return. Otherwise, we try again, but keep our initial snapshot for purposes of checking for someone doing our work for us.

If we fail too many times in a row, we fall back to `synchronize_sched`.

## Name

`rcu_barrier_bh` — Wait until all in-flight `call_rcu_bh` callbacks complete.

## Synopsis

```
void rcu_barrier_bh ( void );
```

## Arguments

*void* no arguments

## Name

`rcu_barrier_sched` — Wait for in-flight `call_rcu_sched` callbacks.

## Synopsis

```
void rcu_barrier_sched ( void );
```

## Arguments

*void* no arguments

## Name

`synchronize_rcu` — wait until a grace period has elapsed.

## Synopsis

```
void synchronize_rcu ( void );
```

## Arguments

*void* no arguments

## Description

Control will return to the caller some time after a full grace period has elapsed, in other words after all currently executing RCU read-side critical sections have completed. Note, however, that upon return from `synchronize_rcu`, the caller might well be executing concurrently with new RCU read-side critical sections that began while `synchronize_rcu` was waiting. RCU read-side critical sections are delimited by `rcu_read_lock` and `rcu_read_unlock`, and may be nested.

See the description of `synchronize_sched` for more detailed information on memory ordering guarantees.

## Name

`synchronize_rcu_expedited` — Brute-force RCU grace period

## Synopsis

```
void synchronize_rcu_expedited ( void );
```

## Arguments

*void* no arguments

## Description

Wait for an RCU-preempt grace period, but expedite it. The basic idea is to invoke `synchronize_sched_expedited` to push all the tasks to the `->blkd_tasks` lists and wait for this list to drain. This consumes significant time on all CPUs and is unfriendly to real-time workloads, so is thus not recommended for any sort of common-case code. In fact, if you are using `synchronize_rcu_expedited` in a loop, please restructure your code to batch your updates, and then Use a single `synchronize_rcu` instead.

## Name

`rcu_barrier` — Wait until all in-flight `call_rcu` callbacks complete.

## Synopsis

```
void rcu_barrier ( void );
```

## Arguments

*void* no arguments

## Description

Note that this primitive does not necessarily wait for an RCU grace period to complete. For example, if there are no RCU callbacks queued anywhere in the system, then `rcu_barrier` is within its rights to return immediately, without waiting for anything, much less an RCU grace period.

## Name

`rcu_expedite_gp` — Expedite future RCU grace periods

## Synopsis

```
void rcu_expedite_gp ( void );
```

## Arguments

*void* no arguments

## Description

After a call to this function, future calls to `synchronize_rcu` and friends act as the corresponding `synchronize_rcu_expedited` function had instead been called.

## Name

`rcu_unexpedite_gp` — Cancel prior `rcu_expedite_gp` invocation

## Synopsis

```
void rcu_unexpedite_gp ( void );
```

## Arguments

*void* no arguments

## Description

Undo a prior call to `rcu_expedite_gp`. If all prior calls to `rcu_expedite_gp` are undone by a subsequent call to `rcu_unexpedite_gp`, and if the `rcu_expedited` `sysfs/boot` parameter is not set, then all subsequent calls to `synchronize_rcu` and friends will return to their normal non-expedited behavior.

## Name

`rcu_read_lock_held` — might we be in RCU read-side critical section?

## Synopsis

```
int rcu_read_lock_held ( void );
```

## Arguments

*void* no arguments

## Description

If `CONFIG_DEBUG_LOCK_ALLOC` is selected, returns nonzero iff in an RCU read-side critical section. In absence of `CONFIG_DEBUG_LOCK_ALLOC`, this assumes we are in an RCU read-side critical section unless it can prove otherwise. This is useful for debug checks in functions that require that they be called within an RCU read-side critical section.

Checks `debug_lockdep_rcu_enabled` to prevent false positives during boot and while lockdep is disabled.

Note that `rcu_read_lock` and the matching `rcu_read_unlock` must occur in the same context, for example, it is illegal to invoke `rcu_read_unlock` in process context if the matching `rcu_read_lock` was invoked from within an irq handler.

Note that `rcu_read_lock` is disallowed if the CPU is either idle or offline from an RCU perspective, so check for those as well.

## Name

`rcu_read_lock_bh_held` — might we be in RCU-bh read-side critical section?

## Synopsis

```
int rcu_read_lock_bh_held ( void );
```

## Arguments

*void* no arguments

## Description

Check for bottom half being disabled, which covers both the `CONFIG_PROVE_RCU` and not cases. Note that if someone uses `rcu_read_lock_bh`, but then later enables BH, lockdep (if enabled) will show the situation. This is useful for debug checks in functions that require that they be called within an RCU read-side critical section.

Check `debug_lockdep_rcu_enabled` to prevent false positives during boot.

Note that `rcu_read_lock` is disallowed if the CPU is either idle or offline from an RCU perspective, so check for those as well.

## Name

`init_rcu_head_on_stack` — initialize on-stack `rcu_head` for debugobjects

## Synopsis

```
void init_rcu_head_on_stack (struct rcu_head * head);
```

## Arguments

*head* pointer to `rcu_head` structure to be initialized

## Description

This function informs debugobjects of a new `rcu_head` structure that has been allocated as an auto variable on the stack. This function is not required for `rcu_head` structures that are statically defined or that are dynamically allocated on the heap. This function has no effect for !`CONFIG_DEBUG_OBJECTS_RCU_HEAD` kernel builds.

## Name

`destroy_rcu_head_on_stack` — destroy on-stack `rcu_head` for debugobjects

## Synopsis

```
void destroy_rcu_head_on_stack (struct rcu_head * head);
```

## Arguments

*head* pointer to `rcu_head` structure to be initialized

## Description

This function informs debugobjects that an on-stack `rcu_head` structure is about to go out of scope. As with `init_rcu_head_on_stack`, this function is not required for `rcu_head` structures that are statically defined or that are dynamically allocated on the heap. Also as with `init_rcu_head_on_stack`, this function has no effect for `!CONFIG_DEBUG_OBJECTS_RCU_HEAD` kernel builds.

## Name

`synchronize_rcu_tasks` — wait until an rcu-tasks grace period has elapsed.

## Synopsis

```
void synchronize_rcu_tasks ( void );
```

## Arguments

*void* no arguments

## Description

Control will return to the caller some time after a full rcu-tasks grace period has elapsed, in other words after all currently executing rcu-tasks read-side critical sections have elapsed. These read-side critical sections are delimited by calls to `schedule`, `cond_resched_rcu_qs`, idle execution, userspace execution, calls to `synchronize_rcu_tasks`, and (in theory, anyway) `cond_resched`.

This is a very specialized primitive, intended only for a few uses in tracing and other situations requiring manipulation of function preambles and profiling hooks. The `synchronize_rcu_tasks` function is not (yet) intended for heavy use from multiple CPUs.

Note that this guarantee implies further memory-ordering guarantees. On systems with more than one CPU, when `synchronize_rcu_tasks` returns, each CPU is guaranteed to have executed a full memory barrier since the end of its last RCU-tasks read-side critical section whose beginning preceded the call to `synchronize_rcu_tasks`. In addition, each CPU having an RCU-tasks read-side critical section that extends beyond the return from `synchronize_rcu_tasks` is guaranteed to have executed a full memory barrier after the beginning of `synchronize_rcu_tasks` and before the beginning of that RCU-tasks read-side critical section. Note that these guarantees include CPUs that are offline, idle, or executing in user mode, as well as CPUs that are executing in the kernel.

Furthermore, if CPU A invoked `synchronize_rcu_tasks`, which returned to its caller on CPU B, then both CPU A and CPU B are guaranteed to have executed a full memory barrier during the execution of `synchronize_rcu_tasks` -- even if CPU A and CPU B are the same CPU (but again only if the system has more than one CPU).

## Name

`rcu_barrier_tasks` — Wait for in-flight `call_rcu_tasks` callbacks.

## Synopsis

```
void rcu_barrier_tasks ( void );
```

## Arguments

*void* no arguments

## Description

Although the current implementation is guaranteed to wait, it is not obligated to, for example, if there are no pending callbacks.

# Device Resource Management

## Name

`devres_alloc` — Allocate device resource data

## Synopsis

```
void * devres_alloc (dr_release_t release, size_t size, gfp_t gfp);
```

## Arguments

*release* Release function devres will be associated with

*size* Allocation size

*gfp* Allocation flags

## Description

Allocate devres of *size* bytes. The allocated area is zeroed, then associated with *release*. The returned pointer can be passed to other `devres_*`() functions.

## RETURNS

Pointer to allocated devres on success, NULL on failure.

## Name

`devres_for_each_res` — Resource iterator

## Synopsis

```
void devres_for_each_res (struct device * dev, dr_release_t release,  
dr_match_t match, void * match_data, void (*fn) (struct device *, void  
*, void *), void * data);
```

## Arguments

|                   |  |
|-------------------|--|
| <i>dev</i>        | Device to iterate resource from                          |
| <i>release</i>    | Look for resources associated with this release function |
| <i>match</i>      | Match function (optional)                                |
| <i>match_data</i> | Data for the match function                              |
| <i>fn</i>         | Function to be called for each matched resource.         |
| <i>data</i>       | Data for <i>fn</i> , the 3rd parameter of <i>fn</i>      |

## Description

Call *fn* for each devres of *dev* which is associated with *release* and for which *match* returns 1.

## RETURNS

void

## Name

`devres_free` — Free device resource data

## Synopsis

```
void devres_free (void * res);
```

## Arguments

*res* Pointer to devres data to free

## Description

Free devres created with `devres_alloc`.

## Name

`devres_add` — Register device resource

## Synopsis

```
void devres_add (struct device * dev, void * res);
```

## Arguments

*dev* Device to add resource to

*res* Resource to register

## Description

Register devres *res* to *dev*. *res* should have been allocated using `devres_alloc`. On driver detach, the associated release function will be invoked and devres will be freed automatically.

## Name

`devres_find` — Find device resource

## Synopsis

```
void * devres_find (struct device * dev, dr_release_t release, dr_match_t  
match, void * match_data);
```

## Arguments

|                   |  |
|-------------------|--|
| <i>dev</i>        | Device to lookup resource from                           |
| <i>release</i>    | Look for resources associated with this release function |
| <i>match</i>      | Match function (optional)                                |
| <i>match_data</i> | Data for the match function                              |

## Description

Find the latest devres of *dev* which is associated with *release* and for which *match* returns 1. If *match* is NULL, it's considered to match all.

## RETURNS

Pointer to found devres, NULL if not found.

## Name

`devres_get` — Find devres, if non-existent, add one atomically

## Synopsis

```
void * devres_get (struct device * dev, void * new_res, dr_match_t  
match, void * match_data);
```

## Arguments

|                   |   |
|-------------------|---|
| <i>dev</i>        | Device to lookup or add devres for                    |
| <i>new_res</i>    | Pointer to new initialized devres to add if not found |
| <i>match</i>      | Match function (optional)                             |
| <i>match_data</i> | Data for the match function                           |

## Description

Find the latest devres of *dev* which has the same release function as *new\_res* and for which *match* return 1. If found, *new\_res* is freed; otherwise, *new\_res* is added atomically.

## RETURNS

Pointer to found or added devres.

## Name

`devres_remove` — Find a device resource and remove it

## Synopsis

```
void * devres_remove (struct device * dev, dr_release_t release,  
dr_match_t match, void * match_data);
```

## Arguments

|                   |  |
|-------------------|--|
| <i>dev</i>        | Device to find resource from                             |
| <i>release</i>    | Look for resources associated with this release function |
| <i>match</i>      | Match function (optional)                                |
| <i>match_data</i> | Data for the match function                              |

## Description

Find the latest devres of *dev* associated with *release* and for which *match* returns 1. If *match* is NULL, it's considered to match all. If found, the resource is removed atomically and returned.

## RETURNS

Pointer to removed devres on success, NULL if not found.

## Name

`devres_destroy` — Find a device resource and destroy it

## Synopsis

```
int devres_destroy (struct device * dev, dr_release_t release,
dr_match_t match, void * match_data);
```

## Arguments

|                   |  |
|-------------------|--|
| <i>dev</i>        | Device to find resource from                             |
| <i>release</i>    | Look for resources associated with this release function |
| <i>match</i>      | Match function (optional)                                |
| <i>match_data</i> | Data for the match function                              |

## Description

Find the latest devres of *dev* associated with *release* and for which *match* returns 1. If *match* is NULL, it's considered to match all. If found, the resource is removed atomically and freed.

Note that the release function for the resource will not be called, only the devres-allocated data will be freed. The caller becomes responsible for freeing any other data.

## RETURNS

0 if devres is found and freed, -ENOENT if not found.

## Name

`devres_release` — Find a device resource and destroy it, calling `release`

## Synopsis

```
int devres_release (struct device * dev, dr_release_t release,
dr_match_t match, void * match_data);
```

## Arguments

|                   |  |
|-------------------|--|
| <i>dev</i>        | Device to find resource from                             |
| <i>release</i>    | Look for resources associated with this release function |
| <i>match</i>      | Match function (optional)                                |
| <i>match_data</i> | Data for the match function                              |

## Description

Find the latest devres of *dev* associated with *release* and for which *match* returns 1. If *match* is NULL, it's considered to match all. If found, the resource is removed atomically, the release function called and the resource freed.

## RETURNS

0 if devres is found and freed, -ENOENT if not found.

## Name

`devres_open_group` — Open a new devres group

## Synopsis

```
void * devres_open_group (struct device * dev, void * id, gfp_t gfp);
```

## Arguments

*dev* Device to open devres group for

*id* Separator ID

*gfp* Allocation flags

## Description

Open a new devres group for *dev* with *id*. For *id*, using a pointer to an object which won't be used for another group is recommended. If *id* is NULL, address-wise unique ID is created.

## RETURNS

ID of the new group, NULL on failure.

## Name

`devres_close_group` — Close a devres group

## Synopsis

```
void devres_close_group (struct device * dev, void * id);
```

## Arguments

*dev* Device to close devres group for

*id* ID of target group, can be NULL

## Description

Close the group identified by *id*. If *id* is NULL, the latest open group is selected.

## Name

`devres_remove_group` — Remove a devres group

## Synopsis

```
void devres_remove_group (struct device * dev, void * id);
```

## Arguments

*dev* Device to remove group for

*id* ID of target group, can be NULL

## Description

Remove the group identified by *id*. If *id* is NULL, the latest open group is selected. Note that removing a group doesn't affect any other resources.

## Name

`devres_release_group` — Release resources in a devres group

## Synopsis

```
int devres_release_group (struct device * dev, void * id);
```

## Arguments

*dev* Device to release group for

*id* ID of target group, can be NULL

## Description

Release all resources in the group identified by *id*. If *id* is NULL, the latest open group is selected. The selected group and groups properly nested inside the selected group are removed.

## RETURNS

The number of released non-group resources.

## Name

`devm_add_action` — add a custom action to list of managed resources

## Synopsis

```
int devm_add_action (struct device * dev, void (*action) (void *), void  
* data);
```

## Arguments

*dev* Device that owns the action

*action* Function that should be called

*data* Pointer to data passed to *action* implementation

## Description

This adds a custom action to the list of managed resources so that it gets executed as part of standard resource unwinding.

## Name

`devm_remove_action` — removes previously added custom action

## Synopsis

```
void devm_remove_action (struct device * dev, void (*action) (void *),  
void * data);
```

## Arguments

*dev* Device that owns the action

*action* Function implementing the action

*data* Pointer to data passed to *action* implementation

## Description

Removes instance of *action* previously added by `devm_add_action`. Both action and data should match one of the existing entries.

## Name

`devm_kmalloc` — Resource-managed `kmalloc`

## Synopsis

```
void * devm_kmalloc (struct device * dev, size_t size, gfp_t gfp);
```

## Arguments

*dev* Device to allocate memory for

*size* Allocation size

*gfp* Allocation `gfp` flags

## Description

Managed `kmalloc`. Memory allocated with this function is automatically freed on driver detach. Like all other devres resources, guaranteed alignment is unsigned long long.

## RETURNS

Pointer to allocated memory on success, `NULL` on failure.

## Name

`devm_kstrdup` — Allocate resource managed space and copy an existing string into that.

## Synopsis

```
char * devm_kstrdup (struct device * dev, const char * s, gfp_t gfp);
```

## Arguments

*dev* Device to allocate memory for

*s* the string to duplicate

*gfp* the GFP mask used in the `devm_kmalloc` call when allocating memory

## RETURNS

Pointer to allocated string on success, NULL on failure.

## Name

`devm_kvasprintf` — Allocate resource managed space and format a string into that.

## Synopsis

```
char * devm_kvasprintf (struct device * dev, gfp_t gfp, const char *  
fmt, va_list ap);
```

## Arguments

*dev* Device to allocate memory for

*gfp* the GFP mask used in the `devm_kmalloc` call when allocating memory

*fmt* The `printf`-style format string

*ap* Arguments for the format string

## RETURNS

Pointer to allocated string on success, NULL on failure.

## Name

`devm_kasprintf` — Allocate resource managed space and format a string into that.

## Synopsis

```
char * devm_kasprintf (struct device * dev, gfp_t gfp, const char *  
fmt, ...);
```

## Arguments

*dev* Device to allocate memory for

*gfp* the GFP mask used in the `devm_kmalloc` call when allocating memory

*fmt* The `printf`-style format string @...: Arguments for the format string

... variable arguments

## RETURNS

Pointer to allocated string on success, NULL on failure.

## Name

`devm_kfree` — Resource-managed `kfree`

## Synopsis

```
void devm_kfree (struct device * dev, void * p);
```

## Arguments

*dev* Device this memory belongs to

*p* Memory to free

## Description

Free memory allocated with `devm_kmalloc`.

## Name

`devm_kmemdup` — Resource-managed `kmemdup`

## Synopsis

```
void * devm_kmemdup (struct device * dev, const void * src, size_t len,  
gfp_t gfp);
```

## Arguments

*dev* Device this memory belongs to

*src* Memory region to duplicate

*len* Memory region length

*gfp* GFP mask to use

## Description

Duplicate region of a memory using resource managed `kmalloc`

## Name

`devm_get_free_pages` — Resource-managed `__get_free_pages`

## Synopsis

```
unsigned long devm_get_free_pages (struct device * dev, gfp_t gfp_mask,  
unsigned int order);
```

## Arguments

*dev*            Device to allocate memory for

*gfp\_mask*      Allocation gfp flags

*order*         Allocation size is (1 << order) pages

## Description

Managed `get_free_pages`. Memory allocated with this function is automatically freed on driver detach.

## RETURNS

Address of allocated memory on success, 0 on failure.

## Name

`devm_free_pages` — Resource-managed `free_pages`

## Synopsis

```
void devm_free_pages (struct device * dev, unsigned long addr);
```

## Arguments

*dev* Device this memory belongs to

*addr* Memory to free

## Description

Free memory allocated with `devm_get_free_pages`. Unlike `free_pages`, there is no need to supply the *order*.

---

# **Chapter 2. Device drivers infrastructure**

## **The Basic Device Driver-Model Structures**

## Name

struct bus\_type — The bus type of the device

## Synopsis

```

struct bus_type {
    const char * name;
    const char * dev_name;
    struct device * dev_root;
    struct device_attribute * dev_attrs;
    const struct attribute_group ** bus_groups;
    const struct attribute_group ** dev_groups;
    const struct attribute_group ** drv_groups;
    int (* match) (struct device *dev, struct device_driver *drv);
    int (* uevent) (struct device *dev, struct kobj_uevent_env *env);
    int (* probe) (struct device *dev);
    int (* remove) (struct device *dev);
    void (* shutdown) (struct device *dev);
    int (* online) (struct device *dev);
    int (* offline) (struct device *dev);
    int (* suspend) (struct device *dev, pm_message_t state);
    int (* resume) (struct device *dev);
    const struct dev_pm_ops * pm;
    const struct iommu_ops * iommu_ops;
    struct subsys_private * p;
    struct lock_class_key lock_key;
};

```

## Members

|            |   |
|------------|---|
| name       | The name of the bus.  |
| dev_name   | Used for subsystems to enumerate devices like (“foou”, dev->id).  |
| dev_root   | Default device to use as the parent.  |
| dev_attrs  | Default attributes of the devices on the bus.   |
| bus_groups | Default attributes of the bus.  |
| dev_groups | Default attributes of the devices on the bus.   |
| drv_groups | Default attributes of the device drivers on the bus.  |
| match      | Called, perhaps multiple times, whenever a new device or driver is added for this bus. It should return a nonzero value if the given device can be handled by the given driver. |
| uevent     | Called when a device is added, removed, or a few other things that generate uevents to add the environment variables.   |
| probe      | Called when a new device or driver add to this bus, and callback the specific driver's probe to initial the matched device.   |
| remove     | Called when a device removed from this bus.   |

|           |  |
|-----------|--|
| shutdown  | Called at shut-down time to quiesce the device.  |
| online    | Called to put the device back online (after offlining it).   |
| offline   | Called to put the device offline for hot-removal. May fail.  |
| suspend   | Called when a device on this bus wants to go to sleep mode.  |
| resume    | Called to bring a device on this bus out of sleep mode.  |
| pm        | Power management operations of this bus, callback the specific device driver's pm-ops.   |
| iommu_ops | IOMMU specific operations for this bus, used to attach IOMMU driver implementations to a bus and allow the driver to do bus-specific setup |
| p         | The private data of the driver core, only the driver core can touch this.  |
| lock_key  | Lock class key for use by the lock validator   |

## Description

A bus is a channel between the processor and one or more devices. For the purposes of the device model, all devices are connected via a bus, even if it is an internal, virtual, “platform” bus. Buses can plug into each other. A USB controller is usually a PCI device, for example. The device model represents the actual connections between buses and the devices they control. A bus is represented by the `bus_type` structure. It contains the name, the default attributes, the bus' methods, PM operations, and the driver core's private data.

## Name

struct device\_driver — The basic device driver structure

## Synopsis

```
struct device_driver {
    const char * name;
    struct bus_type * bus;
    struct module * owner;
    const char * mod_name;
    bool suppress_bind_attrs;
    const struct of_device_id * of_match_table;
    const struct acpi_device_id * acpi_match_table;
    int (* probe) (struct device *dev);
    int (* remove) (struct device *dev);
    void (* shutdown) (struct device *dev);
    int (* suspend) (struct device *dev, pm_message_t state);
    int (* resume) (struct device *dev);
    const struct attribute_group ** groups;
    const struct dev_pm_ops * pm;
    struct driver_private * p;
};
```

## Members

|                     |   |
|---------------------|---|
| name                | Name of the device driver.  |
| bus                 | The bus which the device of this driver belongs to.   |
| owner               | The module owner.   |
| mod_name            | Used for built-in modules.  |
| suppress_bind_attrs | Disables bind/unbind via sysfs.   |
| of_match_table      | The open firmware table.  |
| acpi_match_table    | The ACPI match table.   |
| probe               | Called to query the existence of a specific device, whether this driver can work with it, and bind the driver to a specific device. |
| remove              | Called when the device is removed from the system to unbind a device from this driver.  |
| shutdown            | Called at shut-down time to quiesce the device.   |
| suspend             | Called to put the device to sleep mode. Usually to a low power state.   |
| resume              | Called to bring a device from sleep mode.   |
| groups              | Default attributes that get created by the driver core automatically.   |
| pm                  | Power management operations of the device which matched this driver.  |

p

Driver core's private data, no one other than the driver core can touch this.

## Description

The device driver-model tracks all of the drivers known to the system. The main reason for this tracking is to enable the driver core to match up drivers with new devices. Once drivers are known objects within the system, however, a number of other things become possible. Device drivers can export information and configuration variables that are independent of any specific device.

## Name

struct subsys\_interface — interfaces to device functions

## Synopsis

```
struct subsys_interface {
    const char * name;
    struct bus_type * subsys;
    struct list_head node;
    int (* add_dev) (struct device *dev, struct subsys_interface *sif);
    int (* remove_dev) (struct device *dev, struct subsys_interface *sif);
};
```

## Members

|            |   |
|------------|---|
| name       | name of the device function                       |
| subsys     | subsystem of the devices to attach to             |
| node       | the list of functions registered at the subsystem |
| add_dev    | device hookup to device function handler          |
| remove_dev | device hookup to device function handler          |

## Description

Simple interfaces attached to a subsystem. Multiple interfaces can attach to a subsystem and its devices. Unlike drivers, they do not exclusively claim or control devices. Interfaces usually represent a specific functionality of a subsystem/class of devices.

## Name

struct class — device classes

## Synopsis

```

struct class {
    const char * name;
    struct module * owner;
    struct class_attribute * class_attrs;
    const struct attribute_group ** dev_groups;
    struct kobject * dev_kobj;
    int (* dev_uevent) (struct device *dev, struct kobj_uevent_env *env);
    char *(* devnode) (struct device *dev, umode_t *mode);
    void (* class_release) (struct class *class);
    void (* dev_release) (struct device *dev);
    int (* suspend) (struct device *dev, pm_message_t state);
    int (* resume) (struct device *dev);
    const struct kobj_ns_type_operations * ns_type;
    const void *(* namespace) (struct device *dev);
    const struct dev_pm_ops * pm;
    struct subsys_private * p;
};

```

## Members

|               |   |
|---------------|---|
| name          | Name of the class.  |
| owner         | The module owner.   |
| class_attrs   | Default attributes of this class.   |
| dev_groups    | Default attributes of the devices that belong to the class.   |
| dev_kobj      | The kobject that represents this class and links it into the hierarchy.   |
| dev_uevent    | Called when a device is added, removed from this class, or a few other things that generate uevents to add the environment variables. |
| devnode       | Callback to provide the devtmpfs.   |
| class_release | Called to release this class.   |
| dev_release   | Called to release the device.   |
| suspend       | Used to put the device to sleep mode, usually to a low power state.   |
| resume        | Used to bring the device from the sleep mode.   |
| ns_type       | Callbacks so sysfs can determine namespaces.  |
| namespace     | Namespace of the device belongs to this class.  |
| pm            | The default device power management operations of this class.   |
| p             | The private data of the driver core, no one other than the driver core can touch this.  |

## Description

A class is a higher-level view of a device that abstracts out low-level implementation details. Drivers may see a SCSI disk or an ATA disk, but, at the class level, they are all simply disks. Classes allow user space to work with devices based on what they do, rather than how they are connected or how they work.

## Name

struct device — The basic device structure

## Synopsis

```
struct device {
    struct device * parent;
    struct device_private * p;
    struct kobject kobj;
    const char * init_name;
    const struct device_type * type;
    struct mutex mutex;
    struct bus_type * bus;
    struct device_driver * driver;
    void * platform_data;
    void * driver_data;
    struct dev_pm_info power;
    struct dev_pm_domain * pm_domain;
#ifdef CONFIG_PINCTRL
    struct dev_pin_info * pins;
#endif
#ifdef CONFIG_NUMA
    int numa_node;
#endif
    u64 * dma_mask;
    u64 coherent_dma_mask;
    unsigned long dma_pfn_offset;
    struct device_dma_parameters * dma_parms;
    struct list_head dma_pools;
    struct dma_coherent_mem * dma_mem;
#ifdef CONFIG_DMA_CMA
    struct cma * cma_area;
#endif
    struct dev_archdata archdata;
    struct device_node * of_node;
    struct fwnode_handle * fwnode;
    dev_t devt;
    u32 id;
    spinlock_t devres_lock;
    struct list_head devres_head;
    struct klist_node knode_class;
    struct class * class;
    const struct attribute_group ** groups;
    void (* release) (struct device *dev);
    struct iommu_group * iommu_group;
    bool offline_disabled:1;
    bool offline:1;
};
```

## Members

|                   |  |
|-------------------|--|
| parent            | The device's “parent” device, the device to which it is attached. In most cases, a parent device is some sort of bus or host controller. If parent is NULL, the device, is a top-level device, which is not usually what you want. |
| p                 | Holds the private data of the driver core portions of the device. See the comment of the struct device_private for detail.   |
| kobj              | A top-level, abstract class from which other classes are derived.  |
| init_name         | Initial name of the device.  |
| type              | The type of device. This identifies the device type and carries type-specific information.   |
| mutex             | Mutex to synchronize calls to its driver.  |
| bus               | Type of bus device is on.  |
| driver            | Which driver has allocated this  |
| platform_data     | Platform data specific to the device.  |
| driver_data       | Private pointer for driver specific info.  |
| power             | For device power management. See Documentation/power/devices.txt for details.  |
| pm_domain         | Provide callbacks that are executed during system suspend, hibernation, system resume and during runtime PM transitions along with subsystem-level and driver-level callbacks.   |
| pins              | For device pin management. See Documentation/pinctrl.txt for details.  |
| numa_node         | NUMA node this device is close to.   |
| dma_mask          | Dma mask (if dma'ble device).  |
| coherent_dma_mask | Like dma_mask, but for alloc_coherent mapping as not all hardware supports 64-bit addresses for consistent allocations such descriptors.   |
| dma_pfn_offset    | offset of DMA memory range relatively of RAM   |
| dma_parms         | A low level driver may set these to teach IOMMU code about segment limitations.  |
| dma_pools         | Dma pools (if dma'ble device).   |
| dma_mem           | Internal for coherent mem override.  |
| cma_area          | Contiguous memory area for dma allocations   |
| archdata          | For arch-specific additions.   |
| of_node           | Associated device tree node.   |
| fwnode            | Associated device node supplied by platform firmware.  |

|                               |  |
|-------------------------------|--|
| <code>devt</code>             | For creating the sysfs “dev”.  |
| <code>id</code>               | device instance  |
| <code>devres_lock</code>      | Spinlock to protect the resource of the device.  |
| <code>devres_head</code>      | The resources list of the device.  |
| <code>knode_class</code>      | The node used to add the device to the class list.   |
| <code>class</code>            | The class of the device.   |
| <code>groups</code>           | Optional attribute groups.   |
| <code>release</code>          | Callback to free the device after all references have gone away. This should be set by the allocator of the device (i.e. the bus driver that discovered the device). |
| <code>iommu_group</code>      | IOMMU group the device belongs to.   |
| <code>offline_disabled</code> | If set, the device is permanently online.  |
| <code>offline</code>          | Set after successful invocation of bus type's <code>.offline</code> .  |

## Example

For devices on custom boards, as typical of embedded and SOC based hardware, Linux often uses `platform_data` to point to board-specific structures describing devices and how they are wired. That can include what ports are available, chip variants, which GPIO pins act in what additional roles, and so on. This shrinks the “Board Support Packages” (BSPs) and minimizes board-specific `#ifdefs` in drivers.

## Description

At the lowest level, every device in a Linux system is represented by an instance of `struct device`. The device structure contains the information that the device model core needs to model the system. Most subsystems, however, track additional information about the devices they host. As a result, it is rare for devices to be represented by bare device structures; instead, that structure, like `kobject` structures, is usually embedded within a higher-level representation of the device.

## Name

`module_driver` — Helper macro for drivers that don't do anything special in module init/exit. This eliminates a lot of boilerplate. Each module may only use this macro once, and calling it replaces `module_init` and `module_exit`.

## Synopsis

```
module_driver ( __driver, __register, __unregister, ... );
```

## Arguments

|                           |   |
|---------------------------|---|
| <code>__driver</code>     | driver name   |
| <code>__register</code>   | register function for this driver type  |
| <code>__unregister</code> | unregister function for this driver type @...: Additional arguments to be passed to <code>__register</code> and <code>__unregister</code> . |
| <code>...</code>          | variable arguments  |

## Description

Use this macro to construct bus specific macros for registering drivers, and do not use it on its own.

# Device Drivers Base

## Name

`driver_init` — initialize driver model.

## Synopsis

```
void driver_init ( void );
```

## Arguments

*void* no arguments

## Description

Call the driver model init functions to initialize their subsystems. Called early from `init/main.c`.

## Name

`driver_for_each_device` — Iterator for devices bound to a driver.

## Synopsis

```
int driver_for_each_device (struct device_driver * drv, struct device
* start, void * data, int (*fn) (struct device *, void *));
```

## Arguments

*drv*     Driver we're iterating.

*start*   Device to begin with

*data*    Data to pass to the callback.

*fn*      Function to call for each device.

## Description

Iterate over the *drv*'s list of devices calling *fn* for each one.

## Name

`driver_find_device` — device iterator for locating a particular device.

## Synopsis

```
struct device * driver_find_device (struct device_driver * drv, struct
device * start, void * data, int (*match) (struct device *dev, void
*data));
```

## Arguments

*drv*     The device's driver

*start*   Device to begin with

*data*    Data to pass to match function

*match*   Callback function to check device

## Description

This is similar to the `driver_for_each_device` function above, but it returns a reference to a device that is 'found' for later use, as determined by the `match` callback.

The callback should return 0 if the device doesn't match and non-zero if it does. If the callback returns non-zero, this function will return to the caller and not iterate over any more devices.

## Name

`driver_create_file` — create sysfs file for driver.

## Synopsis

```
int driver_create_file (struct device_driver * drv, const struct  
driver_attribute * attr);
```

## Arguments

*drv* driver.

*attr* driver attribute descriptor.

## Name

`driver_remove_file` — remove sysfs file for driver.

## Synopsis

```
void driver_remove_file (struct device_driver * drv, const struct  
driver_attribute * attr);
```

## Arguments

*drv* driver.

*attr* driver attribute descriptor.

## Name

`driver_register` — register driver with bus

## Synopsis

```
int driver_register (struct device_driver * drv);
```

## Arguments

*drv* driver to register

## Description

We pass off most of the work to the `bus_add_driver` call, since most of the things we have to do deal with the bus structures.

## Name

`driver_unregister` — remove driver from system.

## Synopsis

```
void driver_unregister (struct device_driver * drv);
```

## Arguments

*drv* driver.

## Description

Again, we pass off most of the work to the bus-level call.

## Name

`driver_find` — locate driver on a bus by its name.

## Synopsis

```
struct device_driver * driver_find (const char * name, struct bus_type  
* bus);
```

## Arguments

*name* name of the driver.

*bus* bus to scan for the driver.

## Description

Call `kset_find_obj` to iterate over list of drivers on a bus to find driver by name. Return driver if found.

This routine provides no locking to prevent the driver it returns from being unregistered or unloaded while the caller is using it. The caller is responsible for preventing this.

## Name

`dev_driver_string` — Return a device's driver name, if at all possible

## Synopsis

```
const char * dev_driver_string (const struct device * dev);
```

## Arguments

*dev* struct device to get the name of

## Description

Will return the device's driver's name if it is bound to a device. If the device is not bound to a driver, it will return the name of the bus it is attached to. If it is not attached to a bus either, an empty string will be returned.

## Name

`device_create_file` — create sysfs attribute file for device.

## Synopsis

```
int device_create_file (struct device * dev, const struct
device_attribute * attr);
```

## Arguments

*dev* device.

*attr* device attribute descriptor.

## Name

`device_remove_file` — remove sysfs attribute file.

## Synopsis

```
void device_remove_file (struct device * dev, const struct  
device_attribute * attr);
```

## Arguments

*dev* device.

*attr* device attribute descriptor.

## Name

`device_remove_file_self` — remove sysfs attribute file from its own method.

## Synopsis

```
bool device_remove_file_self (struct device * dev, const struct
device_attribute * attr);
```

## Arguments

*dev* device.

*attr* device attribute descriptor.

## Description

See `kernfs_remove_self` for details.

## Name

`device_create_bin_file` — create sysfs binary attribute file for device.

## Synopsis

```
int device_create_bin_file (struct device * dev, const struct  
bin_attribute * attr);
```

## Arguments

*dev* device.

*attr* device binary attribute descriptor.

## Name

`device_remove_bin_file` — remove sysfs binary attribute file

## Synopsis

```
void device_remove_bin_file (struct device * dev, const struct  
bin_attribute * attr);
```

## Arguments

*dev* device.

*attr* device binary attribute descriptor.

## Name

`device_initialize` — init device structure.

## Synopsis

```
void device_initialize (struct device * dev);
```

## Arguments

*dev* device.

## Description

This prepares the device for use by other layers by initializing its fields. It is the first half of `device_register`, if called by that function, though it can also be called separately, so one may use *dev*'s fields. In particular, `get_device/put_device` may be used for reference counting of *dev* after calling this function.

All fields in *dev* must be initialized by the caller to 0, except for those explicitly set to some other value. The simplest approach is to use `kzalloc` to allocate the structure containing *dev*.

## NOTE

Use `put_device` to give up your reference instead of freeing *dev* directly once you have called this function.

## Name

`dev_set_name` — set a device name

## Synopsis

```
int dev_set_name (struct device * dev, const char * fmt, ...);
```

## Arguments

*dev* device

*fmt* format string for the device's name

... variable arguments

## Name

`device_add` — add device to device hierarchy.

## Synopsis

```
int device_add (struct device * dev);
```

## Arguments

*dev* device.

## Description

This is part 2 of `device_register`, though may be called separately if `_iff_device_initialize` has been called separately.

This adds *dev* to the `kobject` hierarchy via `kobject_add`, adds it to the global and sibling lists for the device, then adds it to the other relevant subsystems of the driver model.

Do not call this routine or `device_register` more than once for any device structure. The driver model core is not designed to work with devices that get unregistered and then spring back to life. (Among other things, it's very hard to guarantee that all references to the previous incarnation of *dev* have been dropped.) Allocate and register a fresh new struct device instead.

## NOTE

Never directly free *dev* after calling this function, even if it returned an error! Always use `put_device` to give up your reference instead.

## Name

`device_register` — register a device with the system.

## Synopsis

```
int device_register (struct device * dev);
```

## Arguments

*dev* pointer to the device structure

## Description

This happens in two clean steps - initialize the device and add it to the system. The two steps can be called separately, but this is the easiest and most common. I.e. you should only call the two helpers separately if have a clearly defined need to use and refcount the device before it is added to the hierarchy.

For more information, see the kerneldoc for `device_initialize` and `device_add`.

## NOTE

Never directly free *dev* after calling this function, even if it returned an error! Always use `put_device` to give up the reference initialized in this function instead.

## Name

`get_device` — increment reference count for device.

## Synopsis

```
struct device * get_device (struct device * dev);
```

## Arguments

*dev* device.

## Description

This simply forwards the call to `kobject_get`, though we do take care to provide for the case that we get a NULL pointer passed in.

## Name

`put_device` — decrement reference count.

## Synopsis

```
void put_device (struct device * dev);
```

## Arguments

*dev* device in question.

## Name

`device_del` — delete device from system.

## Synopsis

```
void device_del (struct device * dev);
```

## Arguments

*dev* device.

## Description

This is the first part of the device unregistration sequence. This removes the device from the lists we control from here, has it removed from the other driver model subsystems it was added to in `device_add`, and removes it from the kobject hierarchy.

## NOTE

this should be called manually `_iff_ device_add` was also called manually.

## Name

`device_unregister` — unregister device from system.

## Synopsis

```
void device_unregister (struct device * dev);
```

## Arguments

*dev* device going away.

## Description

We do this in two parts, like we do `device_register`. First, we remove it from all the subsystems with `device_del`, then we decrement the reference count via `put_device`. If that is the final reference count, the device will be cleaned up via `device_release` above. Otherwise, the structure will stick around until the final reference to the device is dropped.

## Name

`device_for_each_child` — device child iterator.

## Synopsis

```
int device_for_each_child (struct device * parent, void * data, int
(*fn) (struct device *dev, void *data));
```

## Arguments

*parent* parent struct device.

*data* data for the callback.

*fn* function to be called for each device.

## Description

Iterate over *parent*'s child devices, and call *fn* for each, passing it *data*.

We check the return of *fn* each time. If it returns anything other than 0, we break out and return that value.

## Name

`device_find_child` — device iterator for locating a particular device.

## Synopsis

```
struct device * device_find_child (struct device * parent, void * data,
int (*match) (struct device *dev, void *data));
```

## Arguments

*parent* parent struct device

*data* Data to pass to match function

*match* Callback function to check device

## Description

This is similar to the `device_for_each_child` function above, but it returns a reference to a device that is 'found' for later use, as determined by the `match` callback.

The callback should return 0 if the device doesn't match and non-zero if it does. If the callback returns non-zero and a reference to the current device can be obtained, this function will return to the caller and not iterate over any more devices.

## NOTE

you will need to drop the reference with `put_device` after use.

## Name

`__root_device_register` — allocate and register a root device

## Synopsis

```
struct device * __root_device_register (const char * name, struct module
* owner);
```

## Arguments

*name* root device name

*owner* owner module of the root device, usually `THIS_MODULE`

## Description

This function allocates a root device and registers it using `device_register`. In order to free the returned device, use `root_device_unregister`.

Root devices are dummy devices which allow other devices to be grouped under `/sys/devices`. Use this function to allocate a root device and then use it as the parent of any device which should appear under `/sys/devices/{name}`

The `/sys/devices/{name}` directory will also contain a 'module' symlink which points to the *owner* directory in `sysfs`.

Returns struct device pointer on success, or `ERR_PTR` on error.

## Note

You probably want to use `root_device_register`.

## Name

`root_device_unregister` — unregister and free a root device

## Synopsis

```
void root_device_unregister (struct device * dev);
```

## Arguments

*dev* device going away

## Description

This function unregisters and cleans up a device that was created by `root_device_register`.

## Name

`device_create_vargs` — creates a device and registers it with sysfs

## Synopsis

```
struct device * device_create_vargs (struct class * class, struct device  
* parent, dev_t devt, void * drvdata, const char * fmt, va_list args);
```

## Arguments

*class* pointer to the struct class that this device should be registered to

*parent* pointer to the parent struct device of this new device, if any

*devt* the dev\_t for the char device to be added

*drvdata* the data to be added to the device for callbacks

*fmt* string for the device's name

*args* va\_list for the device's name

## Description

This function can be used by char device classes. A struct device will be created in sysfs, registered to the specified class.

A “dev” file will be created, showing the dev\_t for the device, if the dev\_t is not 0,0. If a pointer to a parent struct device is passed in, the newly created struct device will be a child of that device in sysfs. The pointer to the struct device will be returned from the call. Any further sysfs files that might be required can be created using this pointer.

Returns struct device pointer on success, or ERR\_PTR on error.

## Note

the struct class passed to this function must have previously been created with a call to `class_create`.

## Name

`device_create` — creates a device and registers it with sysfs

## Synopsis

```
struct device * device_create (struct class * class, struct device *  
parent, dev_t devt, void * drvdata, const char * fmt, ...);
```

## Arguments

*class* pointer to the struct class that this device should be registered to

*parent* pointer to the parent struct device of this new device, if any

*devt* the dev\_t for the char device to be added

*drvdata* the data to be added to the device for callbacks

*fmt* string for the device's name

... variable arguments

## Description

This function can be used by char device classes. A struct device will be created in sysfs, registered to the specified class.

A “dev” file will be created, showing the dev\_t for the device, if the dev\_t is not 0,0. If a pointer to a parent struct device is passed in, the newly created struct device will be a child of that device in sysfs. The pointer to the struct device will be returned from the call. Any further sysfs files that might be required can be created using this pointer.

Returns struct device pointer on success, or ERR\_PTR on error.

## Note

the struct class passed to this function must have previously been created with a call to `class_create`.

## Name

`device_create_with_groups` — creates a device and registers it with sysfs

## Synopsis

```
struct device * device_create_with_groups (struct class * class, struct
device * parent, dev_t devt, void * drvdata, const struct attribute_group
** groups, const char * fmt, ...);
```

## Arguments

*class* pointer to the struct class that this device should be registered to

*parent* pointer to the parent struct device of this new device, if any

*devt* the dev\_t for the char device to be added

*drvdata* the data to be added to the device for callbacks

*groups* NULL-terminated list of attribute groups to be created

*fmt* string for the device's name

... variable arguments

## Description

This function can be used by char device classes. A struct device will be created in sysfs, registered to the specified class. Additional attributes specified in the `groups` parameter will also be created automatically.

A “dev” file will be created, showing the dev\_t for the device, if the dev\_t is not 0,0. If a pointer to a parent struct device is passed in, the newly created struct device will be a child of that device in sysfs. The pointer to the struct device will be returned from the call. Any further sysfs files that might be required can be created using this pointer.

Returns struct device pointer on success, or `ERR_PTR` on error.

## Note

the struct class passed to this function must have previously been created with a call to `class_create`.

## Name

`device_destroy` — removes a device that was created with `device_create`

## Synopsis

```
void device_destroy (struct class * class, dev_t devt);
```

## Arguments

*class* pointer to the struct class that this device was registered with

*devt* the `dev_t` of the device that was previously registered

## Description

This call unregisters and cleans up a device that was created with a call to `device_create`.

## Name

`device_rename` — renames a device

## Synopsis

```
int device_rename (struct device * dev, const char * new_name);
```

## Arguments

*dev*            the pointer to the struct device to be renamed

*new\_name*    the new name of the device

## Description

It is the responsibility of the caller to provide mutual exclusion between two different calls of `device_rename` on the same device to ensure that `new_name` is valid and won't conflict with other devices.

## Note

Don't call this function. Currently, the networking layer calls this function, but that will change. The following text from Kay Sievers offers

## some insight

Renaming devices is racy at many levels, symlinks and other stuff are not replaced atomically, and you get a “move” uevent, but it's not easy to connect the event to the old and new device. Device nodes are not renamed at all, there isn't even support for that in the kernel now.

In the meantime, during renaming, your target name might be taken by another driver, creating conflicts. Or the old name is taken directly after you renamed it -- then you get events for the same DEVPATH, before you even see the “move” event. It's just a mess, and nothing new should ever rely on kernel device renaming. Besides that, it's not even implemented now for other things than (driver-core wise very simple) network devices.

We are currently about to change network renaming in udev to completely disallow renaming of devices in the same namespace as the kernel uses, because we can't solve the problems properly, that arise with swapping names of multiple interfaces without races. Means, renaming of `eth[0-9]*` will only be allowed to some other name than `eth[0-9]*`, for the aforementioned reasons.

Make up a “real” name in the driver before you register anything, or add some other attributes for userspace to find the device, or use udev to add symlinks -- but never rename kernel devices later, it's a complete mess. We don't even want to get into that and try to implement the missing pieces in the core. We really have other pieces to fix in the driver core mess. :)

## Name

`device_move` — moves a device to a new parent

## Synopsis

```
int device_move (struct device * dev, struct device * new_parent, enum  
dpm_order dpm_order);
```

## Arguments

*dev*                the pointer to the struct device to be moved

*new\_parent*        the new parent of the device (can be NULL)

*dpm\_order*         how to reorder the `dpm_list`

## Name

`set_primary_fwnode` — Change the primary firmware node of a given device.

## Synopsis

```
void set_primary_fwnode (struct device * dev, struct fwnode_handle *  
fwnode);
```

## Arguments

*dev* Device to handle.

*fwnode* New primary firmware node of the device.

## Description

Set the device's firmware node pointer to *fwnode*, but if a secondary firmware node of the device is present, preserve it.

## Name

`register_syscore_ops` — Register a set of system core operations.

## Synopsis

```
void register_syscore_ops (struct syscore_ops * ops);
```

## Arguments

*ops* System core operations to register.

## Name

`unregister_syscore_ops` — Unregister a set of system core operations.

## Synopsis

```
void unregister_syscore_ops (struct syscore_ops * ops);
```

## Arguments

*ops* System core operations to unregister.

## Name

`syscore_suspend` — Execute all the registered system core suspend callbacks.

## Synopsis

```
int syscore_suspend ( void );
```

## Arguments

*void* no arguments

## Description

This function is executed with one CPU on-line and disabled interrupts.

## Name

`syscore_resume` — Execute all the registered system core resume callbacks.

## Synopsis

```
void syscore_resume ( void );
```

## Arguments

*void* no arguments

## Description

This function is executed with one CPU on-line and disabled interrupts.

## Name

`__class_create` — create a struct class structure

## Synopsis

```
struct class * __class_create (struct module * owner, const char * name,  
struct lock_class_key * key);
```

## Arguments

*owner* pointer to the module that is to “own” this struct class

*name* pointer to a string for the name of this class.

*key* the `lock_class_key` for this class; used by mutex lock debugging

## Description

This is used to create a struct class pointer that can then be used in calls to `device_create`.

Returns struct class pointer on success, or `ERR_PTR` on error.

Note, the pointer created here is to be destroyed when finished by making a call to `class_destroy`.

## Name

`class_destroy` — destroys a struct class structure

## Synopsis

```
void class_destroy (struct class * cls);
```

## Arguments

*cls* pointer to the struct class that is to be destroyed

## Description

Note, the pointer to be destroyed must have been created with a call to `class_create`.

## Name

`class_dev_iter_init` — initialize class device iterator

## Synopsis

```
void class_dev_iter_init (struct class_dev_iter * iter, struct class *  
class, struct device * start, const struct device_type * type);
```

## Arguments

*iter* class iterator to initialize

*class* the class we wanna iterate over

*start* the device to start iterating from, if any

*type* device\_type of the devices to iterate over, NULL for all

## Description

Initialize class iterator *iter* such that it iterates over devices of *class*. If *start* is set, the list iteration will start there, otherwise if it is NULL, the iteration starts at the beginning of the list.

## Name

`class_dev_iter_next` — iterate to the next device

## Synopsis

```
struct device * class_dev_iter_next (struct class_dev_iter * iter);
```

## Arguments

*iter* class iterator to proceed

## Description

Proceed *iter* to the next device and return it. Returns NULL if iteration is complete.

The returned device is referenced and won't be released till iterator is proceed to the next device or exited. The caller is free to do whatever it wants to do with the device including calling back into class code.

## Name

`class_dev_iter_exit` — finish iteration

## Synopsis

```
void class_dev_iter_exit (struct class_dev_iter * iter);
```

## Arguments

*iter* class iterator to finish

## Description

Finish an iteration. Always call this function after iteration is complete whether the iteration ran till the end or not.

## Name

`class_for_each_device` — device iterator

## Synopsis

```
int class_for_each_device (struct class * class, struct device * start,  
void * data, int (*fn) (struct device *, void *));
```

## Arguments

*class* the class we're iterating

*start* the device to start with in the list, if any.

*data* data for the callback

*fn* function to be called for each device

## Description

Iterate over *class*'s list of devices, and call *fn* for each, passing it *data*. If *start* is set, the list iteration will start there, otherwise if it is NULL, the iteration starts at the beginning of the list.

We check the return of *fn* each time. If it returns anything other than 0, we break out and return that value.

*fn* is allowed to do anything including calling back into class code. There's no locking restriction.

## Name

`class_find_device` — device iterator for locating a particular device

## Synopsis

```
struct device * class_find_device (struct class * class, struct device *  
start, const void * data, int (*match) (struct device *, const void *));
```

## Arguments

*class* the class we're iterating

*start* Device to begin with

*data* data for the match function

*match* function to check device

## Description

This is similar to the `class_for_each_dev` function above, but it returns a reference to a device that is 'found' for later use, as determined by the `match` callback.

The callback should return 0 if the device doesn't match and non-zero if it does. If the callback returns non-zero, this function will return to the caller and not iterate over any more devices.

Note, you will need to drop the reference with `put_device` after use.

`fn` is allowed to do anything including calling back into class code. There's no locking restriction.

## Name

`class_compat_register` — register a compatibility class

## Synopsis

```
struct class_compat * class_compat_register (const char * name);
```

## Arguments

*name* the name of the class

## Description

Compatibility class are meant as a temporary user-space compatibility workaround when converting a family of class devices to a bus devices.

## Name

`class_compat_unregister` — unregister a compatibility class

## Synopsis

```
void class_compat_unregister (struct class_compat * cls);
```

## Arguments

*cls* the class to unregister

## Name

`class_compat_create_link` — create a compatibility class device link to a bus device

## Synopsis

```
int class_compat_create_link (struct class_compat * cls, struct device  
* dev, struct device * device_link);
```

## Arguments

*cls*            the compatibility class

*dev*            the target bus device

*device\_link*   an optional device to which a “device” link should be created

## Name

`class_compat_remove_link` — remove a compatibility class device link to a bus device

## Synopsis

```
void class_compat_remove_link (struct class_compat * cls, struct device  
* dev, struct device * device_link);
```

## Arguments

*cls*            the compatibility class

*dev*            the target bus device

*device\_link*   an optional device to which a “device” link was previously created

## Name

`unregister_node` — unregister a node device

## Synopsis

```
void unregister_node (struct node * node);
```

## Arguments

*node* node going away

## Description

Unregisters a node device *node*. All the devices on the node must be unregistered before calling this function.

## Name

`request_firmware` — send firmware request and wait for it

## Synopsis

```
int request_firmware (const struct firmware ** firmware_p, const char
* name, struct device * device);
```

## Arguments

*firmware\_p* pointer to firmware image

*name* name of firmware file

*device* device for which firmware is being loaded

## Description

*firmware\_p* will be used to return a firmware image by the name of *name* for device *device*.

Should be called from user context where sleeping is allowed.

*name* will be used as `$FIRMWARE` in the uevent environment and should be distinctive enough not to be confused with any other firmware image for this or any other device.

Caller must hold the reference count of *device*.

The function can be called safely inside device's suspend and resume callback.

## Name

`request_firmware_direct` — load firmware directly without usermode helper

## Synopsis

```
int request_firmware_direct (const struct firmware ** firmware_p, const
char * name, struct device * device);
```

## Arguments

*firmware\_p* pointer to firmware image

*name* name of firmware file

*device* device for which firmware is being loaded

## Description

This function works pretty much like `request_firmware`, but this doesn't fall back to usermode helper even if the firmware couldn't be loaded directly from fs. Hence it's useful for loading optional firmwares, which aren't always present, without extra long timeouts of udev.

## Name

`release_firmware` — release the resource associated with a firmware image

## Synopsis

```
void release_firmware (const struct firmware * fw);
```

## Arguments

*fw* firmware resource to release

## Name

`request_firmware_nowait` — asynchronous version of `request_firmware`

## Synopsis

```
int request_firmware_nowait (struct module * module, bool uevent, const
char * name, struct device * device, gfp_t gfp, void * context, void
(*cont) (const struct firmware *fw, void *context));
```

## Arguments

*module*    module requesting the firmware

*uevent*    sends uevent to copy the firmware image if this flag is non-zero else the firmware copy must be done manually.

*name*       name of firmware file

*device*    device for which firmware is being loaded

*gfp*        allocation flags

*context*    will be passed over to *cont*, and *fw* may be NULL if firmware request fails.

*cont*       function will be called asynchronously when the firmware request is over.

## Description

Caller must hold the reference count of *device*.

Asynchronous variant of `request_firmware` for user contexts: - sleep for as small periods as possible since it may increase kernel boot time of built-in device drivers requesting firmware in their `->probe` methods, if *gfp* is `GFP_KERNEL`.

- can't sleep at all if *gfp* is `GFP_ATOMIC`.

## Name

`transport_class_register` — register an initial transport class

## Synopsis

```
int transport_class_register (struct transport_class * tclass);
```

## Arguments

*tclass* a pointer to the transport class structure to be initialised

## Description

The transport class contains an embedded class which is used to identify it. The caller should initialise this structure with zeros and then generic class must have been initialised with the actual transport class unique name. There's a macro `DECLARE_TRANSPORT_CLASS` to do this (declared classes still must be registered).

Returns 0 on success or error on failure.

## Name

`transport_class_unregister` — unregister a previously registered class

## Synopsis

```
void transport_class_unregister (struct transport_class * tclass);
```

## Arguments

*tclass* The transport class to unregister

## Description

Must be called prior to deallocating the memory for the transport class.

## Name

`anon_transport_class_register` — register an anonymous class

## Synopsis

```
int anon_transport_class_register (struct anon_transport_class * atc);
```

## Arguments

*atc* The anon transport class to register

## Description

The anonymous transport class contains both a transport class and a container. The idea of an anonymous class is that it never actually has any device attributes associated with it (and thus saves on container storage). So it can only be used for triggering events. Use `prezero` and then use `DECLARE_ANON_TRANSPORT_CLASS` to initialise the anon transport class storage.

## Name

`anon_transport_class_unregister` — unregister an anon class

## Synopsis

```
void anon_transport_class_unregister (struct anon_transport_class *  
atc);
```

## Arguments

*atc* Pointer to the anon transport class to unregister

## Description

Must be called prior to deallocating the memory for the anon transport class.

## Name

`transport_setup_device` — declare a new dev for transport class association but don't make it visible yet.

## Synopsis

```
void transport_setup_device (struct device * dev);
```

## Arguments

*dev* the generic device representing the entity being added

## Description

Usually, *dev* represents some component in the HBA system (either the HBA itself or a device remote across the HBA bus). This routine is simply a trigger point to see if any set of transport classes wishes to associate with the added device. This allocates storage for the class device and initialises it, but does not yet add it to the system or add attributes to it (you do this with `transport_add_device`). If you have no need for a separate setup and add operations, use `transport_register_device` (see `transport_class.h`).

## Name

`transport_add_device` — declare a new dev for transport class association

## Synopsis

```
void transport_add_device (struct device * dev);
```

## Arguments

*dev* the generic device representing the entity being added

## Description

Usually, *dev* represents some component in the HBA system (either the HBA itself or a device remote across the HBA bus). This routine is simply a trigger point used to add the device to the system and register attributes for it.

## Name

`transport_configure_device` — configure an already set up device

## Synopsis

```
void transport_configure_device (struct device * dev);
```

## Arguments

*dev* generic device representing device to be configured

## Description

The idea of `configure` is simply to provide a point within the setup process to allow the transport class to extract information from a device after it has been setup. This is used in SCSI because we have to have a setup device to begin using the HBA, but after we send the initial inquiry, we use `configure` to extract the device parameters. The device need not have been added to be configured.

## Name

`transport_remove_device` — remove the visibility of a device

## Synopsis

```
void transport_remove_device (struct device * dev);
```

## Arguments

*dev* generic device to remove

## Description

This call removes the visibility of the device (to the user from sysfs), but does not destroy it. To eliminate a device entirely you must also call `transport_destroy_device`. If you don't need to do remove and destroy as separate operations, use `transport_unregister_device` (see `transport_class.h`) which will perform both calls for you.

## Name

`transport_destroy_device` — destroy a removed device

## Synopsis

```
void transport_destroy_device (struct device * dev);
```

## Arguments

*dev* device to eliminate from the transport class.

## Description

This call triggers the elimination of storage associated with the transport `classdev`. Note: all it really does is relinquish a reference to the `classdev`. The memory will not be freed until the last reference goes to zero. Note also that the `classdev` retains a reference count on `dev`, so `dev` too will remain for as long as the transport class device remains around.

## Name

`device_bind_driver` — bind a driver to one device.

## Synopsis

```
int device_bind_driver (struct device * dev);
```

## Arguments

*dev* device.

## Description

Allow manual attachment of a driver to a device. Caller must have already set `dev->driver`.

Note that this does not modify the bus reference count nor take the bus's `rwsem`. Please verify those are accounted for before calling this. (It is ok to call with no other effort from a driver's `probe` method.)

This function must be called with the device lock held.

## Name

`wait_for_device_probe` —

## Synopsis

```
void wait_for_device_probe ( void );
```

## Arguments

*void* no arguments

## Description

Wait for device probing to be completed.

## Name

`device_attach` — try to attach device to a driver.

## Synopsis

```
int device_attach (struct device * dev);
```

## Arguments

*dev* device.

## Description

Walk the list of drivers that the bus has and call `driver_probe_device` for each pair. If a compatible pair is found, break out and return.

Returns 1 if the device was bound to a driver; 0 if no matching driver was found; `-ENODEV` if the device is not registered.

When called for a USB interface, `dev->parent` lock must be held.

## Name

`driver_attach` — try to bind driver to devices.

## Synopsis

```
int driver_attach (struct device_driver * drv);
```

## Arguments

*drv* driver.

## Description

Walk the list of devices that the bus has on it and try to match the driver with each one. If `driver_probe_device` returns 0 and the `dev->driver` is set, we've found a compatible pair.

## Name

`device_release_driver` — manually detach device from driver.

## Synopsis

```
void device_release_driver (struct device * dev);
```

## Arguments

*dev* device.

## Description

Manually detach device from driver. When called for a USB interface, *dev->parent* lock must be held.

## Name

`platform_device_register_resndata` — add a platform-level device with resources and platform-specific data

## Synopsis

```
struct platform_device * platform_device_register_resndata (struct de-  
vice * parent, const char * name, int id, const struct resource * res,  
unsigned int num, const void * data, size_t size);
```

## Arguments

*parent* parent device for the device we're adding

*name* base name of the device we're adding

*id* instance id

*res* set of resources that needs to be allocated for the device

*num* number of resources

*data* platform specific data for this platform device

*size* size of platform specific data

## Description

Returns struct `platform_device` pointer on success, or `ERR_PTR` on error.

## Name

`platform_device_register_simple` — add a platform-level device and its resources

## Synopsis

```
struct platform_device * platform_device_register_simple (const char *  
name, int id, const struct resource * res, unsigned int num);
```

## Arguments

*name* base name of the device we're adding

*id* instance id

*res* set of resources that needs to be allocated for the device

*num* number of resources

## Description

This function creates a simple platform device that requires minimal resource and memory management. Canned release function freeing memory allocated for the device allows drivers using such devices to be unloaded without waiting for the last reference to the device to be dropped.

This interface is primarily intended for use with legacy drivers which probe hardware directly. Because such drivers create sysfs device nodes themselves, rather than letting system infrastructure handle such device enumeration tasks, they don't fully conform to the Linux driver model. In particular, when such drivers are built as modules, they can't be "hotplugged".

Returns struct `platform_device` pointer on success, or `ERR_PTR` on error.

## Name

`platform_device_register_data` — add a platform-level device with platform-specific data

## Synopsis

```
struct platform_device * platform_device_register_data (struct device
* parent, const char * name, int id, const void * data, size_t size);
```

## Arguments

*parent* parent device for the device we're adding

*name* base name of the device we're adding

*id* instance id

*data* platform specific data for this platform device

*size* size of platform specific data

## Description

This function creates a simple platform device that requires minimal resource and memory management. Canned release function freeing memory allocated for the device allows drivers using such devices to be unloaded without waiting for the last reference to the device to be dropped.

Returns struct `platform_device` pointer on success, or `ERR_PTR` on error.

## Name

`platform_get_resource` — get a resource for a device

## Synopsis

```
struct resource * platform_get_resource (struct platform_device * dev,  
unsigned int type, unsigned int num);
```

## Arguments

*dev* platform device

*type* resource type

*num* resource index

## Name

`platform_get_irq` — get an IRQ for a device

## Synopsis

```
int platform_get_irq (struct platform_device * dev, unsigned int num);
```

## Arguments

*dev* platform device

*num* IRQ number index

## Name

`platform_get_resource_byname` — get a resource for a device by name

## Synopsis

```
struct resource * platform_get_resource_byname (struct platform_device  
* dev, unsigned int type, const char * name);
```

## Arguments

*dev* platform device

*type* resource type

*name* resource name

## Name

`platform_get_irq_byname` — get an IRQ for a device by name

## Synopsis

```
int platform_get_irq_byname (struct platform_device * dev, const char
* name);
```

## Arguments

*dev* platform device

*name* IRQ name

## Name

`platform_add_devices` — add a numbers of platform devices

## Synopsis

```
int platform_add_devices (struct platform_device ** devs, int num);
```

## Arguments

*devs* array of platform devices to add

*num* number of platform devices in array

## Name

`platform_device_put` — destroy a platform device

## Synopsis

```
void platform_device_put (struct platform_device * pdev);
```

## Arguments

*pdev* platform device to free

## Description

Free all memory associated with a platform device. This function must only be externally called in error cases. All other usage is a bug.

## Name

`platform_device_alloc` — create a platform device

## Synopsis

```
struct platform_device * platform_device_alloc (const char * name, int
id);
```

## Arguments

*name* base name of the device we're adding

*id* instance id

## Description

Create a platform device object which can have other objects attached to it, and which will have attached objects freed when it is released.

## Name

`platform_device_add_resources` — add resources to a platform device

## Synopsis

```
int platform_device_add_resources (struct platform_device * pdev, const
struct resource * res, unsigned int num);
```

## Arguments

*pdev* platform device allocated by `platform_device_alloc` to add resources to

*res* set of resources that needs to be allocated for the device

*num* number of resources

## Description

Add a copy of the resources to the platform device. The memory associated with the resources will be freed when the platform device is released.

## Name

`platform_device_add_data` — add platform-specific data to a platform device

## Synopsis

```
int platform_device_add_data (struct platform_device * pdev, const void
* data, size_t size);
```

## Arguments

*pdev* platform device allocated by `platform_device_alloc` to add resources to

*data* platform specific data for this platform device

*size* size of platform specific data

## Description

Add a copy of platform specific data to the platform device's `platform_data` pointer. The memory associated with the platform data will be freed when the platform device is released.

## Name

`platform_device_add` — add a platform device to device hierarchy

## Synopsis

```
int platform_device_add (struct platform_device * pdev);
```

## Arguments

*pdev* platform device we're adding

## Description

This is part 2 of `platform_device_register`, though may be called separately if `pdev` was allocated by `platform_device_alloc`.

## Name

`platform_device_del` — remove a platform-level device

## Synopsis

```
void platform_device_del (struct platform_device * pdev);
```

## Arguments

*pdev* platform device we're removing

## Description

Note that this function will also release all memory- and port-based resources owned by the device (*dev->resource*). This function must `_only_` be externally called in error cases. All other usage is a bug.

## Name

`platform_device_register` — add a platform-level device

## Synopsis

```
int platform_device_register (struct platform_device * pdev);
```

## Arguments

*pdev* platform device we're adding

## Name

`platform_device_unregister` — unregister a platform-level device

## Synopsis

```
void platform_device_unregister (struct platform_device * pdev);
```

## Arguments

*pdev* platform device we're unregistering

## Description

Unregistration is done in 2 steps. First we release all resources and remove it from the subsystem, then we drop reference count by calling `platform_device_put`.

## Name

`platform_device_register_full` — add a platform-level device with resources and platform-specific data

## Synopsis

```
struct platform_device * platform_device_register_full (const struct
platform_device_info * pdevinfo);
```

## Arguments

*pdevinfo* data used to create device

## Description

Returns struct `platform_device` pointer on success, or `ERR_PTR` on error.

## Name

`__platform_driver_register` — register a driver for platform-level devices

## Synopsis

```
int __platform_driver_register (struct platform_driver * drv, struct
module * owner);
```

## Arguments

*drv* platform driver structure

*owner* owning module/driver

## Name

`platform_driver_unregister` — unregister a driver for platform-level devices

## Synopsis

```
void platform_driver_unregister (struct platform_driver * drv);
```

## Arguments

*drv* platform driver structure

## Name

`__platform_driver_probe` — register driver for non-hotpluggable device

## Synopsis

```
int __platform_driver_probe (struct platform_driver * drv, int (*probe)
                             (struct platform_device *), struct module * module);
```

## Arguments

*drv* platform driver structure

*probe* the driver probe routine, probably from an `__init` section

*module* module which will be the owner of the driver

## Description

Use this instead of `platform_driver_register` when you know the device is not hotpluggable and has already been registered, and you want to remove its run-once `probe` infrastructure from memory after the driver has bound to the device.

One typical use for this would be with drivers for controllers integrated into system-on-chip processors, where the controller devices have been configured as part of board setup.

Note that this is incompatible with deferred probing.

Returns zero if the driver registered and bound to a device, else returns a negative error code and with the driver not registered.

## Name

`__platform_create_bundle` — register driver and create corresponding device

## Synopsis

```
struct platform_device * __platform_create_bundle (struct
platform_driver * driver, int (*probe) (struct platform_device *),
struct resource * res, unsigned int n_res, const void * data, size_t
size, struct module * module);
```

## Arguments

*driver* platform driver structure

*probe* the driver probe routine, probably from an `__init` section

*res* set of resources that needs to be allocated for the device

*n\_res* number of resources

*data* platform specific data for this platform device

*size* size of platform specific data

*module* module which will be the owner of the driver

## Description

Use this in legacy-style modules that probe hardware directly and register a single platform device and corresponding platform driver.

Returns `struct platform_device` pointer on success, or `ERR_PTR` on error.

## Name

`bus_for_each_dev` — device iterator.

## Synopsis

```
int bus_for_each_dev (struct bus_type * bus, struct device * start, void
* data, int (*fn) (struct device *, void *));
```

## Arguments

*bus* bus type.

*start* device to start iterating from.

*data* data for the callback.

*fn* function to be called for each device.

## Description

Iterate over *bus*'s list of devices, and call *fn* for each, passing it *data*. If *start* is not NULL, we use that device to begin iterating from.

We check the return of *fn* each time. If it returns anything other than 0, we break out and return that value.

## NOTE

The device that returns a non-zero value is not retained in any way, nor is its refcount incremented. If the caller needs to retain this data, it should do so, and increment the reference count in the supplied callback.

## Name

`bus_find_device` — device iterator for locating a particular device.

## Synopsis

```
struct device * bus_find_device (struct bus_type * bus, struct device  
* start, void * data, int (*match) (struct device *dev, void *data));
```

## Arguments

*bus* bus type

*start* Device to begin with

*data* Data to pass to match function

*match* Callback function to check device

## Description

This is similar to the `bus_for_each_dev` function above, but it returns a reference to a device that is 'found' for later use, as determined by the `match` callback.

The callback should return 0 if the device doesn't match and non-zero if it does. If the callback returns non-zero, this function will return to the caller and not iterate over any more devices.

## Name

`bus_find_device_by_name` — device iterator for locating a particular device of a specific name

## Synopsis

```
struct device * bus_find_device_by_name (struct bus_type * bus, struct
device * start, const char * name);
```

## Arguments

*bus* bus type

*start* Device to begin with

*name* name of the device to match

## Description

This is similar to the `bus_find_device` function above, but it handles searching by a name automatically, no need to write another `strcmp` matching function.

## Name

`subsys_find_device_by_id` — find a device with a specific enumeration number

## Synopsis

```
struct device * subsys_find_device_by_id (struct bus_type * subsys,  
unsigned int id, struct device * hint);
```

## Arguments

*subsys* subsystem

*id* index 'id' in struct device

*hint* device to check first

## Description

Check the hint's next object and if it is a match return it directly, otherwise, fall back to a full list search. Either way a reference for the returned object is taken.

## Name

`bus_for_each_drv` — driver iterator

## Synopsis

```
int bus_for_each_drv (struct bus_type * bus, struct device_driver *  
start, void * data, int (*fn) (struct device_driver *, void *));
```

## Arguments

*bus* bus we're dealing with.

*start* driver to start iterating on.

*data* data to pass to the callback.

*fn* function to call for each driver.

## Description

This is nearly identical to the device iterator above. We iterate over each driver that belongs to *bus*, and call *fn* for each. If *fn* returns anything but 0, we break out and return it. If *start* is not NULL, we use it as the head of the list.

## NOTE

we don't return the driver that returns a non-zero value, nor do we leave the reference count incremented for that driver. If the caller needs to know that info, it must set it in the callback. It must also be sure to increment the refcount so it doesn't disappear before returning to the caller.

## Name

`bus_rescan_devices` — rescan devices on the bus for possible drivers

## Synopsis

```
int bus_rescan_devices (struct bus_type * bus);
```

## Arguments

*bus* the bus to scan.

## Description

This function will look for devices on the bus with no driver attached and rescan it against existing drivers to see if it matches any by calling `device_attach` for the unbound devices.

## Name

`device_reprobe` — remove driver for a device and probe for a new driver

## Synopsis

```
int device_reprobe (struct device * dev);
```

## Arguments

*dev* the device to reprobe

## Description

This function detaches the attached driver (if any) for the given device and restarts the driver probing process. It is intended to use if probing criteria changed during a devices lifetime and driver attachment should change accordingly.

## Name

`bus_register` — register a driver-core subsystem

## Synopsis

```
int bus_register (struct bus_type * bus);
```

## Arguments

*bus* bus to register

## Description

Once we have that, we register the bus with the kobject infrastructure, then register the children subsystems it has: the devices and drivers that belong to the subsystem.

## Name

`bus_unregister` — remove a bus from the system

## Synopsis

```
void bus_unregister (struct bus_type * bus);
```

## Arguments

*bus* bus.

## Description

Unregister the child subsystems and the bus itself. Finally, we call `bus_put` to release the refcount

## Name

`subsys_dev_iter_init` — initialize subsys device iterator

## Synopsis

```
void subsys_dev_iter_init (struct subsys_dev_iter * iter, struct  
bus_type * subsys, struct device * start, const struct device_type *  
type);
```

## Arguments

*iter*     subsys iterator to initialize

*subsys*   the subsys we wanna iterate over

*start*    the device to start iterating from, if any

*type*     device\_type of the devices to iterate over, NULL for all

## Description

Initialize subsys iterator *iter* such that it iterates over devices of *subsys*. If *start* is set, the list iteration will start there, otherwise if it is NULL, the iteration starts at the beginning of the list.

## Name

`subsys_dev_iter_next` — iterate to the next device

## Synopsis

```
struct device * subsys_dev_iter_next (struct subsys_dev_iter * iter);
```

## Arguments

*iter* subsys iterator to proceed

## Description

Proceed *iter* to the next device and return it. Returns NULL if iteration is complete.

The returned device is referenced and won't be released till iterator is proceed to the next device or exited. The caller is free to do whatever it wants to do with the device including calling back into subsys code.

## Name

`subsys_dev_iter_exit` — finish iteration

## Synopsis

```
void subsys_dev_iter_exit (struct subsys_dev_iter * iter);
```

## Arguments

*iter* subsys iterator to finish

## Description

Finish an iteration. Always call this function after iteration is complete whether the iteration ran till the end or not.

## Name

`subsys_system_register` — register a subsystem at `/sys/devices/system/`

## Synopsis

```
int subsys_system_register (struct bus_type * subsys, const struct  
attribute_group ** groups);
```

## Arguments

*subsys* system subsystem

*groups* default attributes for the root device

## Description

All 'system' subsystems have a `/sys/devices/system/<name>` root device with the name of the subsystem. The root device can carry subsystem-wide attributes. All registered devices are below this single root device and are named after the subsystem with a simple enumeration number appended. The registered devices are not explicitly named; only 'id' in the device needs to be set.

Do not use this interface for anything new, it exists for compatibility with bad ideas only. New subsystems should use plain subsystems; and add the subsystem-wide attributes should be added to the subsystem directory itself and not some create fake root-device placed in `/sys/devices/system/<name>`.

## Name

`subsys_virtual_register` — register a subsystem at `/sys/devices/virtual/`

## Synopsis

```
int subsys_virtual_register (struct bus_type * subsys, const struct  
attribute_group ** groups);
```

## Arguments

*subsys* virtual subsystem

*groups* default attributes for the root device

## Description

All 'virtual' subsystems have a `/sys/devices/system/<name>` root device with the name of the subsystem. The root device can carry subsystem-wide attributes. All registered devices are below this single root device. There's no restriction on device naming. This is for kernel software constructs which need sysfs interface.

# Device Drivers DMA Management

## Name

`dma_buf_export` — Creates a new `dma_buf`, and associates an anon file with this buffer, so it can be exported. Also connect the allocator specific data and ops to the buffer. Additionally, provide a name string for exporter; useful in debugging.

## Synopsis

```
struct dma_buf * dma_buf_export (const struct dma_buf_export_info *  
exp_info);
```

## Arguments

*exp\_info* [in] holds all the export related information provided by the exporter. see struct `dma_buf_export_info` for further details.

## Description

Returns, on success, a newly created `dma_buf` object, which wraps the supplied private data and operations for `dma_buf_ops`. On either missing ops, or error in allocating struct `dma_buf`, will return negative error.

## Name

`dma_buf_fd` — returns a file descriptor for the given `dma_buf`

## Synopsis

```
int dma_buf_fd (struct dma_buf * dmabuf, int flags);
```

## Arguments

*dmabuf* [in] pointer to `dma_buf` for which fd is required.

*flags* [in] flags to give to fd

## Description

On success, returns an associated 'fd'. Else, returns error.

## Name

`dma_buf_get` — returns the `dma_buf` structure related to an `fd`

## Synopsis

```
struct dma_buf * dma_buf_get (int fd);
```

## Arguments

*fd* [in] `fd` associated with the `dma_buf` to be returned

## Description

On success, returns the `dma_buf` structure associated with an `fd`; uses file's refcounting done by `fget` to increase refcount. returns `ERR_PTR` otherwise.

## Name

`dma_buf_put` — decreases refcount of the buffer

## Synopsis

```
void dma_buf_put (struct dma_buf * dmabuf);
```

## Arguments

*dmabuf* [in] buffer to reduce refcount of

## Description

Uses file's refcounting done implicitly by `fput`

## Name

`dma_buf_attach` — Add the device to `dma_buf`'s attachments list; optionally, calls `attach` of `dma_buf_ops` to allow device-specific attach functionality

## Synopsis

```
struct dma_buf_attachment * dma_buf_attach (struct dma_buf * dmabuf,  
struct device * dev);
```

## Arguments

*dmabuf* [in] buffer to attach device to.

*dev* [in] device to be attached.

## Description

Returns `struct dma_buf_attachment *` for this attachment; returns `ERR_PTR` on error.

## Name

`dma_buf_detach` — Remove the given attachment from `dmabuf`'s attachments list; optionally calls `detach` of `dma_buf_ops` for device-specific detach

## Synopsis

```
void dma_buf_detach (struct dma_buf * dmabuf, struct dma_buf_attachment  
* attach);
```

## Arguments

*dmabuf* [in] buffer to detach from.

*attach* [in] attachment to be detached; is free'd after this call.

## Name

`dma_buf_map_attachment` — Returns the scatterlist table of the attachment; mapped into `_device_ address space`. Is a wrapper for `map_dma_buf` of the `dma_buf_ops`.

## Synopsis

```
struct sg_table * dma_buf_map_attachment (struct dma_buf_attachment *  
attach, enum dma_data_direction direction);
```

## Arguments

*attach* [in] attachment whose scatterlist is to be returned

*direction* [in] direction of DMA transfer

## Description

Returns `sg_table` containing the scatterlist to be returned; returns `ERR_PTR` on error.

## Name

`dma_buf_unmap_attachment` — unmaps and decreases usecount of the buffer; might deallocate the scatterlist associated. Is a wrapper for `unmap_dma_buf` of `dma_buf_ops`.

## Synopsis

```
void dma_buf_unmap_attachment (struct dma_buf_attachment * attach,  
struct sg_table * sg_table, enum dma_data_direction direction);
```

## Arguments

*attach* [in] attachment to unmap buffer from

*sg\_table* [in] scatterlist info of the buffer to unmap

*direction* [in] direction of DMA transfer

## Name

`dma_buf_begin_cpu_access` — Must be called before accessing a `dma_buf` from the cpu in the kernel context. Calls `begin_cpu_access` to allow exporter-specific preparations. Coherency is only guaranteed in the specified range for the specified access direction.

## Synopsis

```
int dma_buf_begin_cpu_access (struct dma_buf * dmabuf, size_t start,
size_t len, enum dma_data_direction direction);
```

## Arguments

*dmabuf* [in] buffer to prepare cpu access for.

*start* [in] start of range for cpu access.

*len* [in] length of range for cpu access.

*direction* [in] length of range for cpu access.

## Description

Can return negative error values, returns 0 on success.

## Name

`dma_buf_end_cpu_access` — Must be called after accessing a `dma_buf` from the cpu in the kernel context. Calls `end_cpu_access` to allow exporter-specific actions. Coherency is only guaranteed in the specified range for the specified access direction.

## Synopsis

```
void dma_buf_end_cpu_access (struct dma_buf * dmabuf, size_t start,  
size_t len, enum dma_data_direction direction);
```

## Arguments

*dmabuf* [in] buffer to complete cpu access for.

*start* [in] start of range for cpu access.

*len* [in] length of range for cpu access.

*direction* [in] length of range for cpu access.

## Description

This call must always succeed.

## Name

`dma_buf_kmap_atomic` — Map a page of the buffer object into kernel address space. The same restrictions as for `kmap_atomic` and friends apply.

## Synopsis

```
void * dma_buf_kmap_atomic (struct dma_buf * dmabuf, unsigned long page_num);
```

## Arguments

*dmabuf* [in] buffer to map page from.

*page\_num* [in] page in PAGE\_SIZE units to map.

## Description

This call must always succeed, any necessary preparations that might fail need to be done in `begin_cpu_access`.

## Name

`dma_buf_kunmap_atomic` — Unmap a page obtained by `dma_buf_kmap_atomic`.

## Synopsis

```
void dma_buf_kunmap_atomic (struct dma_buf * dmabuf, unsigned long
page_num, void * vaddr);
```

## Arguments

*dmabuf* [in] buffer to unmap page from.

*page\_num* [in] page in PAGE\_SIZE units to unmap.

*vaddr* [in] kernel space pointer obtained from `dma_buf_kmap_atomic`.

## Description

This call must always succeed.

## Name

`dma_buf_kmap` — Map a page of the buffer object into kernel address space. The same restrictions as for `kmap` and `friends` apply.

## Synopsis

```
void * dma_buf_kmap (struct dma_buf * dmabuf, unsigned long page_num);
```

## Arguments

*dmabuf* [in] buffer to map page from.

*page\_num* [in] page in `PAGE_SIZE` units to map.

## Description

This call must always succeed, any necessary preparations that might fail need to be done in `begin_cpu_access`.

## Name

`dma_buf_kunmap` — Unmap a page obtained by `dma_buf_kmap`.

## Synopsis

```
void dma_buf_kunmap (struct dma_buf * dmabuf, unsigned long page_num,  
void * vaddr);
```

## Arguments

*dmabuf* [in] buffer to unmap page from.

*page\_num* [in] page in PAGE\_SIZE units to unmap.

*vaddr* [in] kernel space pointer obtained from `dma_buf_kmap`.

## Description

This call must always succeed.

## Name

`dma_buf_mmap` — Setup up a userspace mmap with the given vma

## Synopsis

```
int dma_buf_mmap (struct dma_buf * dmabuf, struct vm_area_struct * vma,
unsigned long pgoff);
```

## Arguments

*dmabuf* [in] buffer that should back the vma

*vma* [in] vma for the mmap

*pgoff* [in] offset in pages where this mmap should start within the dma-buf buffer.

## Description

This function adjusts the passed in vma so that it points at the file of the dma\_buf operation. It also adjusts the starting pgoff and does bounds checking on the size of the vma. Then it calls the exporters mmap function to set up the mapping.

Can return negative error values, returns 0 on success.

## Name

`dma_buf_vmap` — Create virtual mapping for the buffer object into kernel address space. Same restrictions as for `vmap` and friends apply.

## Synopsis

```
void * dma_buf_vmap (struct dma_buf * dmabuf);
```

## Arguments

*dmabuf* [in] buffer to vmap

## Description

This call may fail due to lack of virtual mapping address space. These calls are optional in drivers. The intended use for them is for mapping objects linear in kernel space for high use objects. Please attempt to use `kmap/kunmap` before thinking about these interfaces.

Returns `NULL` on error.

## Name

`dma_buf_vunmap` — Unmap a vmap obtained by `dma_buf_vmap`.

## Synopsis

```
void dma_buf_vunmap (struct dma_buf * dmabuf, void * vaddr);
```

## Arguments

*dmabuf* [in] buffer to vunmap

*vaddr* [in] vmap to vunmap

## Name

`fence_context_alloc` — allocate an array of fence contexts

## Synopsis

```
unsigned fence_context_alloc (unsigned num);
```

## Arguments

*num* [in] amount of contexts to allocate

## Description

This function will return the first index of the number of fences allocated. The fence context is used for setting `fence->context` to a unique number.

## Name

`fence_signal_locked` — signal completion of a fence

## Synopsis

```
int fence_signal_locked (struct fence * fence);
```

## Arguments

*fence* the fence to signal

## Description

Signal completion for software callbacks on a fence, this will unblock `fence_wait` calls and run all the callbacks added with `fence_add_callback`. Can be called multiple times, but since a fence can only go from unsignaled to signaled state, it will only be effective the first time.

Unlike `fence_signal`, this function must be called with `fence->lock` held.

## Name

`fence_signal` — signal completion of a fence

## Synopsis

```
int fence_signal (struct fence * fence);
```

## Arguments

*fence* the fence to signal

## Description

Signal completion for software callbacks on a fence, this will unblock `fence_wait` calls and run all the callbacks added with `fence_add_callback`. Can be called multiple times, but since a fence can only go from unsignaled to signaled state, it will only be effective the first time.

## Name

`fence_wait_timeout` — sleep until the fence gets signaled or until timeout elapses

## Synopsis

```
signed long fence_wait_timeout (struct fence * fence, bool intr, signed  
long timeout);
```

## Arguments

*fence* [in] the fence to wait on

*intr* [in] if true, do an interruptible wait

*timeout* [in] timeout value in jiffies, or `MAX_SCHEDULE_TIMEOUT`

## Description

Returns `-ERESTARTSYS` if interrupted, 0 if the wait timed out, or the remaining timeout in jiffies on success. Other error values may be returned on custom implementations.

Performs a synchronous wait on this fence. It is assumed the caller directly or indirectly (buf-mgr between reservation and committing) holds a reference to the fence, otherwise the fence might be freed before return, resulting in undefined behavior.

## Name

`fence_enable_sw_signaling` — enable signaling on fence

## Synopsis

```
void fence_enable_sw_signaling (struct fence * fence);
```

## Arguments

*fence* [in] the fence to enable

## Description

this will request for sw signaling to be enabled, to make the fence complete as soon as possible

## Name

`fence_add_callback` — add a callback to be called when the fence is signaled

## Synopsis

```
int fence_add_callback (struct fence * fence, struct fence_cb * cb,  
fence_func_t func);
```

## Arguments

*fence* [in] the fence to wait on

*cb* [in] the callback to register

*func* [in] the function to call

## Description

`cb` will be initialized by `fence_add_callback`, no initialization by the caller is required. Any number of callbacks can be registered to a fence, but a callback can only be registered to one fence at a time.

Note that the callback can be called from an atomic context. If fence is already signaled, this function will return `-ENOENT` (and *not* call the callback)

Add a software callback to the fence. Same restrictions apply to `refcount` as it does to `fence_wait`, however the caller doesn't need to

## keep a refcount to fence afterwards

when software access is enabled, the creator of the fence is required to keep the fence alive until after it signals with `fence_signal`. The callback itself can be called from irq context.

## Name

`fence_remove_callback` — remove a callback from the signaling list

## Synopsis

```
bool fence_remove_callback (struct fence * fence, struct fence_cb * cb);
```

## Arguments

*fence* [in] the fence to wait on

*cb* [in] the callback to remove

## Description

Remove a previously queued callback from the fence. This function returns true if the callback is successfully removed, or false if the fence has already been signaled.

**\*WARNING\***: Cancelling a callback should only be done if you really know what you're doing, since deadlocks and race conditions could occur all too easily. For this reason, it should only ever be done on hardware lockup recovery, with a reference held to the fence.

## Name

`fence_default_wait` — default sleep until the fence gets signaled or until timeout elapses

## Synopsis

```
signed long fence_default_wait (struct fence * fence, bool intr, signed  
long timeout);
```

## Arguments

*fence* [in] the fence to wait on

*intr* [in] if true, do an interruptible wait

*timeout* [in] timeout value in jiffies, or `MAX_SCHEDULE_TIMEOUT`

## Description

Returns `-ERESTARTSYS` if interrupted, 0 if the wait timed out, or the remaining timeout in jiffies on success.

## Name

`fence_init` — Initialize a custom fence.

## Synopsis

```
void fence_init (struct fence * fence, const struct fence_ops * ops,  
spinlock_t * lock, unsigned context, unsigned seqno);
```

## Arguments

*fence* [in] the fence to initialize

*ops* [in] the `fence_ops` for operations on this fence

*lock* [in] the irqsafe spinlock to use for locking this fence

*context* [in] the execution context this fence is run on

*seqno* [in] a linear increasing sequence number for this context

## Description

Initializes an allocated fence, the caller doesn't have to keep its refcount after committing with this fence, but it will need to hold a refcount again if `fence_ops.enable_signaling` gets called. This can be used for other implementing other types of fence.

`context` and `seqno` are used for easy comparison between fences, allowing to check which fence is later by simply using `fence_later`.

## Name

`/usr/src/linux-4.1.27-24//drivers/dma-buf/seqno-fence.c` — Document generation inconsistency

## Oops

### Warning

The template for this document tried to insert the structured comment from the file `/usr/src/linux-4.1.27-24//drivers/dma-buf/seqno-fence.c` at this point, but none was found. This dummy section is inserted to allow generation to continue.

## Name

struct fence — software synchronization primitive

## Synopsis

```

struct fence {
    struct kref refcount;
    const struct fence_ops * ops;
    struct rcu_head rcu;
    struct list_head cb_list;
    spinlock_t * lock;
    unsigned context;
    unsigned seqno;
    unsigned long flags;
    ktime_t timestamp;
    int status;
};

```

## Members

|           |  |
|-----------|--|
| refcount  | refcount for this fence  |
| ops       | fence_ops associated with this fence   |
| rcu       | used for releasing fence with kfree_rcu  |
| cb_list   | list of all callbacks to call  |
| lock      | spin_lock_irqsave used for locking   |
| context   | execution context this fence belongs to, returned by fence_context_alloc   |
| seqno     | the sequence number of this fence inside the execution context, can be compared to decide which fence would be signaled later. |
| flags     | A mask of FENCE_FLAG_* defined below   |
| timestamp | Timestamp when the fence was signaled.   |
| status    | Optional, only valid if < 0, must be set before calling fence_signal, indicates that the fence has completed with an error.    |

## Description

the flags member must be manipulated and read using the appropriate atomic ops (bit\_\*), so taking the spinlock will not be needed most of the time.

FENCE\_FLAG\_SIGNALED\_BIT - fence is already signaled  
 FENCE\_FLAG\_ENABLE\_SIGNAL\_BIT - enable\_signaling might have been called\*  
 FENCE\_FLAG\_USER\_BITS - start of the unused bits, can be used by the implementer of the fence for its own purposes. Can be used in different ways by different fence implementers, so do not rely on this.

\*) Since atomic bitops are used, this is not guaranteed to be the case. Particularly, if the bit was set, but fence\_signal was called right before this bit was set, it would have been able to

set the `FENCE_FLAG_SIGNALED_BIT`, before `enable_signaling` was called. Adding a check for `FENCE_FLAG_SIGNALED_BIT` after setting `FENCE_FLAG_ENABLE_SIGNAL_BIT` closes this race, and makes sure that after `fence_signal` was called, any `enable_signaling` call will have either been completed, or never called at all.

## Name

struct fence\_cb — callback for fence\_add\_callback

## Synopsis

```
struct fence_cb {  
    struct list_head node;  
    fence_func_t func;  
};
```

## Members

node used by fence\_add\_callback to append this struct to fence::cb\_list

func fence\_func\_t to call

## Description

This struct will be initialized by fence\_add\_callback, additional data can be passed along by embedding fence\_cb in another struct.

## Name

struct fence\_ops — operations implemented for fence

## Synopsis

```
struct fence_ops {
    const char * (* get_driver_name) (struct fence *fence);
    const char * (* get_timeline_name) (struct fence *fence);
    bool (* enable_signaling) (struct fence *fence);
    bool (* signaled) (struct fence *fence);
    signed long (* wait) (struct fence *fence, bool intr, signed long timeout);
    void (* release) (struct fence *fence);
    int (* fill_driver_data) (struct fence *fence, void *data, int size);
    void (* fence_value_str) (struct fence *fence, char *str, int size);
    void (* timeline_value_str) (struct fence *fence, char *str, int size);
};
```

## Members

|                    |  |
|--------------------|--|
| get_driver_name    | returns the driver name.   |
| get_timeline_name  | return the name of the context this fence belongs to.  |
| enable_signaling   | enable software signaling of fence.  |
| signaled           | [optional] peek whether the fence is signaled, can be null.                                    |
| wait               | custom wait implementation, or fence_default_wait.   |
| release            | [optional] called on destruction of fence, can be null   |
| fill_driver_data   | [optional] callback to fill in free-form debug info Returns amount of bytes filled, or -errno. |
| fence_value_str    | [optional] fills in the value of the fence as a string   |
| timeline_value_str | [optional] fills in the current value of the timeline as a string                              |

## Notes on enable\_signaling

For fence implementations that have the capability for hw->hw signaling, they can implement this op to enable the necessary irqs, or insert commands into cmdstream, etc. This is called in the first wait or add\_callback path to let the fence implementation know that there is another driver waiting on the signal (ie. hw->sw case).

This function can be called called from atomic context, but not from irq context, so normal spinlocks can be used.

A return value of false indicates the fence already passed, or some failure occurred that made it impossible to enable signaling. True indicates successful enabling.

fence->status may be set in enable\_signaling, but only when false is returned.

Calling fence\_signal before enable\_signaling is called allows for a tiny race window in which enable\_signaling is called during, before, or after fence\_signal. To fight this, it is recommended that before

enable\_signaling returns true an extra reference is taken on the fence, to be released when the fence is signaled. This will mean fence\_signal will still be called twice, but the second time will be a noop since it was already signaled.

## Notes on signaled

May set fence->status if returning true.

## Notes on wait

Must not be NULL, set to fence\_default\_wait for default implementation. the fence\_default\_wait implementation should work for any fence, as long as enable\_signaling works correctly.

Must return -ERESTARTSYS if the wait is intr = true and the wait was interrupted, and remaining jiffies if fence has signaled, or 0 if wait timed out. Can also return other error values on custom implementations, which should be treated as if the fence is signaled. For example a hardware lockup could be reported like that.

## Notes on release

Can be NULL, this function allows additional commands to run on destruction of the fence. Can be called from irq context. If pointer is set to NULL, kfree will get called instead.

## Name

`fence_get` — increases refcount of the fence

## Synopsis

```
struct fence * fence_get (struct fence * fence);
```

## Arguments

*fence* [in] fence to increase refcount of

## Description

Returns the same fence, with refcount increased by 1.

## Name

`fence_get_rcu` — get a fence from a `reservation_object_list` with rcu read lock

## Synopsis

```
struct fence * fence_get_rcu (struct fence * fence);
```

## Arguments

*fence* [in] fence to increase refcount of

## Description

Function returns NULL if no refcount could be obtained, or the fence.

## Name

`fence_put` — decreases refcount of the fence

## Synopsis

```
void fence_put (struct fence * fence);
```

## Arguments

*fence* [in] fence to reduce refcount of

## Name

`fence_is_signaled_locked` — Return an indication if the fence is signaled yet.

## Synopsis

```
bool fence_is_signaled_locked (struct fence * fence);
```

## Arguments

*fence* [in] the fence to check

## Description

Returns true if the fence was already signaled, false if not. Since this function doesn't enable signaling, it is not guaranteed to ever return true if `fence_add_callback`, `fence_wait` or `fence_enable_sw_signaling` haven't been called before.

This function requires `fence->lock` to be held.

## Name

`fence_is_signaled` — Return an indication if the fence is signaled yet.

## Synopsis

```
bool fence_is_signaled (struct fence * fence);
```

## Arguments

*fence* [in] the fence to check

## Description

Returns true if the fence was already signaled, false if not. Since this function doesn't enable signaling, it is not guaranteed to ever return true if `fence_add_callback`, `fence_wait` or `fence_enable_sw_signaling` haven't been called before.

It's recommended for seqno fences to call `fence_signal` when the operation is complete, it makes it possible to prevent issues from wraparound between time of issue and time of use by checking the return value of this function before calling hardware-specific wait instructions.

## Name

`fence_later` — return the chronologically later fence

## Synopsis

```
struct fence * fence_later (struct fence * f1, struct fence * f2);
```

## Arguments

*f1* [in] the first fence from the same context

*f2* [in] the second fence from the same context

## Description

Returns NULL if both fences are signaled, otherwise the fence that would be signaled last. Both fences must be from the same context, since a seqno is not re-used across contexts.

## Name

`fence_wait` — sleep until the fence gets signaled

## Synopsis

```
signed long fence_wait (struct fence * fence, bool intr);
```

## Arguments

*fence* [in] the fence to wait on

*intr* [in] if true, do an interruptible wait

## Description

This function will return `-ERESTARTSYS` if interrupted by a signal, or 0 if the fence was signaled. Other error values may be returned on custom implementations.

Performs a synchronous wait on this fence. It is assumed the caller directly or indirectly holds a reference to the fence, otherwise the fence might be freed before return, resulting in undefined behavior.

## Name

`to_seqno_fence` — cast a `fence` to a `seqno_fence`

## Synopsis

```
struct seqno_fence * to_seqno_fence (struct fence * fence);
```

## Arguments

*fence* fence to cast to a `seqno_fence`

## Description

Returns NULL if the `fence` is not a `seqno_fence`, or the `seqno_fence` otherwise.

## Name

`seqno_fence_init` — initialize a seqno fence

## Synopsis

```
void seqno_fence_init (struct seqno_fence * fence, spinlock_t * lock,  
struct dma_buf * sync_buf, uint32_t context, uint32_t seqno_ofs,  
uint32_t seqno, enum seqno_fence_condition cond, const struct fence_ops  
* ops);
```

## Arguments

|                  |  |
|------------------|--|
| <i>fence</i>     | seqno_fence to initialize                          |
| <i>lock</i>      | pointer to spinlock to use for fence               |
| <i>sync_buf</i>  | buffer containing the memory location to signal on |
| <i>context</i>   | the execution context this fence is a part of      |
| <i>seqno_ofs</i> | the offset within <i>sync_buf</i>                  |
| <i>seqno</i>     | the sequence # to signal on                        |
| <i>cond</i>      | fence wait condition                               |
| <i>ops</i>       | the fence_ops for operations on this seqno fence   |

## Description

This function initializes a struct `seqno_fence` with passed parameters, and takes a reference on `sync_buf` which is released on fence destruction.

A `seqno_fence` is a `dma_fence` which can complete in software when `enable_signaling` is called, but it also completes when `(s32)((sync_buf)[seqno_ofs] - seqno) >= 0` is true

The `seqno_fence` will take a refcount on the `sync_buf` until it's destroyed, but actual lifetime of `sync_buf` may be longer if one of the callers take a reference to it.

Certain hardware have instructions to insert this type of wait condition in the command stream, so no intervention from software would be needed. This type of fence can be destroyed before completed, however a reference on the `sync_buf` dma-buf can be taken. It is encouraged to re-use the same dma-buf for `sync_buf`, since mapping or unmapping the `sync_buf` to the device's vm can be expensive.

It is recommended for creators of `seqno_fence` to call `fence_signal` before destruction. This will prevent possible issues from wraparound at time of issue vs time of check, since users can check `fence_is_signaled` before submitting instructions for the hardware to wait on the fence. However, when `ops.enable_signaling` is not called, it doesn't have to be done as soon as possible, just before there's any real danger of `seqno` wraparound.

## Name

`/usr/src/linux-4.1.27-24//drivers/dma-buf/reservation.c` — Document generation inconsistency

## Oops

### Warning

The template for this document tried to insert the structured comment from the file `/usr/src/linux-4.1.27-24//drivers/dma-buf/reservation.c` at this point, but none was found. This dummy section is inserted to allow generation to continue.

## Name

`/usr/src/linux-4.1.27-24//include/linux/reservation.h` — Document generation inconsistency

## Oops

### Warning

The template for this document tried to insert the structured comment from the file `/usr/src/linux-4.1.27-24//include/linux/reservation.h` at this point, but none was found. This dummy section is inserted to allow generation to continue.

## Name

`dma_alloc_from_coherent` — try to allocate memory from the per-device coherent area

## Synopsis

```
int dma_alloc_from_coherent (struct device * dev, ssize_t size,
dma_addr_t * dma_handle, void ** ret);
```

## Arguments

|                   |   |
|-------------------|---|
| <i>dev</i>        | device from which we allocate memory                                    |
| <i>size</i>       | size of requested memory area   |
| <i>dma_handle</i> | This will be filled with the correct dma handle                         |
| <i>ret</i>        | This pointer will be filled with the virtual address to allocated area. |

## Description

This function should be only called from per-arch `dma_alloc_coherent` to support allocation from per-device coherent memory pools.

Returns 0 if `dma_alloc_coherent` should continue with allocating from generic memory areas, or !0 if `dma_alloc_coherent` should return *ret*.

## Name

`dma_release_from_coherent` — try to free the memory allocated from per-device coherent memory pool

## Synopsis

```
int dma_release_from_coherent (struct device * dev, int order, void *  
vaddr);
```

## Arguments

*dev* device from which the memory was allocated

*order* the order of pages allocated

*vaddr* virtual address of allocated pages

## Description

This checks whether the memory was allocated from the per-device coherent memory pool and if so, releases that memory.

Returns 1 if we correctly released the memory, or 0 if `dma_release_coherent` should proceed with releasing memory from generic pools.

## Name

`dma_mmap_from_coherent` — try to mmap the memory allocated from per-device coherent memory pool to userspace

## Synopsis

```
int dma_mmap_from_coherent (struct device * dev, struct vm_area_struct * vma, void * vaddr, size_t size, int * ret);
```

## Arguments

*dev* device from which the memory was allocated

*vma* `vm_area` for the userspace memory

*vaddr* cpu address returned by `dma_alloc_from_coherent`

*size* size of the memory buffer allocated by `dma_alloc_from_coherent`

*ret* result from `remap_pfn_range`

## Description

This checks whether the memory was allocated from the per-device coherent memory pool and if so, maps that memory to the provided `vma`.

Returns 1 if we correctly mapped the memory, or 0 if the caller should proceed with mapping memory from generic pools.

## Name

`dmam_alloc_coherent` — Managed `dma_alloc_coherent`

## Synopsis

```
void * dmam_alloc_coherent (struct device * dev, size_t size, dma_addr_t  
* dma_handle, gfp_t gfp);
```

## Arguments

*dev*            Device to allocate coherent memory for

*size*           Size of allocation

*dma\_handle*    Out argument for allocated DMA handle

*gfp*            Allocation flags

## Description

Managed `dma_alloc_coherent`. Memory allocated using this function will be automatically released on driver detach.

## RETURNS

Pointer to allocated memory on success, NULL on failure.

## Name

`dmam_free_coherent` — Managed `dma_free_coherent`

## Synopsis

```
void dmam_free_coherent (struct device * dev, size_t size, void * vaddr,  
dma_addr_t dma_handle);
```

## Arguments

|                   |                                       |
|-------------------|---------------------------------------|
| <i>dev</i>        | Device to free coherent memory for    |
| <i>size</i>       | Size of allocation                    |
| <i>vaddr</i>      | Virtual address of the memory to free |
| <i>dma_handle</i> | DMA handle of the memory to free      |

## Description

Managed `dma_free_coherent`.

## Name

`dmam_alloc_noncoherent` — Managed `dma_alloc_non_coherent`

## Synopsis

```
void * dmam_alloc_noncoherent (struct device * dev, size_t size,  
dma_addr_t * dma_handle, gfp_t gfp);
```

## Arguments

*dev* Device to allocate `non_coherent` memory for

*size* Size of allocation

*dma\_handle* Out argument for allocated DMA handle

*gfp* Allocation flags

## Description

Managed `dma_alloc_non_coherent`. Memory allocated using this function will be automatically released on driver detach.

## RETURNS

Pointer to allocated memory on success, NULL on failure.

## Name

`dmam_free_noncoherent` — Managed `dma_free_noncoherent`

## Synopsis

```
void dmam_free_noncoherent (struct device * dev, size_t size, void *  
vaddr, dma_addr_t dma_handle);
```

## Arguments

*dev*            Device to free noncoherent memory for

*size*           Size of allocation

*vaddr*          Virtual address of the memory to free

*dma\_handle*    DMA handle of the memory to free

## Description

Managed `dma_free_noncoherent`.

## Name

`dmam_declare_coherent_memory` — Managed `dma_declare_coherent_memory`

## Synopsis

```
int dmam_declare_coherent_memory (struct device * dev, phys_addr_t
phys_addr, dma_addr_t device_addr, size_t size, int flags);
```

## Arguments

|                    |  |
|--------------------|--|
| <i>dev</i>         | Device to declare coherent memory for              |
| <i>phys_addr</i>   | Physical address of coherent memory to be declared |
| <i>device_addr</i> | Device address of coherent memory to be declared   |
| <i>size</i>        | Size of coherent memory to be declared             |
| <i>flags</i>       | Flags  |

## Description

Managed `dma_declare_coherent_memory`.

## RETURNS

0 on success, -errno on failure.

## Name

`dmam_release_declared_memory` — Managed `dma_release_declared_memory`.

## Synopsis

```
void dmam_release_declared_memory (struct device * dev);
```

## Arguments

*dev* Device to release declared coherent memory for

## Description

Managed `dmam_release_declared_memory`.

# Device Drivers Power Management

## Name

`dpm_resume_start` — Execute “noirq” and “early” device callbacks.

## Synopsis

```
void dpm_resume_start (pm_message_t state);
```

## Arguments

*state* PM transition of the system being carried out.

## Name

`dpm_resume_end` — Execute “resume” callbacks and complete system transition.

## Synopsis

```
void dpm_resume_end (pm_message_t state);
```

## Arguments

*state* PM transition of the system being carried out.

## Description

Execute “resume” callbacks for all devices and complete the PM transition of the system.

## Name

`dpm_suspend_end` — Execute “late” and “noirq” device suspend callbacks.

## Synopsis

```
int dpm_suspend_end (pm_message_t state);
```

## Arguments

*state* PM transition of the system being carried out.

## Name

`dpm_suspend_start` — Prepare devices for PM transition and suspend them.

## Synopsis

```
int dpm_suspend_start (pm_message_t state);
```

## Arguments

*state* PM transition of the system being carried out.

## Description

Prepare all non-sysdev devices for system PM transition and execute “suspend” callbacks for them.

## Name

`device_pm_wait_for_dev` — Wait for suspend/resume of a device to complete.

## Synopsis

```
int device_pm_wait_for_dev (struct device * subordinate, struct device  
* dev);
```

## Arguments

*subordinate* Device that needs to wait for *dev*.

*dev* Device to wait for.

## Name

`dpm_for_each_dev` — device iterator.

## Synopsis

```
void dpm_for_each_dev (void * data, void (*fn) (struct device *, void *));
```

## Arguments

*data* data for the callback.

*fn* function to be called for each device.

## Description

Iterate over devices in `dpm_list`, and call *fn* for each device, passing it *data*.

# Device Drivers ACPI Support

## Name

`acpi_match_device` — Match a struct device against a given list of ACPI IDs

## Synopsis

```
const struct acpi_device_id * acpi_match_device (const struct  
acpi_device_id * ids, const struct device * dev);
```

## Arguments

*ids* Array of struct `acpi_device_id` object to match against.

*dev* The device structure to match.

## Description

Check if *dev* has a valid ACPI handle and if there is a struct `acpi_device` object for that handle and use that object to match against a given list of device IDs.

Return a pointer to the first matching ID on success or `NULL` on failure.

## Name

`acpi_bus_register_driver` — register a driver with the ACPI bus

## Synopsis

```
int acpi_bus_register_driver (struct acpi_driver * driver);
```

## Arguments

*driver* driver being registered

## Description

Registers a driver with the ACPI bus. Searches the namespace for all devices that match the driver's criteria and binds. Returns zero for success or a negative error status for failure.

## Name

`acpi_bus_unregister_driver` — unregisters a driver with the ACPI bus

## Synopsis

```
void acpi_bus_unregister_driver (struct acpi_driver * driver);
```

## Arguments

*driver* driver to unregister

## Description

Unregisters a driver with the ACPI bus. Searches the namespace for all devices that match the driver's criteria and unbinds.

## Name

`acpi_bus_scan` — Add ACPI device node objects in a given namespace scope.

## Synopsis

```
int acpi_bus_scan (acpi_handle handle);
```

## Arguments

*handle* Root of the namespace scope to scan.

## Description

Scan a given ACPI tree (probably recently hot-plugged) and create and add found devices.

If no devices were found, `-ENODEV` is returned, but it does not mean that there has been a real error. There just have been no suitable ACPI objects in the table trunk from which the kernel could create a device and add an appropriate driver.

Must be called under `acpi_scan_lock`.

## Name

`acpi_bus_trim` — Detach scan handlers and drivers from ACPI device objects.

## Synopsis

```
void acpi_bus_trim (struct acpi_device * adev);
```

## Arguments

*adev* Root of the ACPI namespace scope to walk.

## Description

Must be called under `acpi_scan_lock`.

## Name

`create_pnp_modalias` — Create hid/cid(s) string for modalias and uevent

## Synopsis

```
int create_pnp_modalias (struct acpi_device * acpi_dev, char * modalias,  
int size);
```

## Arguments

*acpi\_dev* ACPI device object.

*modalias* Buffer to print into.

*size* Size of the buffer.

## Description

Creates hid/cid(s) string needed for modalias and uevent e.g. on a device with hid:IBM0001 and cid:ACPI0001 you get:

## modalias

"acpi:IBM0001:ACPI0001"

## Return

0: no `_HID` and no `_CID` -EINVAL: output error -ENOMEM: output is truncated

## Name

`create_of_modalias` — Creates DT compatible string for modalias and uevent

## Synopsis

```
int create_of_modalias (struct acpi_device * acpi_dev, char * modalias,
int size);
```

## Arguments

*acpi\_dev* ACPI device object.

*modalias* Buffer to print into.

*size* Size of the buffer.

## Expose DT compatible modalias as of

`NnameTCcompatible`. This function should only be called for devices having PRP0001 in their list of ACPI/PNP IDs.

## Name

`acpi_of_match_device` — Match device object using the “compatible” property.

## Synopsis

```
bool acpi_of_match_device (struct acpi_device * adev, const struct  
of_device_id * of_match_table);
```

## Arguments

*adev*                   ACPI device object to match.

*of\_match\_table*   List of device IDs to match against.

## Description

If *dev* has an ACPI companion which has the special PRP0001 device ID in its list of identifiers and a `_DSD` object with the “compatible” property, use that property to match against the given list of identifiers.

## Name

`acpi_scan_drop_device` — Drop an ACPI device object.

## Synopsis

```
void acpi_scan_drop_device (acpi_handle handle, void * context);
```

## Arguments

*handle*    Handle of an ACPI namespace node, not used.

*context*    Address of the ACPI device object to drop.

## Description

This is invoked by `acpi_ns_delete_node` during the removal of the ACPI namespace node the device object pointed to by `context` is attached to.

The unregistration is carried out asynchronously to avoid running `acpi_device_del` under the ACPICA's namespace mutex and the list is used to ensure the correct ordering (the device objects must be unregistered in the same order in which the corresponding namespace nodes are deleted).

## Device drivers PnP support

## Name

`pnp_register_protocol` — adds a pnp protocol to the pnp layer

## Synopsis

```
int pnp_register_protocol (struct pnp_protocol * protocol);
```

## Arguments

*protocol* pointer to the corresponding pnp\_protocol structure

## Ex protocols

ISAPNP, PNPBIOS, etc

## Name

`pnp_unregister_protocol` — removes a pnp protocol from the pnp layer

## Synopsis

```
void pnp_unregister_protocol (struct pnp_protocol * protocol);
```

## Arguments

*protocol* pointer to the corresponding `pnp_protocol` structure

## Name

`pnp_request_card_device` — Searches for a PnP device under the specified card

## Synopsis

```
struct pnp_dev * pnp_request_card_device (struct pnp_card_link * click,  
const char * id, struct pnp_dev * from);
```

## Arguments

*click* pointer to the card link, cannot be NULL

*id* pointer to a PnP ID structure that explains the rules for finding the device

*from* Starting place to search from. If NULL it will start from the beginning.

## Name

`pnp_release_card_device` — call this when the driver no longer needs the device

## Synopsis

```
void pnp_release_card_device (struct pnp_dev * dev);
```

## Arguments

*dev* pointer to the PnP device structure

## Name

`pnp_register_card_driver` — registers a PnP card driver with the PnP Layer

## Synopsis

```
int pnp_register_card_driver (struct pnp_card_driver * drv);
```

## Arguments

*drv* pointer to the driver to register

## Name

`pnp_unregister_card_driver` — unregisters a PnP card driver from the PnP Layer

## Synopsis

```
void pnp_unregister_card_driver (struct pnp_card_driver * drv);
```

## Arguments

*drv* pointer to the driver to unregister

## Name

`pnp_add_id` — adds an EISA id to the specified device

## Synopsis

```
struct pnp_id * pnp_add_id (struct pnp_dev * dev, const char * id);
```

## Arguments

*dev* pointer to the desired device

*id* pointer to an EISA id string

## Name

`pnp_start_dev` — low-level start of the PnP device

## Synopsis

```
int pnp_start_dev (struct pnp_dev * dev);
```

## Arguments

*dev* pointer to the desired device

## Description

assumes that resources have already been allocated

## Name

`pnp_stop_dev` — low-level disable of the PnP device

## Synopsis

```
int pnp_stop_dev (struct pnp_dev * dev);
```

## Arguments

*dev* pointer to the desired device

## Description

does not free resources

## Name

`pnp_activate_dev` — activates a PnP device for use

## Synopsis

```
int pnp_activate_dev (struct pnp_dev * dev);
```

## Arguments

*dev* pointer to the desired device

## Description

does not validate or set resources so be careful.

## Name

`pnp_disable_dev` — disables device

## Synopsis

```
int pnp_disable_dev (struct pnp_dev * dev);
```

## Arguments

*dev* pointer to the desired device

## Description

inform the correct pnp protocol so that resources can be used by other devices

## Name

`pnp_is_active` — Determines if a device is active based on its current resources

## Synopsis

```
int pnp_is_active (struct pnp_dev * dev);
```

## Arguments

*dev* pointer to the desired PnP device

## Userspace IO devices

## Name

`uio_event_notify` — trigger an interrupt event

## Synopsis

```
void uio_event_notify (struct uio_info * info);
```

## Arguments

*info* UIO device capabilities

## Name

`__uio_register_device` — register a new userspace IO device

## Synopsis

```
int __uio_register_device (struct module * owner, struct device * parent,  
struct uio_info * info);
```

## Arguments

*owner*    module that creates the new device

*parent*    parent device

*info*    UIO device capabilities

## Description

returns zero on success or a negative error code.

## Name

`uio_unregister_device` — unregister a industrial IO device

## Synopsis

```
void uio_unregister_device (struct uio_info * info);
```

## Arguments

*info* UIO device capabilities

## Name

struct uio\_mem — description of a UIO memory region

## Synopsis

```
struct uio_mem {
    const char * name;
    phys_addr_t addr;
    resource_size_t size;
    int memtype;
    void __iomem * internal_addr;
    struct uio_map * map;
};
```

## Members

|               |   |
|---------------|---|
| name          | name of the memory region for identification  |
| addr          | address of the device's memory (phys_addr is used since addr can be logical, virtual, or physical & phys_addr_t should always be large enough to handle any of the address types) |
| size          | size of IO  |
| memtype       | type of memory addr points to   |
| internal_addr | ioremap-ped version of addr, for driver internal use  |
| map           | for use by the UIO core only.   |

## Name

struct uio\_port — description of a UIO port region

## Synopsis

```
struct uio_port {
    const char * name;
    unsigned long start;
    unsigned long size;
    int porttype;
    struct uio_portio * portio;
};
```

## Members

|          |  |
|----------|--|
| name     | name of the port region for identification |
| start    | start of port region                       |
| size     | size of port region                        |
| porttype | type of port (see UIO_PORT_* below)        |
| portio   | for use by the UIO core only.              |

## Name

struct uio\_info — UIO device capabilities

## Synopsis

```

struct uio_info {
    struct uio_device * uio_dev;
    const char * name;
    const char * version;
    struct uio_mem mem[MAX_UIO_MAPS];
    struct uio_port port[MAX_UIO_PORT_REGIONS];
    long irq;
    unsigned long irq_flags;
    void * priv;
    irqreturn_t (* handler) (int irq, struct uio_info *dev_info);
    int (* mmap) (struct uio_info *info, struct vm_area_struct *vma);
    int (* open) (struct uio_info *info, struct inode *inode);
    int (* release) (struct uio_info *info, struct inode *inode);
    int (* irqcontrol) (struct uio_info *info, s32 irq_on);
};

```

## Members

|                            |  |
|----------------------------|--|
| uio_dev                    | the UIO device this info belongs to                      |
| name                       | device name  |
| version                    | device driver version                                    |
| mem[MAX_UIO_MAPS]          | list of mappable memory regions, size==0 for end of list |
| port[MAX_UIO_PORT_REGIONS] | list of port regions, size==0 for end of list            |
| irq                        | interrupt number or UIO_IRQ_CUSTOM                       |
| irq_flags                  | flags for request_irq                                    |
| priv                       | optional private data                                    |
| handler                    | the device's irq handler                                 |
| mmap                       | mmap operation for this uio device                       |
| open                       | open operation for this uio device                       |
| release                    | release operation for this uio device                    |
| irqcontrol                 | disable/enable irqs when 0/1 is written to /dev/uioX     |

---

# Chapter 3. Parallel Port Devices

## Name

`parport_yield` — relinquish a parallel port temporarily

## Synopsis

```
int parport_yield (struct pardevice * dev);
```

## Arguments

*dev* a device on the parallel port

## Description

This function relinquishes the port if it would be helpful to other drivers to do so. Afterwards it tries to reclaim the port using `parport_claim`, and the return value is the same as for `parport_claim`. If it fails, the port is left unclaimed and it is the driver's responsibility to reclaim the port.

The `parport_yield` and `parport_yield_blocking` functions are for marking points in the driver at which other drivers may claim the port and use their devices. Yielding the port is similar to releasing it and reclaiming it, but is more efficient because no action is taken if there are no other devices needing the port. In fact, nothing is done even if there are other devices waiting but the current device is still within its “timeslice”. The default timeslice is half a second, but it can be adjusted via the `/proc` interface.

## Name

`parport_yield_blocking` — relinquish a parallel port temporarily

## Synopsis

```
int parport_yield_blocking (struct pardevice * dev);
```

## Arguments

*dev* a device on the parallel port

## Description

This function relinquishes the port if it would be helpful to other drivers to do so. Afterwards it tries to reclaim the port using `parport_claim_or_block`, and the return value is the same as for `parport_claim_or_block`.

## Name

`parport_wait_event` — wait for an event on a parallel port

## Synopsis

```
int parport_wait_event (struct parport * port, signed long timeout);
```

## Arguments

*port*      port to wait on

*timeout*   time to wait (in jiffies)

## Description

This function waits for up to *timeout* jiffies for an interrupt to occur on a parallel port. If the port timeout is set to zero, it returns immediately.

If an interrupt occurs before the timeout period elapses, this function returns zero immediately. If it times out, it returns one. An error code less than zero indicates an error (most likely a pending signal), and the calling code should finish what it's doing as soon as it can.

## Name

`parport_wait_peripheral` — wait for status lines to change in 35ms

## Synopsis

```
int parport_wait_peripheral (struct parport * port, unsigned char mask,
unsigned char result);
```

## Arguments

*port* port to watch

*mask* status lines to watch

*result* desired values of chosen status lines

## Description

This function waits until the masked status lines have the desired values, or until 35ms have elapsed (see IEEE 1284-1994 page 24 to 25 for why this value in particular is hardcoded). The *mask* and *result* parameters are bitmasks, with the bits defined by the constants in `parport.h`: `PARPORT_STATUS_BUSY`, and so on.

The port is polled quickly to start off with, in anticipation of a fast response from the peripheral. This fast polling time is configurable (using `/proc`), and defaults to 500usec. If the timeout for this port (see `parport_set_timeout`) is zero, the fast polling time is 35ms, and this function does not call `schedule`.

If the timeout for this port is non-zero, after the fast polling fails it uses `parport_wait_event` to wait for up to 10ms, waking up if an interrupt occurs.

## Name

`parport_negotiate` — negotiate an IEEE 1284 mode

## Synopsis

```
int parport_negotiate (struct parport * port, int mode);
```

## Arguments

*port* port to use

*mode* mode to negotiate to

## Description

Use this to negotiate to a particular IEEE 1284 transfer mode. The *mode* parameter should be one of the constants in `parport.h` starting `IEEE1284_MODE_XXX`.

The return value is 0 if the peripheral has accepted the negotiation to the mode specified, -1 if the peripheral is not IEEE 1284 compliant (or not present), or 1 if the peripheral has rejected the negotiation.

## Name

`parport_write` — write a block of data to a parallel port

## Synopsis

```
ssize_t parport_write (struct parport * port, const void * buffer,  
size_t len);
```

## Arguments

*port* port to write to

*buffer* data buffer (in kernel space)

*len* number of bytes of data to transfer

## Description

This will write up to *len* bytes of *buffer* to the port specified, using the IEEE 1284 transfer mode most recently negotiated to (using `parport_negotiate`), as long as that mode supports forward transfers (host to peripheral).

It is the caller's responsibility to ensure that the first *len* bytes of *buffer* are valid.

This function returns the number of bytes transferred (if zero or positive), or else an error code.

## Name

`parport_read` — read a block of data from a parallel port

## Synopsis

```
ssize_t parport_read (struct parport * port, void * buffer, size_t len);
```

## Arguments

*port* port to read from

*buffer* data buffer (in kernel space)

*len* number of bytes of data to transfer

## Description

This will read up to *len* bytes of *buffer* to the port specified, using the IEEE 1284 transfer mode most recently negotiated to (using `parport_negotiate`), as long as that mode supports reverse transfers (peripheral to host).

It is the caller's responsibility to ensure that the first *len* bytes of *buffer* are available to write to.

This function returns the number of bytes transferred (if zero or positive), or else an error code.

## Name

`parport_set_timeout` — set the inactivity timeout for a device

## Synopsis

```
long parport_set_timeout (struct pardevice * dev, long inactivity);
```

## Arguments

*dev*            device on a port

*inactivity*    inactivity timeout (in jiffies)

## Description

This sets the inactivity timeout for a particular device on a port. This affects functions like `parport_wait_peripheral`. The special value 0 means not to call `schedule` while dealing with this device.

The return value is the previous inactivity timeout.

Any callers of `parport_wait_event` for this device are woken up.

## Name

`parport_register_driver` — register a parallel port device driver

## Synopsis

```
int parport_register_driver (struct parport_driver * drv);
```

## Arguments

*drv* structure describing the driver

## Description

This can be called by a parallel port device driver in order to receive notifications about ports being found in the system, as well as ports no longer available.

The *drv* structure is allocated by the caller and must not be deallocated until after calling `parport_unregister_driver`.

The driver's `attach` function may block. The port that `attach` is given will be valid for the duration of the callback, but if the driver wants to take a copy of the pointer it must call `parport_get_port` to do so. Calling `parport_register_device` on that port will do this for you.

The driver's `detach` function may block. The port that `detach` is given will be valid for the duration of the callback, but if the driver wants to take a copy of the pointer it must call `parport_get_port` to do so.

Returns 0 on success. Currently it always succeeds.

## Name

`parport_unregister_driver` — deregister a parallel port device driver

## Synopsis

```
void parport_unregister_driver (struct parport_driver * drv);
```

## Arguments

*drv* structure describing the driver that was given to `parport_register_driver`

## Description

This should be called by a parallel port device driver that has registered itself using `parport_register_driver` when it is about to be unloaded.

When it returns, the driver's `attach` routine will no longer be called, and for each port that `attach` was called for, the `detach` routine will have been called.

All the driver's `attach` and `detach` calls are guaranteed to have finished by the time this function returns.

## Name

`parport_get_port` — increment a port's reference count

## Synopsis

```
struct parport * parport_get_port (struct parport * port);
```

## Arguments

*port* the port

## Description

This ensures that a struct `parport` pointer remains valid until the matching `parport_put_port` call.

## Name

`parport_put_port` — decrement a port's reference count

## Synopsis

```
void parport_put_port (struct parport * port);
```

## Arguments

*port* the port

## Description

This should be called once for each call to `parport_get_port`, once the port is no longer needed.

## Name

`parport_register_port` — register a parallel port

## Synopsis

```
struct parport * parport_register_port (unsigned long base, int irq,  
int dma, struct parport_operations * ops);
```

## Arguments

*base* base I/O address

*irq* IRQ line

*dma* DMA channel

*ops* pointer to the port driver's port operations structure

## Description

When a parallel port (lowlevel) driver finds a port that should be made available to parallel port device drivers, it should call `parport_register_port`. The *base*, *irq*, and *dma* parameters are for the convenience of port drivers, and for ports where they aren't meaningful needn't be set to anything special. They can be altered afterwards by adjusting the relevant members of the `parport` structure that is returned and represents the port. They should not be tampered with after calling `parport_announce_port`, however.

If there are parallel port device drivers in the system that have registered themselves using `parport_register_driver`, they are not told about the port at this time; that is done by `parport_announce_port`.

The *ops* structure is allocated by the caller, and must not be deallocated before calling `parport_remove_port`.

If there is no memory to allocate a new `parport` structure, this function will return `NULL`.

## Name

`parport_announce_port` — tell device drivers about a parallel port

## Synopsis

```
void parport_announce_port (struct parport * port);
```

## Arguments

*port* parallel port to announce

## Description

After a port driver has registered a parallel port with `parport_register_port`, and performed any necessary initialisation or adjustments, it should call `parport_announce_port` in order to notify all device drivers that have called `parport_register_driver`. Their attach functions will be called, with *port* as the parameter.

## Name

`parport_remove_port` — deregister a parallel port

## Synopsis

```
void parport_remove_port (struct parport * port);
```

## Arguments

*port* parallel port to deregister

## Description

When a parallel port driver is forcibly unloaded, or a parallel port becomes inaccessible, the port driver must call this function in order to deal with device drivers that still want to use it.

The `parport` structure associated with the port has its operations structure replaced with one containing 'null' operations that return errors or just don't do anything.

Any drivers that have registered themselves using `parport_register_driver` are notified that the port is no longer accessible by having their `detach` routines called with *port* as the parameter.

## Name

`parport_register_device` — register a device on a parallel port

## Synopsis

```
struct pardevice * parport_register_device (struct parport * port, const
char * name, int (*pf) (void *), void (*kf) (void *), void (*irq_func)
(void *), int flags, void * handle);
```

## Arguments

|                 |                                      |
|-----------------|--------------------------------------|
| <i>port</i>     | port to which the device is attached |
| <i>name</i>     | a name to refer to the device        |
| <i>pf</i>       | preemption callback                  |
| <i>kf</i>       | kick callback (wake-up)              |
| <i>irq_func</i> | interrupt handler                    |
| <i>flags</i>    | registration flags                   |
| <i>handle</i>   | data for callback functions          |

## Description

This function, called by parallel port device drivers, declares that a device is connected to a port, and tells the system all it needs to know.

The *name* is allocated by the caller and must not be deallocated until the caller calls `parport_unregister_device` for that device.

The preemption callback function, *pf*, is called when this device driver has claimed access to the port but another device driver wants to use it. It is given *handle* as its parameter, and should return zero if it is willing for the system to release the port to another driver on its behalf. If it wants to keep control of the port it should return non-zero, and no action will be taken. It is good manners for the driver to try to release the port at the earliest opportunity after its preemption callback rejects a preemption attempt. Note that if a preemption callback is happy for preemption to go ahead, there is no need to release the port; it is done automatically. This function may not block, as it may be called from interrupt context. If the device driver does not support preemption, *pf* can be NULL.

The wake-up (“kick”) callback function, *kf*, is called when the port is available to be claimed for exclusive access; that is, `parport_claim` is guaranteed to succeed when called from inside the wake-up callback function. If the driver wants to claim the port it should do so; otherwise, it need not take any action. This function may not block, as it may be called from interrupt context. If the device driver does not want to be explicitly invited to claim the port in this way, *kf* can be NULL.

The interrupt handler, *irq\_func*, is called when an interrupt arrives from the parallel port. Note that if a device driver wants to use interrupts it should use `parport_enable_irq`, and can also check the `irq` member of the `parport` structure representing the port.

The parallel port (lowlevel) driver is the one that has called `request_irq` and whose interrupt handler is called first. This handler does whatever needs to be done to the hardware to acknowledge the interrupt

(for PC-style ports there is nothing special to be done). It then tells the IEEE 1284 code about the interrupt, which may involve reacting to an IEEE 1284 event depending on the current IEEE 1284 phase. After this, it calls *irq\_func*. Needless to say, *irq\_func* will be called from interrupt context, and may not block.

The `PARPORT_DEV_EXCL` flag is for preventing port sharing, and so should only be used when sharing the port with other device drivers is impossible and would lead to incorrect behaviour. Use it sparingly! Normally, *flags* will be zero.

This function returns a pointer to a structure that represents the device on the port, or `NULL` if there is not enough memory to allocate space for that structure.

## Name

`parport_unregister_device` — deregister a device on a parallel port

## Synopsis

```
void parport_unregister_device (struct pardevice * dev);
```

## Arguments

*dev* pointer to structure representing device

## Description

This undoes the effect of `parport_register_device`.

## Name

`parport_find_number` — find a parallel port by number

## Synopsis

```
struct parport * parport_find_number (int number);
```

## Arguments

*number* parallel port number

## Description

This returns the parallel port with the specified number, or `NULL` if there is none.

There is an implicit `parport_get_port` done already; to throw away the reference to the port that `parport_find_number` gives you, use `parport_put_port`.

## Name

`parport_find_base` — find a parallel port by base address

## Synopsis

```
struct parport * parport_find_base (unsigned long base);
```

## Arguments

*base* base I/O address

## Description

This returns the parallel port with the specified base address, or NULL if there is none.

There is an implicit `parport_get_port` done already; to throw away the reference to the port that `parport_find_base` gives you, use `parport_put_port`.

## Name

`parport_claim` — claim access to a parallel port device

## Synopsis

```
int parport_claim (struct pardevice * dev);
```

## Arguments

*dev* pointer to structure representing a device on the port

## Description

This function will not block and so can be used from interrupt context. If `parport_claim` succeeds in claiming access to the port it returns zero and the port is available to use. It may fail (returning non-zero) if the port is in use by another driver and that driver is not willing to relinquish control of the port.

## Name

`parport_claim_or_block` — claim access to a parallel port device

## Synopsis

```
int parport_claim_or_block (struct pardevice * dev);
```

## Arguments

*dev* pointer to structure representing a device on the port

## Description

This behaves like `parport_claim`, but will block if necessary to wait for the port to be free. A return value of 1 indicates that it slept; 0 means that it succeeded without needing to sleep. A negative error code indicates failure.

## Name

`parport_release` — give up access to a parallel port device

## Synopsis

```
void parport_release (struct pardevice * dev);
```

## Arguments

*dev* pointer to structure representing parallel port device

## Description

This function cannot fail, but it should not be called without the port claimed. Similarly, if the port is already claimed you should not try claiming it again.

## Name

`parport_open` — find a device by canonical device number

## Synopsis

```
struct pardevice * parport_open (int devnum, const char * name);
```

## Arguments

*devnum* canonical device number

*name* name to associate with the device

## Description

This function is similar to `parport_register_device`, except that it locates a device by its number rather than by the port it is attached to.

All parameters except for *devnum* are the same as for `parport_register_device`. The return value is the same as for `parport_register_device`.

## Name

`parport_close` — close a device opened with `parport_open`

## Synopsis

```
void parport_close (struct pardevice * dev);
```

## Arguments

*dev* device to close

## Description

This is to `parport_open` as `parport_unregister_device` is to `parport_register_device`.

---

# **Chapter 4. Message-based devices**

## **Fusion message devices**

## Name

`mpt_register` — Register protocol-specific main callback handler.

## Synopsis

```
u8 mpt_register (MPT_CALLBACK cbfunc, MPT_DRIVER_CLASS dclass, char *
func_name);
```

## Arguments

*cbfunc*        callback function pointer

*dclass*        Protocol driver's class (MPT\_DRIVER\_CLASS enum value)

*func\_name*    call function's name

## Description

This routine is called by a protocol-specific driver (SCSI host, LAN, SCSI target) to register its reply callback routine. Each protocol-specific driver must do this before it will be able to use any IOC resources, such as obtaining request frames.

## NOTES

The SCSI protocol driver currently calls this routine thrice in order to register separate callbacks; one for “normal” SCSI IO; one for MptScsiTaskMgmt requests; one for Scan/DV requests.

Returns u8 valued “handle” in the range (and S.O.D. order) {N,...,7,6,5,...,1} if successful. A return value of MPT\_MAX\_PROTOCOL\_DRIVERS (including zero!) should be considered an error by the caller.

## Name

`mpt_deregister` — Deregister a protocol drivers resources.

## Synopsis

```
void mpt_deregister (u8 cb_idx);
```

## Arguments

*cb\_idx* previously registered callback handle

## Description

Each protocol-specific driver should call this routine when its module is unloaded.

## Name

`mpt_event_register` — Register protocol-specific event callback handler.

## Synopsis

```
int mpt_event_register (u8 cb_idx, MPT_EVHANDLER ev_cbfunc);
```

## Arguments

*cb\_idx*        previously registered (via `mpt_register`) callback handle

*ev\_cbfunc*    callback function

## Description

This routine can be called by one or more protocol-specific drivers if/when they choose to be notified of MPT events.

Returns 0 for success.

## Name

`mpt_event_deregister` — Deregister protocol-specific event callback handler

## Synopsis

```
void mpt_event_deregister (u8 cb_idx);
```

## Arguments

*cb\_idx* previously registered callback handle

## Description

Each protocol-specific driver should call this routine when it does not (or can no longer) handle events, or when its module is unloaded.

## Name

`mpt_reset_register` — Register protocol-specific IOC reset handler.

## Synopsis

```
int mpt_reset_register (u8 cb_idx, MPT_RESETHANDLER reset_func);
```

## Arguments

*cb\_idx*            previously registered (via `mpt_register`) callback handle

*reset\_func*      reset function

## Description

This routine can be called by one or more protocol-specific drivers if/when they choose to be notified of IOC resets.

Returns 0 for success.

## Name

`mpt_reset_deregister` — Deregister protocol-specific IOC reset handler.

## Synopsis

```
void mpt_reset_deregister (u8 cb_idx);
```

## Arguments

*cb\_idx* previously registered callback handle

## Description

Each protocol-specific driver should call this routine when it does not (or can no longer) handle IOC reset handling, or when its module is unloaded.

## Name

`mpt_device_driver_register` — Register device driver hooks

## Synopsis

```
int mpt_device_driver_register (struct mpt_pci_driver * dd_cbfunc, u8  
cb_idx);
```

## Arguments

*dd\_cbfunc* driver callbacks struct

*cb\_idx* MPT protocol driver index

## Name

`mpt_device_driver_deregister` — DeRegister device driver hooks

## Synopsis

```
void mpt_device_driver_deregister (u8 cb_idx);
```

## Arguments

*cb\_idx* MPT protocol driver index

## Name

`mpt_get_msg_frame` — Obtain an MPT request frame from the pool

## Synopsis

```
MPT_FRAME_HDR* mpt_get_msg_frame (u8 cb_idx, MPT_ADAPTER * ioc);
```

## Arguments

*cb\_idx* Handle of registered MPT protocol driver

*ioc* Pointer to MPT adapter structure

## Description

Obtain an MPT request frame from the pool (of 1024) that are allocated per MPT adapter.

Returns pointer to a MPT request frame or NULL if none are available or IOC is not active.

## Name

`mpt_put_msg_frame` — Send a protocol-specific MPT request frame to an IOC

## Synopsis

```
void mpt_put_msg_frame (u8 cb_idx, MPT_ADAPTER * ioc, MPT_FRAME_HDR *  
mf);
```

## Arguments

*cb\_idx* Handle of registered MPT protocol driver

*ioc* Pointer to MPT adapter structure

*mf* Pointer to MPT request frame

## Description

This routine posts an MPT request frame to the request post FIFO of a specific MPT adapter.

## Name

`mpt_put_msg_frame_hi_pri` — Send a hi-pri protocol-specific MPT request frame

## Synopsis

```
void mpt_put_msg_frame_hi_pri (u8  cb_idx,  MPT_ADAPTER  *  ioc,  
MPT_FRAME_HDR * mf);
```

## Arguments

*cb\_idx* Handle of registered MPT protocol driver

*ioc* Pointer to MPT adapter structure

*mf* Pointer to MPT request frame

## Description

Send a protocol-specific MPT request frame to an IOC using hi-priority request queue.

This routine posts an MPT request frame to the request post FIFO of a specific MPT adapter.

## Name

`mpt_free_msg_frame` — Place MPT request frame back on FreeQ.

## Synopsis

```
void mpt_free_msg_frame (MPT_ADAPTER * ioc, MPT_FRAME_HDR * mf);
```

## Arguments

*ioc* Pointer to MPT adapter structure

*mf* Pointer to MPT request frame

## Description

This routine places a MPT request frame back on the MPT adapter's FreeQ.

## Name

`mpt_send_handshake_request` — Send MPT request via doorbell handshake method.

## Synopsis

```
int mpt_send_handshake_request (u8 cb_idx, MPT_ADAPTER * ioc, int reqBytes, u32 * req, int sleepFlag);
```

## Arguments

|                  |  |
|------------------|--|
| <i>cb_idx</i>    | Handle of registered MPT protocol driver   |
| <i>ioc</i>       | Pointer to MPT adapter structure           |
| <i>reqBytes</i>  | Size of the request in bytes               |
| <i>req</i>       | Pointer to MPT request frame               |
| <i>sleepFlag</i> | Use schedule if CAN_SLEEP else use udelay. |

## Description

This routine is used exclusively to send `MptScsiTaskMgmt` requests since they are required to be sent via doorbell handshake.

## NOTE

It is the callers responsibility to byte-swap fields in the request which are greater than 1 byte in size.

Returns 0 for success, non-zero for failure.

## Name

`mpt_verify_adapter` — Given IOC identifier, set pointer to its adapter structure.

## Synopsis

```
int mpt_verify_adapter (int iocid, MPT_ADAPTER ** iocpp);
```

## Arguments

*iocid* IOC unique identifier (integer)

*iocpp* Pointer to pointer to IOC adapter

## Description

Given a unique IOC identifier, set pointer to the associated MPT adapter structure.

Returns `iocid` and sets `iocpp` if `iocid` is found. Returns -1 if `iocid` is not found.

## Name

`mpt_attach` — Install a PCI intelligent MPT adapter.

## Synopsis

```
int mpt_attach (struct pci_dev * pdev, const struct pci_device_id * id);
```

## Arguments

*pdev* Pointer to `pci_dev` structure

*id* PCI device ID information

## Description

This routine performs all the steps necessary to bring the IOC of a MPT adapter to a OPERATIONAL state. This includes registering memory regions, registering the interrupt, and allocating request and reply memory pools.

This routine also pre-fetches the LAN MAC address of a Fibre Channel MPT adapter.

Returns 0 for success, non-zero for failure.

## TODO

Add support for polled controllers

## Name

`mpt_detach` — Remove a PCI intelligent MPT adapter.

## Synopsis

```
void mpt_detach (struct pci_dev * pdev);
```

## Arguments

*pdev* Pointer to `pci_dev` structure

## Name

`mpt_suspend` — Fusion MPT base driver suspend routine.

## Synopsis

```
int mpt_suspend (struct pci_dev * pdev, pm_message_t state);
```

## Arguments

*pdev*    Pointer to `pci_dev` structure

*state*   new state to enter

## Name

`mpt_resume` — Fusion MPT base driver resume routine.

## Synopsis

```
int mpt_resume (struct pci_dev * pdev);
```

## Arguments

*pdev* Pointer to `pci_dev` structure

## Name

`mpt_GetIocState` — Get the current state of a MPT adapter.

## Synopsis

```
u32 mpt_GetIocState (MPT_ADAPTER * ioc, int cooked);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

*cooked* Request raw or cooked IOC state

## Description

Returns all IOC Doorbell register bits if `cooked==0`, else just the Doorbell bits in `MPI_IOC_STATE_MASK`.

## Name

`mpt_alloc_fw_memory` — allocate firmware memory

## Synopsis

```
int mpt_alloc_fw_memory (MPT_ADAPTER * ioc, int size);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

*size* total FW bytes

## Description

If memory has already been allocated, the same (cached) value is returned.

Return 0 if successful, or non-zero for failure

## Name

`mpt_free_fw_memory` — free firmware memory

## Synopsis

```
void mpt_free_fw_memory (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

## Description

If `alt_img` is NULL, delete from `ioc` structure. Else, delete a secondary image in same format.

## Name

`mptbase_sas_persist_operation` — Perform operation on SAS Persistent Table

## Synopsis

```
int    mptbase_sas_persist_operation    (MPT_ADAPTER    *    ioc,    u8
    persist_opcode);
```

## Arguments

*ioc*                      Pointer to MPT\_ADAPTER structure

*persist\_opcode*    see below

## Description

MPI\_SAS\_OP\_CLEAR\_NOT\_PRESENT - Free all persist TargetID mappings for devices not currently present. MPI\_SAS\_OP\_CLEAR\_ALL\_PERSISTENT - Clear al persist TargetID mappings

## NOTE

Don't use not this function during interrupt time.

Returns 0 for success, non-zero error

## Name

`mpt_raid_phys_disk_pg0` — returns phys disk page zero

## Synopsis

```
int mpt_raid_phys_disk_pg0 (MPT_ADAPTER * ioc, u8 phys_disk_num,  
RaidPhysDiskPage0_t * phys_disk);
```

## Arguments

*ioc* Pointer to a Adapter Structure

*phys\_disk\_num* io unit unique phys disk num generated by the ioc

*phys\_disk* requested payload data returned

## Return

0 on success -EFAULT if read of config page header fails or data pointer not NULL -ENOMEM if pci\_alloc failed

## Name

`mpt_raid_phys_disk_get_num_paths` — returns number paths associated to this `phys_num`

## Synopsis

```
int mpt_raid_phys_disk_get_num_paths (MPT_ADAPTER * ioc, u8
phys_disk_num);
```

## Arguments

*ioc* Pointer to a Adapter Structure

*phys\_disk\_num* io unit unique phys disk num generated by the ioc

## Return

returns number paths

## Name

`mpt_raid_phys_disk_pg1` — returns phys disk page 1

## Synopsis

```
int mpt_raid_phys_disk_pg1 (MPT_ADAPTER * ioc, u8 phys_disk_num,  
RaidPhysDiskPage1_t * phys_disk);
```

## Arguments

*ioc* Pointer to a Adapter Structure

*phys\_disk\_num* io unit unique phys disk num generated by the ioc

*phys\_disk* requested payload data returned

## Return

0 on success -EFAULT if read of config page header fails or data pointer not NULL -ENOMEM if pci\_alloc failed

## Name

`mpt_findImVolumes` — Identify IDs of hidden disks and RAID Volumes

## Synopsis

```
int mpt_findImVolumes (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to a Adapter Structre

## Return

0 on success -EFAULT if read of config page header fails or data pointer not NULL -ENOMEM if pci\_alloc failed

## Name

`mpt_config` — Generic function to issue config message

## Synopsis

```
int mpt_config (MPT_ADAPTER * ioc, CONFIGPARMS * pCfg);
```

## Arguments

*ioc* Pointer to an adapter structure

*pCfg* Pointer to a configuration structure. Struct contains action, page address, direction, physical address and pointer to a configuration page header Page header is updated.

## Description

Returns 0 for success -EPERM if not allowed due to ISR context -EAGAIN if no msg frames currently available -EFAULT for non-successful reply or no reply (timeout)

## Name

`mpt_print_ioc_summary` — Write ASCII summary of IOC to a buffer.

## Synopsis

```
void mpt_print_ioc_summary (MPT_ADAPTER * ioc, char * buffer, int *  
size, int len, int showlan);
```

## Arguments

*ioc*        Pointer to MPT\_ADAPTER structure

*buffer*    Pointer to buffer where IOC summary info should be written

*size*       Pointer to number of bytes we wrote (set by this routine)

*len*        Offset at which to start writing in buffer

*showlan*   Display LAN stuff?

## Description

This routine writes (english readable) ASCII text, which represents a summary of IOC information, to a buffer.

## Name

`mpt_set_taskmgmt_in_progress_flag` — set flags associated with task management

## Synopsis

```
int mpt_set_taskmgmt_in_progress_flag (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

## Description

Returns 0 for SUCCESS or -1 if FAILED.

If -1 is return, then it was not possible to set the flags

## Name

`mpt_clear_taskmgmt_in_progress_flag` — clear flags associated with task management

## Synopsis

```
void mpt_clear_taskmgmt_in_progress_flag (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

## Name

`mpt_halt_firmware` — Halts the firmware if it is operational and panic the kernel

## Synopsis

```
void mpt_halt_firmware (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

## Name

`mpt_Soft_Hard_ResetHandler` — Try less expensive reset

## Synopsis

```
int mpt_Soft_Hard_ResetHandler (MPT_ADAPTER * ioc, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*sleepFlag*    Indicates if sleep or schedule must be called.

## Description

Returns 0 for SUCCESS or -1 if FAILED. Try for softreset first, only if it fails go for expensive HardReset.

## Name

`mpt_HardResetHandler` — Generic reset handler

## Synopsis

```
int mpt_HardResetHandler (MPT_ADAPTER * ioc, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*sleepFlag*    Indicates if sleep or schedule must be called.

## Description

Issues SCSI Task Management call based on input arg values. If TaskMgmt fails, returns associated SCSI request.

## Remark

`_HardResetHandler` can be invoked from an interrupt thread (timer) or a non-interrupt thread. In the former, must not call `schedule`.

## Note

A return of -1 is a FATAL error case, as it means a FW reload/initialization failed.

Returns 0 for SUCCESS or -1 if FAILED.

## Name

`mpt_get_cb_idx` — obtain `cb_idx` for registered driver

## Synopsis

```
u8 mpt_get_cb_idx (MPT_DRIVER_CLASS dclass);
```

## Arguments

*dclass* class driver enum

## Description

Returns `cb_idx`, or zero means it wasn't found

## Name

`mpt_is_discovery_complete` — determine if discovery has completed

## Synopsis

```
int mpt_is_discovery_complete (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* per adapter instance

## Description

Returns 1 when discovery completed, else zero.

## Name

`mpt_remove_dead_ioc_func` — kthread context to remove dead ioc

## Synopsis

```
int mpt_remove_dead_ioc_func (void * arg);
```

## Arguments

*arg* input argument, used to derive ioc

## Description

Return 0 if controller is removed from pci subsystem. Return -1 for other case.

## Name

`mpt_fault_reset_work` — work performed on workq after ioc fault

## Synopsis

```
void mpt_fault_reset_work (struct work_struct * work);
```

## Arguments

*work* input argument, used to derive ioc

## Name

`mpt_interrupt` — MPT adapter (IOC) specific interrupt handler.

## Synopsis

```
irqreturn_t mpt_interrupt (int irq, void * bus_id);
```

## Arguments

*irq*      irq number (not used)

*bus\_id*   bus identifier cookie == pointer to `MPT_ADAPTER` structure

## Description

This routine is registered via the `request_irq` kernel API call, and handles all interrupts generated from a specific MPT adapter (also referred to as a IO Controller or IOC). This routine must clear the interrupt from the adapter and does so by reading the reply FIFO. Multiple replies may be processed per single call to this routine.

This routine handles register-level access of the adapter but dispatches (calls) a protocol-specific callback routine to handle the protocol-specific details of the MPT request completion.

## Name

`mptbase_reply` — MPT base driver's callback routine

## Synopsis

```
int mptbase_reply (MPT_ADAPTER * ioc, MPT_FRAME_HDR * req, MPT_FRAME_HDR * reply);
```

## Arguments

*ioc*     Pointer to MPT\_ADAPTER structure

*req*     Pointer to original MPT request frame

*reply*   Pointer to MPT reply frame (NULL if TurboReply)

## Description

MPT base driver's callback routine; all base driver “internal” request/reply processing is routed here. Currently used for EventNotification and EventAck handling.

Returns 1 indicating original alloc'd request frame ptr should be freed, or 0 if it shouldn't.

## Name

`mpt_add_sge` — Place a simple 32 bit SGE at address `pAddr`.

## Synopsis

```
void mpt_add_sge (void * pAddr, u32 flagslength, dma_addr_t dma_addr);
```

## Arguments

|                    |                                    |
|--------------------|------------------------------------|
| <i>pAddr</i>       | virtual address for SGE            |
| <i>flagslength</i> | SGE flags and data transfer length |
| <i>dma_addr</i>    | Physical address                   |

## Description

This routine places a MPT request frame back on the MPT adapter's FreeQ.

## Name

`mpt_add_sge_64bit` — Place a simple 64 bit SGE at address `pAddr`.

## Synopsis

```
void mpt_add_sge_64bit (void * pAddr, u32 flagslength, dma_addr_t  
dma_addr);
```

## Arguments

|                    |                                    |
|--------------------|------------------------------------|
| <i>pAddr</i>       | virtual address for SGE            |
| <i>flagslength</i> | SGE flags and data transfer length |
| <i>dma_addr</i>    | Physical address                   |

## Description

This routine places a MPT request frame back on the MPT adapter's FreeQ.

## Name

`mpt_add_sge_64bit_1078` — Place a simple 64 bit SGE at address `pAddr` (1078 workaround).

## Synopsis

```
void mpt_add_sge_64bit_1078 (void * pAddr, u32 flagslength, dma_addr_t  
dma_addr);
```

## Arguments

|                    |                                    |
|--------------------|------------------------------------|
| <i>pAddr</i>       | virtual address for SGE            |
| <i>flagslength</i> | SGE flags and data transfer length |
| <i>dma_addr</i>    | Physical address                   |

## Description

This routine places a MPT request frame back on the MPT adapter's FreeQ.

## Name

`mpt_add_chain` — Place a 32 bit chain SGE at address `pAddr`.

## Synopsis

```
void mpt_add_chain (void * pAddr, u8 next, u16 length, dma_addr_t  
dma_addr);
```

## Arguments

|                 |                               |
|-----------------|-------------------------------|
| <i>pAddr</i>    | virtual address for SGE       |
| <i>next</i>     | nextChainOffset value (u32's) |
| <i>length</i>   | length of next SGL segment    |
| <i>dma_addr</i> | Physical address              |

## Name

`mpt_add_chain_64bit` — Place a 64 bit chain SGE at address `pAddr`.

## Synopsis

```
void mpt_add_chain_64bit (void * pAddr, u8 next, u16 length, dma_addr_t  
dma_addr);
```

## Arguments

|                 |                               |
|-----------------|-------------------------------|
| <i>pAddr</i>    | virtual address for SGE       |
| <i>next</i>     | nextChainOffset value (u32's) |
| <i>length</i>   | length of next SGL segment    |
| <i>dma_addr</i> | Physical address              |

## Name

`mpt_host_page_access_control` — control the IOC's Host Page Buffer access

## Synopsis

```
int    mpt_host_page_access_control (MPT_ADAPTER * ioc, u8
access_control_value, int sleepFlag);
```

## Arguments

*ioc* Pointer to MPT adapter structure

*access\_control\_value* define bits below

*sleepFlag* Specifies whether the process can sleep

## Description

Provides mechanism for the host driver to control the IOC's Host Page Buffer access.

|        |         |       |   |                              |    |          |             |        |
|--------|---------|-------|---|------------------------------|----|----------|-------------|--------|
| Access | Control | Value | - | bits[15:12]                  | 0h | Reserved | 1h          | En-    |
| able   | Access  | {     |   | MPI_DB_HPBACK_ENABLE_ACCESS  | }  | 2h       | Disable     | Access |
|        |         | {     |   | MPI_DB_HPBACK_DISABLE_ACCESS | }  | 3h       | Free Buffer | {      |
|        |         |       |   | MPI_DB_HPBACK_FREE_BUFFER    | }  |          |             | }      |

Returns 0 for success, non-zero for failure.

## Name

`mpt_host_page_alloc` — allocate system memory for the fw

## Synopsis

```
int mpt_host_page_alloc (MPT_ADAPTER * ioc, pIOCInit_t ioc_init);
```

## Arguments

*ioc*            Pointer to pointer to IOC adapter

*ioc\_init*      Pointer to ioc init config page

## Description

If we already allocated memory in past, then resend the same pointer. Returns 0 for success, non-zero for failure.

## Name

`mpt_get_product_name` — returns product string

## Synopsis

```
const char* mpt_get_product_name (u16 vendor, u16 device, u8 revision);
```

## Arguments

*vendor*    pci vendor id  
*device*    pci device id  
*revision*  pci revision id

## Description

Returns product string displayed when driver loads, in `/proc/mpt/summary` and `/sysfs/class/scsi_host/host<X>/version_product`

## Name

`mpt_mapresources` — map in memory mapped io

## Synopsis

```
int mpt_mapresources (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to pointer to IOC adapter

## Name

`mpt_do_ioc_recovery` — Initialize or recover MPT adapter.

## Synopsis

```
int mpt_do_ioc_recovery (MPT_ADAPTER * ioc, u32 reason, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT adapter structure

*reason*        Event word / reason

*sleepFlag*    Use schedule if CAN\_SLEEP else use udelay.

## Description

This routine performs all the steps necessary to bring the IOC to a OPERATIONAL state.

This routine also pre-fetches the LAN MAC address of a Fibre Channel MPT adapter.

## Returns

0 for success -1 if failed to get board READY -2 if READY but IOCFacts Failed -3 if READY but PrimeIOCFifos Failed -4 if READY but IOCInit Failed -5 if failed to enable\_device and/or request\_selected\_regions -6 if failed to upload firmware

## Name

`mpt_detect_bound_ports` — Search for matching PCI bus/dev\_function

## Synopsis

```
void mpt_detect_bound_ports (MPT_ADAPTER * ioc, struct pci_dev * pdev);
```

## Arguments

*ioc* Pointer to MPT adapter structure

*pdev* Pointer to (struct pci\_dev) structure

## Description

Search for PCI bus/dev\_function which matches PCI bus/dev\_function (+/-1) for newly discovered 929, 929X, 1030 or 1035.

If match on PCI dev\_function +/-1 is found, bind the two MPT adapters using alt\_ioc pointer fields in their MPT\_ADAPTER structures.

## Name

`mpt_adapter_disable` — Disable misbehaving MPT adapter.

## Synopsis

```
void mpt_adapter_disable (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT adapter structure

## Name

`mpt_adapter_dispose` — Free all resources associated with an MPT adapter

## Synopsis

```
void mpt_adapter_dispose (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT adapter structure

## Description

This routine unregisters h/w resources and frees all alloc'd memory associated with a MPT adapter structure.

## Name

MptDisplayIocCapabilities — Display IOC's capabilities.

## Synopsis

```
void MptDisplayIocCapabilities (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT adapter structure

## Name

MakeIocReady — Get IOC to a READY state, using KickStart if needed.

## Synopsis

```
int MakeIocReady (MPT_ADAPTER * ioc, int force, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*force*         Force hard KickStart of IOC

*sleepFlag*     Specifies whether the process can sleep

## Returns

1 - DIAG reset and READY 0 - READY initially OR soft reset and READY -1 - Any failure on KickStart  
-2 - Msg Unit Reset Failed -3 - IO Unit Reset Failed -4 - IOC owned by a PEER

## Name

`GetIocFacts` — Send IOCFacts request to MPT adapter.

## Synopsis

```
int GetIocFacts (MPT_ADAPTER * ioc, int sleepFlag, int reason);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*sleepFlag*    Specifies whether the process can sleep

*reason*        If recovery, only update facts.

## Description

Returns 0 for success, non-zero for failure.

## Name

GetPortFacts — Send PortFacts request to MPT adapter.

## Synopsis

```
int GetPortFacts (MPT_ADAPTER * ioc, int portnum, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*portnum*       Port number

*sleepFlag*     Specifies whether the process can sleep

## Description

Returns 0 for success, non-zero for failure.

## Name

SendIocInit — Send IOcInit request to MPT adapter.

## Synopsis

```
int SendIocInit (MPT_ADAPTER * ioc, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure  
*sleepFlag*    Specifies whether the process can sleep

## Description

Send IOcInit followed by PortEnable to bring IOC to OPERATIONAL state.

Returns 0 for success, non-zero for failure.

## Name

SendPortEnable — Send PortEnable request to MPT adapter port.

## Synopsis

```
int SendPortEnable (MPT_ADAPTER * ioc, int portnum, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*portnum*      Port number to enable

*sleepFlag*    Specifies whether the process can sleep

## Description

Send PortEnable to bring IOC to OPERATIONAL state.

Returns 0 for success, non-zero for failure.

## Name

`mpt_do_upload` — Construct and Send FWUpload request to MPT adapter port.

## Synopsis

```
int mpt_do_upload (MPT_ADAPTER * ioc, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*sleepFlag*    Specifies whether the process can sleep

## Description

Returns 0 for success, >0 for handshake failure <0 for fw upload failure.

## Remark

If bound IOC and a successful FWUpload was performed on the bound IOC, the second image is discarded and memory is free'd. Both channels must upload to prevent IOC from running in degraded mode.

## Name

`mpt_downloadboot` — DownloadBoot code

## Synopsis

```
int mpt_downloadboot (MPT_ADAPTER * ioc, MpiFwHeader_t * pFwHeader, int
sleepFlag);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

*pFwHeader* Pointer to firmware header info

*sleepFlag* Specifies whether the process can sleep

## Description

FwDownloadBoot requires Programmed IO access.

Returns 0 for success -1 FW Image size is 0 -2 No valid cached\_fw Pointer <0 for fw upload failure.

## Name

KickStart — Perform hard reset of MPT adapter.

## Synopsis

```
int KickStart (MPT_ADAPTER * ioc, int force, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*force*         Force hard reset

*sleepFlag*    Specifies whether the process can sleep

## Description

This routine places MPT adapter in diagnostic mode via the WriteSequence register, and then performs a hard reset of adapter via the Diagnostic register.

## Inputs

sleepflag - CAN\_SLEEP (non-interrupt thread) or NO\_SLEEP (interrupt thread, use mdelay) force - 1 if doorbell active, board fault state board operational, IOC\_RECOVERY or IOC\_BRINGUP and there is an alt\_ioc. 0 else

## Returns

1 - hard reset, READY 0 - no reset due to History bit, READY -1 - no reset due to History bit but not READY OR reset but failed to come READY -2 - no reset, could not enter DIAG mode -3 - reset but bad FW bit

## Name

`mpt_diag_reset` — Perform hard reset of the adapter.

## Synopsis

```
int mpt_diag_reset (MPT_ADAPTER * ioc, int ignore, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*ignore*        Set if to honor and clear to ignore the reset history bit

*sleepFlag*    CAN\_SLEEP if called in a non-interrupt thread, else set to NO\_SLEEP (use mdelay instead)

## Description

This routine places the adapter in diagnostic mode via the WriteSequence register and then performs a hard reset of adapter via the Diagnostic register. Adapter should be in ready state upon successful completion.

## Returns

1 hard reset successful 0 no reset performed because reset history bit set -2 enabling diagnostic mode failed -3 diagnostic reset failed

## Name

SendIocReset — Send IOCRreset request to MPT adapter.

## Synopsis

```
int SendIocReset (MPT_ADAPTER * ioc, u8 reset_type, int sleepFlag);
```

## Arguments

|                   |   |
|-------------------|---|
| <i>ioc</i>        | Pointer to MPT_ADAPTER structure  |
| <i>reset_type</i> | reset type, expected values are MPI_FUNCTION_IOC_MESSAGE_UNIT_RESET or MPI_FUNCTION_IO_UNIT_RESET |
| <i>sleepFlag</i>  | Specifies whether the process can sleep   |

## Description

Send IOCRreset request to the MPT adapter.

Returns 0 for success, non-zero for failure.

## Name

`initChainBuffers` — Allocate memory for and initialize chain buffers

## Synopsis

```
int initChainBuffers (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

## Description

Allocates memory for and initializes chain buffers, chain buffer control arrays and spinlock.

## Name

PrimeIocFifos — Initialize IOC request and reply FIFOs.

## Synopsis

```
int PrimeIocFifos (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

## Description

This routine allocates memory for the MPT reply and request frame pools (if necessary), and primes the IOC reply FIFO with reply frames.

Returns 0 for success, non-zero for failure.

## Name

`mpt_handshake_req_reply_wait` — Send MPT request to and receive reply from IOC via doorbell handshake method.

## Synopsis

```
int mpt_handshake_req_reply_wait (MPT_ADAPTER * ioc, int reqBytes, u32 * req, int replyBytes, u16 * u16reply, int maxwait, int sleepFlag);
```

## Arguments

|                   |   |
|-------------------|---|
| <i>ioc</i>        | Pointer to MPT_ADAPTER structure              |
| <i>reqBytes</i>   | Size of the request in bytes                  |
| <i>req</i>        | Pointer to MPT request frame                  |
| <i>replyBytes</i> | Expected size of the reply in bytes           |
| <i>u16reply</i>   | Pointer to area where reply should be written |
| <i>maxwait</i>    | Max wait time for a reply (in seconds)        |
| <i>sleepFlag</i>  | Specifies whether the process can sleep       |

## NOTES

It is the callers responsibility to byte-swap fields in the request which are greater than 1 byte in size. It is also the callers responsibility to byte-swap response fields which are greater than 1 byte in size.

Returns 0 for success, non-zero for failure.

## Name

WaitForDoorbellAck — Wait for IOC doorbell handshake acknowledge

## Synopsis

```
int WaitForDoorbellAck (MPT_ADAPTER * ioc, int howlong, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*howlong*       How long to wait (in seconds)

*sleepFlag*     Specifies whether the process can sleep

## Description

This routine waits (up to ~2 seconds max) for IOC doorbell handshake ACKnowledge, indicated by the IOP\_DOORBELL\_STATUS bit in its IntStatus register being clear.

Returns a negative value on failure, else wait loop count.

## Name

WaitForDoorbellInt — Wait for IOC to set its doorbell interrupt bit

## Synopsis

```
int WaitForDoorbellInt (MPT_ADAPTER * ioc, int howlong, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*howlong*       How long to wait (in seconds)

*sleepFlag*     Specifies whether the process can sleep

## Description

This routine waits (up to ~2 seconds max) for IOC doorbell interrupt (MPI\_HIS\_DOORBELL\_INTERRUPT) to be set in the IntStatus register.

Returns a negative value on failure, else wait loop count.

## Name

WaitForDoorbellReply — Wait for and capture an IOC handshake reply.

## Synopsis

```
int WaitForDoorbellReply (MPT_ADAPTER * ioc, int howlong, int sleep-  
Flag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*howlong*       How long to wait (in seconds)

*sleepFlag*     Specifies whether the process can sleep

## Description

This routine polls the IOC for a handshake reply, 16 bits at a time. Reply is cached to IOC private area large enough to hold a maximum of 128 bytes of reply data.

Returns a negative value on failure, else size of reply in WORDS.

## Name

GetLanConfigPages — Fetch LANConfig pages.

## Synopsis

```
int GetLanConfigPages (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

## Return

0 for success -ENOMEM if no memory available -EPERM if not allowed due to ISR context -EAGAIN if no msg frames currently available -EFAULT for non-successful reply or no reply (timeout)

## Name

GetIoUnitPage2 — Retrieve BIOS version and boot order information.

## Synopsis

```
int GetIoUnitPage2 (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

## Returns

0 for success -ENOMEM if no memory available -EPERM if not allowed due to ISR context -EAGAIN if no msg frames currently available -EFAULT for non-successful reply or no reply (timeout)

## Name

`mpt_GetScsiPortSettings` — read SCSI Port Page 0 and 2

## Synopsis

```
int mpt_GetScsiPortSettings (MPT_ADAPTER * ioc, int portnum);
```

## Arguments

*ioc*        Pointer to a Adapter Structre

*portnum*    IOC port number

## Return

-EFAULT if read of config page header fails or if no nvrn If read of SCSI Port Page 0 fails, NVRAM = MPT\_HOST\_NVRAM\_INVALID (0xFFFFFFFF)

## Adapter settings

async, narrow Return 1 If read of SCSI Port Page 2 fails, Adapter settings valid NVRAM = MPT\_HOST\_NVRAM\_INVALID (0xFFFFFFFF) Return 1 Else Both valid Return 0 CHECK - what type of locking mechanisms should be used????

## Name

`mpt_readScsiDevicePageHeaders` — save version and length of SDP1

## Synopsis

```
int mpt_readScsiDevicePageHeaders (MPT_ADAPTER * ioc, int portnum);
```

## Arguments

*ioc*        Pointer to a Adapter Structre

*portnum*   IOC port number

## Return

-EFAULT if read of config page header fails or 0 if success.

## Name

`mpt_inactive_raid_list_free` — This clears this link list.

## Synopsis

```
void mpt_inactive_raid_list_free (MPT_ADAPTER * ioc);
```

## Arguments

*ioc* pointer to per adapter structure

## Name

`mpt_inactive_raid_volumes` — sets up link list of `phy_disk_nums` for devices belonging in an inactive volume

## Synopsis

```
void mpt_inactive_raid_volumes (MPT_ADAPTER * ioc, u8 channel, u8 id);
```

## Arguments

*ioc* pointer to per adapter structure

*channel* volume channel

*id* volume target id

## Name

SendEventNotification — Send EventNotification (on or off) request to adapter

## Synopsis

```
int SendEventNotification (MPT_ADAPTER * ioc, u8 EvSwitch, int sleep-Flag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*EvSwitch*     Event switch flags

*sleepFlag*    Specifies whether the process can sleep

## Name

SendEventAck — Send EventAck request to MPT adapter.

## Synopsis

```
int SendEventAck (MPT_ADAPTER * ioc, EventNotificationReply_t * evnp);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

*evnp* Pointer to original EventNotification request

## Name

`mpt_ioc_reset` — Base cleanup for hard reset

## Synopsis

```
int mpt_ioc_reset (MPT_ADAPTER * ioc, int reset_phase);
```

## Arguments

*ioc*                    Pointer to the adapter structure

*reset\_phase*        Indicates pre- or post-reset functionality

## Remark

Frees resources with internally generated commands.

## Name

`procmt_create` — Create MPT\_PROCFS\_MPTBASEDIR entries.

## Synopsis

```
int procmt_create ( void );
```

## Arguments

*void* no arguments

## Description

Returns 0 for success, non-zero for failure.

## Name

`procmt_destroy` — Tear down `MPT_PROCFS_MPTBASEDIR` entries.

## Synopsis

```
void procmt_destroy ( void );
```

## Arguments

*void* no arguments

## Description

Returns 0 for success, non-zero for failure.

## Name

`mpt_SoftResetHandler` — Issues a less expensive reset

## Synopsis

```
int mpt_SoftResetHandler (MPT_ADAPTER * ioc, int sleepFlag);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*sleepFlag*    Indicates if sleep or schedule must be called.

## Description

Returns 0 for SUCCESS or -1 if FAILED.

Message Unit Reset - instructs the IOC to reset the Reply Post and Free FIFO's. All the Message Frames on Reply Free FIFO are discarded. All posted buffers are freed, and event notification is turned off. IOC doesn't reply to any outstanding request. This will transfer IOC to READY state.

## Name

ProcessEventNotification — Route EventNotificationReply to all event handlers

## Synopsis

```
int      ProcessEventNotification      (MPT_ADAPTER      *      ioc,
EventNotificationReply_t * pEventReply, int * evHandlers);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*pEventReply*   Pointer to EventNotification reply frame

*evHandlers*   Pointer to integer, number of event handlers

## Description

Routes a received EventNotificationReply to all currently registered event handlers. Returns sum of event handlers return values.

## Name

`mpt_fc_log_info` — Log information returned from Fibre Channel IOC.

## Synopsis

```
void mpt_fc_log_info (MPT_ADAPTER * ioc, u32 log_info);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure  
*log\_info*      U32 LogInfo reply word from the IOC

## Description

Refer to `lsi/mpi_log_fc.h`.

## Name

`mpt_spi_log_info` — Log information returned from SCSI Parallel IOC.

## Synopsis

```
void mpt_spi_log_info (MPT_ADAPTER * ioc, u32 log_info);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*log\_info*      U32 LogInfo word from the IOC

## Description

Refer to `lsi/sp_log.h`.

## Name

`mpt_sas_log_info` — Log information returned from SAS IOC.

## Synopsis

```
void mpt_sas_log_info (MPT_ADAPTER * ioc, u32 log_info, u8 cb_idx);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*log\_info*      U32 LogInfo reply word from the IOC

*cb\_idx*        callback function's handle

## Description

Refer to `lsi/mpi_log_sas.h`.

## Name

`mpt_iocstatus_info_config` — IOCSTATUS information for config pages

## Synopsis

```
void mpt_iocstatus_info_config (MPT_ADAPTER * ioc, u32 ioc_status,  
MPT_FRAME_HDR * mf);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*ioc\_status*   U32 IOCStatus word from IOC

*mf*            Pointer to MPT request frame

## Description

Refer to `lsi/mpi.h`.

## Name

`mpt_iocstatus_info` — IOCSTATUS information returned from IOC.

## Synopsis

```
void mpt_iocstatus_info (MPT_ADAPTER * ioc, u32 ioc_status,  
MPT_FRAME_HDR * mf);
```

## Arguments

*ioc*            Pointer to MPT\_ADAPTER structure

*ioc\_status*   U32 IOCStatus word from IOC

*mf*            Pointer to MPT request frame

## Description

Refer to `lsi/mpi.h`.

## Name

`fusion_init` — Fusion MPT base driver initialization routine.

## Synopsis

```
int fusion_init ( void );
```

## Arguments

*void* no arguments

## Description

Returns 0 for success, non-zero for failure.

## Name

`fusion_exit` — Perform driver unload cleanup.

## Synopsis

```
void __exit fusion_exit ( void );
```

## Arguments

*void* no arguments

## Description

This routine frees all resources associated with each MPT adapter and removes all `MPT_PROCFS_MPTBASEDIR` entries.

## Name

`mptscsih_info` — Return information about MPT adapter

## Synopsis

```
const char * mptscsih_info (struct Scsi_Host * SHost);
```

## Arguments

*SHost* Pointer to Scsi\_Host structure

## Description

(linux `scsi_host_template.info` routine)

Returns pointer to buffer where information was written.

## Name

`mptscsih_qcmd` — Primary Fusion MPT SCSI initiator IO start routine.

## Synopsis

```
int mptscsih_qcmd (struct scsi_cmnd * SCpnt);
```

## Arguments

*SCpnt* Pointer to `scsi_cmnd` structure

## Description

(linux `scsi_host_template.queuecommand` routine) This is the primary SCSI IO start routine. Create a MPI `SCSIIORequest` from a linux `scsi_cmnd` request and send it to the IOC.

Returns 0. (rtn value discarded by linux scsi mid-layer)

## Name

`mptscsih_IssueTaskMgmt` — Generic send Task Management function.

## Synopsis

```
int mptscsih_IssueTaskMgmt (MPT_SCSI_HOST * hd, u8 type, u8 channel, u8
id, u64 lun, int ctx2abort, ulong timeout);
```

## Arguments

|                  |   |
|------------------|---|
| <i>hd</i>        | Pointer to MPT_SCSI_HOST structure                  |
| <i>type</i>      | Task Management type                                |
| <i>channel</i>   | channel number for task management                  |
| <i>id</i>        | Logical Target ID for reset (if appropriate)        |
| <i>lun</i>       | Logical Unit for reset (if appropriate)             |
| <i>ctx2abort</i> | Context for the task to be aborted (if appropriate) |
| <i>timeout</i>   | timeout for task management control                 |

## Remark

`_HardResetHandler` can be invoked from an interrupt thread (timer) or a non-interrupt thread. In the former, must not call `schedule`.

Not all fields are meaningful for all task types.

Returns 0 for SUCCESS, or FAILED.

## Name

mptscsih\_abort — Abort linux scsi\_cmnd routine, new\_eh variant

## Synopsis

```
int mptscsih_abort (struct scsi_cmnd * SCpnt);
```

## Arguments

*SCpnt* Pointer to scsi\_cmnd structure, IO to be aborted

## Description

(linux scsi\_host\_template.eh\_abort\_handler routine)

Returns SUCCESS or FAILED.

## Name

`mptscsih_dev_reset` — Perform a SCSI TARGET\_RESET! new\_eh variant

## Synopsis

```
int mptscsih_dev_reset (struct scsi_cmnd * SCpnt);
```

## Arguments

*SCpnt* Pointer to `scsi_cmnd` structure, IO which reset is due to

## Description

(linux `scsi_host_template.eh_dev_reset_handler` routine)

Returns SUCCESS or FAILED.

## Name

`mptscsih_bus_reset` — Perform a SCSI BUS\_RESET! new\_eh variant

## Synopsis

```
int mptscsih_bus_reset (struct scsi_cmnd * SCpnt);
```

## Arguments

*SCpnt* Pointer to `scsi_cmnd` structure, IO which reset is due to

## Description

(linux `scsi_host_template.eh_bus_reset_handler` routine)

Returns SUCCESS or FAILED.

## Name

`mptscsih_host_reset` — Perform a SCSI host adapter RESET (new\_eh variant)

## Synopsis

```
int mptscsih_host_reset (struct scsi_cmnd * SCpnt);
```

## Arguments

*SCpnt* Pointer to `scsi_cmnd` structure, IO which reset is due to

## Description

(linux `scsi_host_template.eh_host_reset_handler` routine)

Returns SUCCESS or FAILED.

## Name

`mptscsih_taskmgmt_complete` — Registered with Fusion MPT base driver

## Synopsis

```
int mptscsih_taskmgmt_complete (MPT_ADAPTER * ioc, MPT_FRAME_HDR * mf,  
MPT_FRAME_HDR * mr);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

*mf* Pointer to SCSI task mgmt request frame

*mr* Pointer to SCSI task mgmt reply frame

## Description

This routine is called from `mptbase.c::mpt_interrupt` at the completion of any SCSI task management request. This routine is registered with the MPT (base) driver at driver load/init time via the `mpt_register` API call.

Returns 1 indicating alloc'd request frame ptr should be freed.

## Name

`mptscsih_get_scsi_lookup` — retrieves scmd entry

## Synopsis

```
struct scsi_cmd * mptscsih_get_scsi_lookup (MPT_ADAPTER * ioc, int i);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

*i* index into the array

## Description

Returns the `scsi_cmd` pointer

## Name

`mptscsih_info_scsiio` — debug print info on reply frame

## Synopsis

```
void mptscsih_info_scsiio (MPT_ADAPTER * ioc, struct scsi_cmnd * sc,  
SCSIIOReply_t * pScsiReply);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

*sc* original scsi cmnd pointer

*pScsiReply* Pointer to MPT reply frame

## Description

MPT\_DEBUG\_REPLY needs to be enabled to obtain this info

Refer to lsi/mpi.h.

## Name

`mptscsih_getclear_scsi_lookup` — retrieves and clears `scmd` entry from `ScsiLookup[]` array list

## Synopsis

```
struct scsi_cmd * mptscsih_getclear_scsi_lookup (MPT_ADAPTER * ioc,  
int i);
```

## Arguments

*ioc* Pointer to `MPT_ADAPTER` structure

*i* index into the array

## Description

Returns the `scsi_cmd` pointer

## Name

`mptscsih_set_scsi_lookup` — write a `scmd` entry into the `ScsiLookup[]` array list

## Synopsis

```
void mptscsih_set_scsi_lookup (MPT_ADAPTER * ioc, int i, struct
scsi_cmnd * scmd);
```

## Arguments

*ioc* Pointer to `MPT_ADAPTER` structure

*i* index into the array

*scmd* `scsi_cmnd` pointer

## Name

SCPNT\_TO\_LOOKUP\_IDX — searches for a given scmd in the ScsiLookup[] array list

## Synopsis

```
int SCPNT_TO_LOOKUP_IDX (MPT_ADAPTER * ioc, struct scsi_cmnd * sc);
```

## Arguments

*ioc* Pointer to MPT\_ADAPTER structure

*sc* scsi\_cmnd pointer

## Name

`mptscsih_get_completion_code` — get completion code from MPT request

## Synopsis

```
int mptscsih_get_completion_code (MPT_ADAPTER * ioc, MPT_FRAME_HDR *  
req, MPT_FRAME_HDR * reply);
```

## Arguments

*ioc*     Pointer to MPT\_ADAPTER structure

*req*     Pointer to original MPT request frame

*reply*   Pointer to MPT reply frame (NULL if TurboReply)

## Name

`mptscsih_do_cmd` — Do internal command.

## Synopsis

```
int mptscsih_do_cmd (MPT SCSI_HOST * hd, INTERNAL_CMD * io);
```

## Arguments

*hd* MPT SCSI\_HOST pointer

*io* INTERNAL\_CMD pointer.

## Description

Issue the specified internally generated command and do command specific cleanup. For bus scan / DV only.

## NOTES

If command is Inquiry and status is good, initialize a target structure, save the data

## Remark

Single threaded access only.

## Return

< 0 if an illegal command or no resources

0 if good

> 0 if command complete but some type of completion error.

## Name

`mptscsih_synchronize_cache` — Send SYNCHRONIZE\_CACHE to all disks.

## Synopsis

```
void mptscsih_synchronize_cache (MPT SCSI_HOST * hd, VirtDevice * vdevice);
```

## Arguments

*hd*            Pointer to a SCSI HOST structure

*vdevice*      virtual target device

## Description

Uses the ISR, but with special processing. MUST be single-threaded.

## Name

`mptctl_syscall_down` — Down the MPT adapter syscall semaphore.

## Synopsis

```
int mptctl_syscall_down (MPT_ADAPTER * ioc, int nonblock);
```

## Arguments

*ioc*            Pointer to MPT adapter

*nonblock*    boolean, non-zero if O\_NONBLOCK is set

## Description

All of the `ioctl` commands can potentially sleep, which is illegal with a spinlock held, thus we perform mutual exclusion here.

Returns negative `errno` on error, or zero for success.

## Name

`mptspi_setTargetNegoParms` — Update the target negotiation parameters

## Synopsis

```
void mptspi_setTargetNegoParms (MPT_SCSI_HOST * hd, VirtTarget * target,  
struct scsi_device * sdev);
```

## Arguments

*hd*        Pointer to a SCSI Host Structure

*target*    per target private data

*sdev*      SCSI device

## Description

Update the target negotiation parameters based on the the Inquiry data, adapter capabilities, and NVRAM settings.

## Name

mptspi\_writeIOCPage4 — write IOC Page 4

## Synopsis

```
int mptspi_writeIOCPage4 (MPT_SCSI_HOST * hd, u8 channel, u8 id);
```

## Arguments

*hd*            Pointer to a SCSI Host Structure

*channel*      channel number

*id*            write IOC Page4 for this ID & Bus

## Return

-EAGAIN if unable to obtain a Message Frame or 0 if success.

## Remark

We do not wait for a return, write pages sequentially.

## Name

`mptspi_initTarget` — Target, LUN alloc/free functionality.

## Synopsis

```
void mptspi_initTarget (MPT SCSI_HOST * hd, VirtTarget * vtarget, struct  
scsi_device * sdev);
```

## Arguments

*hd*            Pointer to MPT SCSI\_HOST structure

*vtarget*      per target private data

*sdev*         SCSI device

## NOTE

It's only SAFE to call this routine if data points to sane & valid STANDARD INQUIRY data!

Allocate and initialize memory for this target. Save inquiry data.

## Name

`mptspi_is_raid` — Determines whether target is belonging to volume

## Synopsis

```
int mptspi_is_raid (struct _MPT_SCSI_HOST * hd, u32 id);
```

## Arguments

*hd* Pointer to a SCSI HOST structure

*id* target device id

## Return

non-zero = true zero = false

## Name

`mptspi_print_write_nego` — negotiation parameters debug info that is being sent

## Synopsis

```
void mptspi_print_write_nego (struct _MPT_SCSI_HOST * hd, struct  
scsi_target * starget, u32 ii);
```

## Arguments

*hd* Pointer to a SCSI HOST structure

*starget* SCSI target

*ii* negotiation parameters

## Name

`mptspi_print_read_nego` — negotiation parameters debug info that is being read

## Synopsis

```
void mptspi_print_read_nego (struct _MPT_SCSI_HOST * hd, struct  
scsi_target * starget, u32 ii);
```

## Arguments

*hd* Pointer to a SCSI HOST structure

*starget* SCSI target

*ii* negotiation parameters

## Name

`mptspi_init` — Register MPT adapter(s) as SCSI host(s) with SCSI mid-layer.

## Synopsis

```
int mptspi_init ( void );
```

## Arguments

*void* no arguments

## Description

Returns 0 for success, non-zero for failure.

## Name

mptspi\_exit — Unregisters MPT adapter(s)

## Synopsis

```
void __exit mptspi_exit ( void );
```

## Arguments

*void* no arguments

## Name

`mptfc_init` — Register MPT adapter(s) as SCSI host(s) with SCSI mid-layer.

## Synopsis

```
int mptfc_init ( void );
```

## Arguments

*void* no arguments

## Description

Returns 0 for success, non-zero for failure.

## Name

`mptfc_remove` — Remove fc infrastructure for devices

## Synopsis

```
void mptfc_remove (struct pci_dev * pdev);
```

## Arguments

*pdev* Pointer to `pci_dev` structure

## Name

`mptfc_exit` — Unregisters MPT adapter(s)

## Synopsis

```
void __exit mptfc_exit ( void );
```

## Arguments

*void* no arguments

## Name

`lan_reply` — Handle all data sent from the hardware.

## Synopsis

```
int lan_reply (MPT_ADAPTER * ioc, MPT_FRAME_HDR * mf, MPT_FRAME_HDR *  
reply);
```

## Arguments

*ioc*     Pointer to MPT\_ADAPTER structure

*mf*     Pointer to original MPT request frame (NULL if TurboReply)

*reply*   Pointer to MPT reply frame

## Description

Returns 1 indicating original alloc'd request frame ptr should be freed, or 0 if it shouldn't.

---

# Chapter 5. Sound Devices

## Name

`snd_printk` — printk wrapper

## Synopsis

```
snd_printk ( fmt, args... );
```

## Arguments

*fmt*        format string

*args...*   variable arguments

## Description

Works like `printk` but prints the file and the line of the caller when configured with `CONFIG_SND_VERBOSE_PRINTK`.

## Name

`snd_printd` — debug printk

## Synopsis

```
snd_printd ( fmt, args... );
```

## Arguments

*fmt*        format string

*args...*   variable arguments

## Description

Works like `snd_printk` for debugging purposes. Ignored when `CONFIG_SND_DEBUG` is not set.

## Name

`snd_DEBUG` — give a BUG warning message and stack trace

## Synopsis

```
snd_DEBUG (void);
```

## Arguments

None

## Description

Calls `WARN` if `CONFIG_SND_DEBUG` is set. Ignored when `CONFIG_SND_DEBUG` is not set.

## Name

`snd_printd_ratelimit` —

## Synopsis

```
snd_printd_ratelimit (void);
```

## Arguments

None

## Name

`snd_BUG_ON` — debugging check macro

## Synopsis

```
snd_BUG_ON ( cond );
```

## Arguments

*cond* condition to evaluate

## Description

Has the same behavior as `WARN_ON` when `CONFIG_SND_DEBUG` is set, otherwise just evaluates the conditional and returns the value.

## Name

`snd_printdd` — debug printk

## Synopsis

```
snd_printdd ( format, args... );
```

## Arguments

*format*    format string

*args...*   variable arguments

## Description

Works like `snd_printk` for debugging purposes. Ignored when `CONFIG_SND_DEBUG_VERBOSE` is not set.

## Name

`register_sound_special_device` — register a special sound node

## Synopsis

```
int register_sound_special_device (const struct file_operations * fops,
int unit, struct device * dev);
```

## Arguments

*fops* File operations for the driver

*unit* Unit number to allocate

*dev* device pointer

## Description

Allocate a special sound device by minor number from the sound subsystem.

## Return

The allocated number is returned on success. On failure, a negative error code is returned.

## Name

`register_sound_mixer` — register a mixer device

## Synopsis

```
int register_sound_mixer (const struct file_operations * fops, int dev);
```

## Arguments

*fops* File operations for the driver

*dev* Unit number to allocate

## Description

Allocate a mixer device. Unit is the number of the mixer requested. Pass -1 to request the next free mixer unit.

## Return

On success, the allocated number is returned. On failure, a negative error code is returned.

## Name

`register_sound_midi` — register a midi device

## Synopsis

```
int register_sound_midi (const struct file_operations * fops, int dev);
```

## Arguments

*fops* File operations for the driver

*dev* Unit number to allocate

## Description

Allocate a midi device. Unit is the number of the midi device requested. Pass -1 to request the next free midi unit.

## Return

On success, the allocated number is returned. On failure, a negative error code is returned.

## Name

`register_sound_dsp` — register a DSP device

## Synopsis

```
int register_sound_dsp (const struct file_operations * fops, int dev);
```

## Arguments

*fops* File operations for the driver

*dev* Unit number to allocate

## Description

Allocate a DSP device. Unit is the number of the DSP requested. Pass -1 to request the next free DSP unit.

This function allocates both the audio and dsp device entries together and will always allocate them as a matching pair - eg dsp3/audio3

## Return

On success, the allocated number is returned. On failure, a negative error code is returned.

## Name

`unregister_sound_special` — unregister a special sound device

## Synopsis

```
void unregister_sound_special (int unit);
```

## Arguments

*unit* unit number to allocate

## Description

Release a sound device that was allocated with `register_sound_special`. The unit passed is the return value from the register function.

## Name

`unregister_sound_mixer` — unregister a mixer

## Synopsis

```
void unregister_sound_mixer (int unit);
```

## Arguments

*unit* unit number to allocate

## Description

Release a sound device that was allocated with `register_sound_mixer`. The unit passed is the return value from the register function.

## Name

`unregister_sound_midi` — unregister a midi device

## Synopsis

```
void unregister_sound_midi (int unit);
```

## Arguments

*unit* unit number to allocate

## Description

Release a sound device that was allocated with `register_sound_midi`. The unit passed is the return value from the register function.

## Name

`unregister_sound_dsp` — unregister a DSP device

## Synopsis

```
void unregister_sound_dsp (int unit);
```

## Arguments

*unit* unit number to allocate

## Description

Release a sound device that was allocated with `register_sound_dsp`. The unit passed is the return value from the register function.

Both of the allocated units are released together automatically.

## Name

`snd_pcm_stream_linked` — Check whether the substream is linked with others

## Synopsis

```
int snd_pcm_stream_linked (struct snd_pcm_substream * substream);
```

## Arguments

*substream* substream to check

## Description

Returns true if the given substream is being linked with others.

## Name

`snd_pcm_stream_lock_irqsave` — Lock the PCM stream

## Synopsis

```
snd_pcm_stream_lock_irqsave ( substream, flags );
```

## Arguments

*substream* PCM substream

*flags* irq flags

## Description

This locks the PCM stream like `snd_pcm_stream_lock` but with the local IRQ (only when `nonatomic` is false). In nonatomic case, this is identical as `snd_pcm_stream_lock`.

## Name

`snd_pcm_group_for_each_entry` — iterate over the linked substreams

## Synopsis

```
snd_pcm_group_for_each_entry ( s, substream );
```

## Arguments

*s*            the iterator

*substream*   the substream

## Description

Iterate over the all linked substreams to the given *substream*. When *substream* isn't linked with any others, this gives returns *substream* itself once.

## Name

`snd_pcm_running` — Check whether the substream is in a running state

## Synopsis

```
int snd_pcm_running (struct snd_pcm_substream * substream);
```

## Arguments

*substream* substream to check

## Description

Returns true if the given substream is in the state `RUNNING`, or in the state `DRAINING` for playback.

## Name

`bytes_to_samples` — Unit conversion of the size from bytes to samples

## Synopsis

```
ssize_t bytes_to_samples (struct snd_pcm_runtime * runtime, ssize_t
size);
```

## Arguments

*runtime* PCM runtime instance

*size* size in bytes

## Name

`bytes_to_frames` — Unit conversion of the size from bytes to frames

## Synopsis

```
snd_pcm_sframes_t bytes_to_frames (struct snd_pcm_runtime * runtime,  
ssize_t size);
```

## Arguments

*runtime* PCM runtime instance

*size* size in bytes

## Name

`samples_to_bytes` — Unit conversion of the size from samples to bytes

## Synopsis

```
ssize_t samples_to_bytes (struct snd_pcm_runtime * runtime, ssize_t  
size);
```

## Arguments

*runtime* PCM runtime instance

*size* size in samples

## Name

`frames_to_bytes` — Unit conversion of the size from frames to bytes

## Synopsis

```
ssize_t frames_to_bytes (struct snd_pcm_runtime * runtime,  
snd_pcm_sframes_t size);
```

## Arguments

*runtime* PCM runtime instance

*size* size in frames

## Name

`frame_aligned` — Check whether the byte size is aligned to frames

## Synopsis

```
int frame_aligned (struct snd_pcm_runtime * runtime, ssize_t bytes);
```

## Arguments

*runtime* PCM runtime instance

*bytes* size in bytes

## Name

`snd_pcm_lib_buffer_bytes` — Get the buffer size of the current PCM in bytes

## Synopsis

```
size_t snd_pcm_lib_buffer_bytes (struct snd_pcm_substream * substream);
```

## Arguments

*substream* PCM substream

## Name

`snd_pcm_lib_period_bytes` — Get the period size of the current PCM in bytes

## Synopsis

```
size_t snd_pcm_lib_period_bytes (struct snd_pcm_substream * substream);
```

## Arguments

*substream* PCM substream

## Name

`snd_pcm_playback_avail` — Get the available (writable) space for playback

## Synopsis

```
snd_pcm_uframes_t snd_pcm_playback_avail (struct snd_pcm_runtime * runtime);
```

## Arguments

*runtime* PCM runtime instance

## Description

Result is between 0 ... (boundary - 1)

## Name

`snd_pcm_capture_avail` — Get the available (readable) space for capture

## Synopsis

```
snd_pcm_uframes_t snd_pcm_capture_avail (struct snd_pcm_runtime * runtime);
```

## Arguments

*runtime* PCM runtime instance

## Description

Result is between 0 ... (boundary - 1)

## Name

`snd_pcm_playback_hw_avail` — Get the queued space for playback

## Synopsis

```
snd_pcm_sframes_t snd_pcm_playback_hw_avail (struct snd_pcm_runtime *  
runtime);
```

## Arguments

*runtime* PCM runtime instance

## Name

`snd_pcm_capture_hw_avail` — Get the free space for capture

## Synopsis

```
snd_pcm_sframes_t snd_pcm_capture_hw_avail (struct snd_pcm_runtime *  
runtime);
```

## Arguments

*runtime* PCM runtime instance

## Name

`snd_pcm_playback_ready` — check whether the playback buffer is available

## Synopsis

```
int snd_pcm_playback_ready (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the pcm substream instance

## Description

Checks whether enough free space is available on the playback buffer.

## Return

Non-zero if available, or zero if not.

## Name

`snd_pcm_capture_ready` — check whether the capture buffer is available

## Synopsis

```
int snd_pcm_capture_ready (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the pcm substream instance

## Description

Checks whether enough capture data is available on the capture buffer.

## Return

Non-zero if available, or zero if not.

## Name

`snd_pcm_playback_data` — check whether any data exists on the playback buffer

## Synopsis

```
int snd_pcm_playback_data (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the pcm substream instance

## Description

Checks whether any data exists on the playback buffer.

## Return

Non-zero if any data exists, or zero if not. If `stop_threshold` is bigger or equal to `boundary`, then this function returns always non-zero.

## Name

`snd_pcm_playback_empty` — check whether the playback buffer is empty

## Synopsis

```
int snd_pcm_playback_empty (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the pcm substream instance

## Description

Checks whether the playback buffer is empty.

## Return

Non-zero if empty, or zero if not.

## Name

`snd_pcm_capture_empty` — check whether the capture buffer is empty

## Synopsis

```
int snd_pcm_capture_empty (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the pcm substream instance

## Description

Checks whether the capture buffer is empty.

## Return

Non-zero if empty, or zero if not.

## Name

`snd_pcm_trigger_done` — Mark the master substream

## Synopsis

```
void snd_pcm_trigger_done (struct snd_pcm_substream * substream, struct  
snd_pcm_substream * master);
```

## Arguments

*substream* the pcm substream instance

*master* the linked master substream

## Description

When multiple substreams of the same card are linked and the hardware supports the single-shot operation, the driver calls this in the loop in `snd_pcm_group_for_each_entry` for marking the substream as “done”. Then most of trigger operations are performed only to the given master substream.

The `trigger_master` mark is cleared at timestamp updates at the end of trigger operations.

## Name

`params_channels` — Get the number of channels from the hw params

## Synopsis

```
unsigned int params_channels (const struct snd_pcm_hw_params * p);
```

## Arguments

*p* hw params

## Name

`params_rate` — Get the sample rate from the hw params

## Synopsis

```
unsigned int params_rate (const struct snd_pcm_hw_params * p);
```

## Arguments

*p* hw params

## Name

`params_period_size` — Get the period size (in frames) from the hw params

## Synopsis

```
unsigned int params_period_size (const struct snd_pcm_hw_params * p);
```

## Arguments

*p* hw params

## Name

`params_periods` — Get the number of periods from the hw params

## Synopsis

```
unsigned int params_periods (const struct snd_pcm_hw_params * p);
```

## Arguments

*p* hw params

## Name

`params_buffer_size` — Get the buffer size (in frames) from the hw params

## Synopsis

```
unsigned int params_buffer_size (const struct snd_pcm_hw_params * p);
```

## Arguments

*p* hw params

## Name

`params_buffer_bytes` — Get the buffer size (in bytes) from the hw params

## Synopsis

```
unsigned int params_buffer_bytes (const struct snd_pcm_hw_params * p);
```

## Arguments

*p* hw params

## Name

`snd_pcm_format_cpu_endian` — Check the PCM format is CPU-endian

## Synopsis

```
int snd_pcm_format_cpu_endian (snd_pcm_format_t format);
```

## Arguments

*format* the format to check

## Return

1 if the given PCM format is CPU-endian, 0 if opposite, or a negative error code if endian not specified.

## Name

`snd_pcm_set_runtime_buffer` — Set the PCM runtime buffer

## Synopsis

```
void snd_pcm_set_runtime_buffer (struct snd_pcm_substream * substream,  
struct snd_dma_buffer * bufp);
```

## Arguments

*substream* PCM substream to set

*bufp* the buffer information, NULL to clear

## Description

Copy the buffer information to `runtime->dma_buffer` when *bufp* is non-NULL. Otherwise it clears the current buffer information.

## Name

`snd_pcm_gettime` — Fill the timespec depending on the timestamp mode

## Synopsis

```
void snd_pcm_gettime (struct snd_pcm_runtime * runtime, struct timespec  
* tv);
```

## Arguments

*runtime* PCM runtime instance

*tv* timespec to fill

## Name

`snd_pcm_lib_alloc_vmalloc_buffer` — allocate virtual DMA buffer

## Synopsis

```
int snd_pcm_lib_alloc_vmalloc_buffer (struct snd_pcm_substream * sub-  
stream, size_t size);
```

## Arguments

*substream* the substream to allocate the buffer to

*size* the requested buffer size, in bytes

## Description

Allocates the PCM substream buffer using `vmalloc`, i.e., the memory is contiguous in kernel virtual space, but not in physical memory. Use this if the buffer is accessed by kernel code but not by device DMA.

## Return

1 if the buffer was changed, 0 if not changed, or a negative error code.

## Name

`snd_pcm_lib_alloc_vmalloc_32_buffer` — allocate 32-bit-addressable buffer

## Synopsis

```
int snd_pcm_lib_alloc_vmalloc_32_buffer (struct snd_pcm_substream *  
    substream, size_t size);
```

## Arguments

*substream* the substream to allocate the buffer to

*size* the requested buffer size, in bytes

## Description

This function works like `snd_pcm_lib_alloc_vmalloc_buffer`, but uses `vmalloc_32`, i.e., the pages are allocated from 32-bit-addressable memory.

## Return

1 if the buffer was changed, 0 if not changed, or a negative error code.

## Name

`snd_pcm_sgbuf_get_addr` — Get the DMA address at the corresponding offset

## Synopsis

```
dma_addr_t snd_pcm_sgbuf_get_addr (struct snd_pcm_substream * sub-  
stream, unsigned int ofs);
```

## Arguments

*substream* PCM substream

*ofs* byte offset

## Name

`snd_pcm_sgbuf_get_ptr` — Get the virtual address at the corresponding offset

## Synopsis

```
void * snd_pcm_sgbuf_get_ptr (struct snd_pcm_substream * substream,  
unsigned int ofs);
```

## Arguments

*substream* PCM substream

*ofs* byte offset

## Name

`snd_pcm_sgbuf_get_chunk_size` — Compute the max size that fits within the contig. page from the given size

## Synopsis

```
unsigned int snd_pcm_sgbuf_get_chunk_size (struct snd_pcm_substream *  
substream, unsigned int ofs, unsigned int size);
```

## Arguments

|                  |                      |
|------------------|----------------------|
| <i>substream</i> | PCM substream        |
| <i>ofs</i>       | byte offset          |
| <i>size</i>      | byte size to examine |

## Name

`snd_pcm_mmap_data_open` — increase the mmap counter

## Synopsis

```
void snd_pcm_mmap_data_open (struct vm_area_struct * area);
```

## Arguments

*area* VMA

## Description

PCM mmap callback should handle this counter properly

## Name

`snd_pcm_mmap_data_close` — decrease the mmap counter

## Synopsis

```
void snd_pcm_mmap_data_close (struct vm_area_struct * area);
```

## Arguments

*area* VMA

## Description

PCM mmap callback should handle this counter properly

## Name

`snd_pcm_limit_isa_dma_size` — Get the max size fitting with ISA DMA transfer

## Synopsis

```
void snd_pcm_limit_isa_dma_size (int dma, size_t * max);
```

## Arguments

*dma* DMA number

*max* pointer to store the max size

## Name

`snd_pcm_stream_str` — Get a string naming the direction of a stream

## Synopsis

```
const char * snd_pcm_stream_str (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the pcm substream instance

## Return

A string naming the direction of the stream.

## Name

`snd_pcm_chmap_substream` — get the PCM substream assigned to the given chmap info

## Synopsis

```
struct snd_pcm_substream * snd_pcm_chmap_substream (struct
snd_pcm_chmap * info, unsigned int idx);
```

## Arguments

*info* chmap information

*idx* the substream number index

## Name

`pcm_format_to_bits` — Strong-typed conversion of `pcm_format` to bitwise

## Synopsis

```
u64 pcm_format_to_bits (snd_pcm_format_t pcm_format);
```

## Arguments

*pcm\_format* PCM format

## Name

`snd_pcm_format_name` — Return a name string for the given PCM format

## Synopsis

```
const char * snd_pcm_format_name (snd_pcm_format_t format);
```

## Arguments

*format* PCM format

## Name

`snd_pcm_new_stream` — create a new PCM stream

## Synopsis

```
int snd_pcm_new_stream (struct snd_pcm * pcm, int stream, int
substream_count);
```

## Arguments

|                        |   |
|------------------------|---|
| <i>pcm</i>             | the pcm instance  |
| <i>stream</i>          | the stream direction, <code>SNDRV_PCM_STREAM_XXX</code> |
| <i>substream_count</i> | the number of substreams                                |

## Description

Creates a new stream for the pcm. The corresponding stream on the pcm must have been empty before calling this, i.e. zero must be given to the argument of `snd_pcm_new`.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_new` — create a new PCM instance

## Synopsis

```
int snd_pcm_new (struct snd_card * card, const char * id, int device,
int playback_count, int capture_count, struct snd_pcm ** rpcm);
```

## Arguments

|                       |   |
|-----------------------|---|
| <i>card</i>           | the card instance                         |
| <i>id</i>             | the id string                             |
| <i>device</i>         | the device index (zero based)             |
| <i>playback_count</i> | the number of substreams for playback     |
| <i>capture_count</i>  | the number of substreams for capture      |
| <i>rpcm</i>           | the pointer to store the new pcm instance |

## Description

Creates a new PCM instance.

The pcm operators have to be set afterwards to the new instance via `snd_pcm_set_ops`.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_new_internal` — create a new internal PCM instance

## Synopsis

```
int snd_pcm_new_internal (struct snd_card * card, const char * id, int
device, int playback_count, int capture_count, struct snd_pcm ** rpcm);
```

## Arguments

|                       |   |
|-----------------------|---|
| <i>card</i>           | the card instance                                       |
| <i>id</i>             | the id string   |
| <i>device</i>         | the device index (zero based - shared with normal PCMs) |
| <i>playback_count</i> | the number of substreams for playback                   |
| <i>capture_count</i>  | the number of substreams for capture                    |
| <i>rpcm</i>           | the pointer to store the new pcm instance               |

## Description

Creates a new internal PCM instance with no userspace device or procfs entries. This is used by ASoC Back End PCMs in order to create a PCM that will only be used internally by kernel drivers. i.e. it cannot be opened by userspace. It provides existing ASoC components drivers with a substream and access to any private data.

The pcm operators have to be set afterwards to the new instance via `snd_pcm_set_ops`.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_notify` — Add/remove the notify list

## Synopsis

```
int snd_pcm_notify (struct snd_pcm_notify * notify, int nfree);
```

## Arguments

*notify* PCM notify list

*nfree* 0 = register, 1 = unregister

## Description

This adds the given notifier to the global list so that the callback is called for each registered PCM devices. This exists only for PCM OSS emulation, so far.

## Name

`snd_device_new` — create an ALSA device component

## Synopsis

```
int snd_device_new (struct snd_card * card, enum snd_device_type type,  
void * device_data, struct snd_device_ops * ops);
```

## Arguments

|                    |   |
|--------------------|---|
| <i>card</i>        | the card instance                           |
| <i>type</i>        | the device type, <code>SNDRV_DEV_XXX</code> |
| <i>device_data</i> | the data pointer of this device             |
| <i>ops</i>         | the operator table                          |

## Description

Creates a new device component for the given data pointer. The device will be assigned to the card and managed together by the card.

The data pointer plays a role as the identifier, too, so the pointer address must be unique and unchanged.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_device_disconnect` — disconnect the device

## Synopsis

```
void snd_device_disconnect (struct snd_card * card, void * device_data);
```

## Arguments

*card*            the card instance

*device\_data*   the data pointer to disconnect

## Description

Turns the device into the disconnection state, invoking `dev_disconnect` callback, if the device was already registered.

Usually called from `snd_card_disconnect`.

## Return

Zero if successful, or a negative error code on failure or if the device not found.

## Name

`snd_device_free` — release the device from the card

## Synopsis

```
void snd_device_free (struct snd_card * card, void * device_data);
```

## Arguments

*card*            the card instance

*device\_data*   the data pointer to release

## Description

Removes the device from the list on the card and invokes the callbacks, `dev_disconnect` and `dev_free`, corresponding to the state. Then release the device.

## Name

`snd_device_register` — register the device

## Synopsis

```
int snd_device_register (struct snd_card * card, void * device_data);
```

## Arguments

*card*            the card instance

*device\_data*   the data pointer to register

## Description

Registers the device which was already created via `snd_device_new`. Usually this is called from `snd_card_register`, but it can be called later if any new devices are created after invocation of `snd_card_register`.

## Return

Zero if successful, or a negative error code on failure or if the device not found.

## Name

`snd_iprintf` — printf on the procfs buffer

## Synopsis

```
int snd_iprintf (struct snd_info_buffer * buffer, const char * fmt, ...);
```

## Arguments

*buffer* the procfs buffer

*fmt* the printf format

... variable arguments

## Description

Outputs the string on the procfs buffer just like `printf`.

## Return

The size of output string, or a negative error code.

## Name

`snd_info_get_line` — read one line from the procfs buffer

## Synopsis

```
int snd_info_get_line (struct snd_info_buffer * buffer, char * line,  
int len);
```

## Arguments

*buffer* the procfs buffer

*line* the buffer to store

*len* the max. buffer size

## Description

Reads one line from the buffer and stores the string.

## Return

Zero if successful, or 1 if error or EOF.

## Name

`snd_info_get_str` — parse a string token

## Synopsis

```
const char * snd_info_get_str (char * dest, const char * src, int len);
```

## Arguments

*dest* the buffer to store the string token

*src* the original string

*len* the max. length of token - 1

## Description

Parses the original string and copy a token to the given string buffer.

## Return

The updated pointer of the original string so that it can be used for the next call.

## Name

`snd_info_create_module_entry` — create an info entry for the given module

## Synopsis

```
struct snd_info_entry * snd_info_create_module_entry (struct module *  
module, const char * name, struct snd_info_entry * parent);
```

## Arguments

*module* the module pointer

*name* the file name

*parent* the parent directory

## Description

Creates a new info entry and assigns it to the given module.

## Return

The pointer of the new instance, or NULL on failure.

## Name

`snd_info_create_card_entry` — create an info entry for the given card

## Synopsis

```
struct snd_info_entry * snd_info_create_card_entry (struct snd_card *  
card, const char * name, struct snd_info_entry * parent);
```

## Arguments

*card*     the card instance  
*name*     the file name  
*parent*   the parent directory

## Description

Creates a new info entry and assigns it to the given card.

## Return

The pointer of the new instance, or NULL on failure.

## Name

`snd_card_proc_new` — create an info entry for the given card

## Synopsis

```
int snd_card_proc_new (struct snd_card * card, const char * name, struct
snd_info_entry ** entryp);
```

## Arguments

*card*     the card instance

*name*     the file name

*entryp*   the pointer to store the new info entry

## Description

Creates a new info entry and assigns it to the given card. Unlike `snd_info_create_card_entry`, this function registers the info entry as an ALSA device component, so that it can be unregistered/released without explicit call. Also, you don't have to register this entry via `snd_info_register`, since this will be registered by `snd_card_register` automatically.

The parent is assumed as `card->proc_root`.

For releasing this entry, use `snd_device_free` instead of `snd_info_free_entry`.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_info_free_entry` — release the info entry

## Synopsis

```
void snd_info_free_entry (struct snd_info_entry * entry);
```

## Arguments

*entry* the info entry

## Description

Releases the info entry. Don't call this after registered.

## Name

`snd_info_register` — register the info entry

## Synopsis

```
int snd_info_register (struct snd_info_entry * entry);
```

## Arguments

*entry* the info entry

## Description

Registers the proc info entry.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_rawmidi_receive` — receive the input data from the device

## Synopsis

```
int snd_rawmidi_receive (struct snd_rawmidi_substream * substream, const
unsigned char * buffer, int count);
```

## Arguments

*substream* the rawmidi substream

*buffer* the buffer pointer

*count* the data size to read

## Description

Reads the data from the internal buffer.

## Return

The size of read data, or a negative error code on failure.

## Name

`snd_rawmidi_transmit_empty` — check whether the output buffer is empty

## Synopsis

```
int snd_rawmidi_transmit_empty (struct snd_rawmidi_substream * sub-  
stream);
```

## Arguments

*substream* the rawmidi substream

## Return

1 if the internal output buffer is empty, 0 if not.

## Name

`__snd_rawmidi_transmit_peek` — copy data from the internal buffer

## Synopsis

```
int __snd_rawmidi_transmit_peek (struct snd_rawmidi_substream * sub-  
stream, unsigned char * buffer, int count);
```

## Arguments

*substream* the rawmidi substream

*buffer* the buffer pointer

*count* data size to transfer

## Description

This is a variant of `snd_rawmidi_transmit_peek` without spinlock.

## Name

`snd_rawmidi_transmit_peek` — copy data from the internal buffer

## Synopsis

```
int snd_rawmidi_transmit_peek (struct snd_rawmidi_substream * sub-  
stream, unsigned char * buffer, int count);
```

## Arguments

*substream* the rawmidi substream

*buffer* the buffer pointer

*count* data size to transfer

## Description

Copies data from the internal output buffer to the given buffer.

Call this in the interrupt handler when the midi output is ready, and call `snd_rawmidi_transmit_ack` after the transmission is finished.

## Return

The size of copied data, or a negative error code on failure.

## Name

`__snd_rawmidi_transmit_ack` — acknowledge the transmission

## Synopsis

```
int __snd_rawmidi_transmit_ack (struct snd_rawmidi_substream * sub-  
stream, int count);
```

## Arguments

*substream* the rawmidi substream

*count* the transferred count

## Description

This is a variant of `__snd_rawmidi_transmit_ack` without spinlock.

## Name

`snd_rawmidi_transmit_ack` — acknowledge the transmission

## Synopsis

```
int snd_rawmidi_transmit_ack (struct snd_rawmidi_substream * substream,
int count);
```

## Arguments

*substream* the rawmidi substream

*count* the transferred count

## Description

Advances the hardware pointer for the internal output buffer with the given size and updates the condition. Call after the transmission is finished.

## Return

The advanced size if successful, or a negative error code on failure.

## Name

`snd_rawmidi_transmit` — copy from the buffer to the device

## Synopsis

```
int snd_rawmidi_transmit (struct snd_rawmidi_substream * substream, unsigned char * buffer, int count);
```

## Arguments

*substream* the rawmidi substream

*buffer* the buffer pointer

*count* the data size to transfer

## Description

Copies data from the buffer to the device and advances the pointer.

## Return

The copied size if successful, or a negative error code on failure.

## Name

`snd_rawmidi_new` — create a rawmidi instance

## Synopsis

```
int snd_rawmidi_new (struct snd_card * card, char * id, int device, int
output_count, int input_count, struct snd_rawmidi ** rrawmidi);
```

## Arguments

|                     |   |
|---------------------|---|
| <i>card</i>         | the card instance                             |
| <i>id</i>           | the id string                                 |
| <i>device</i>       | the device index                              |
| <i>output_count</i> | the number of output streams                  |
| <i>input_count</i>  | the number of input streams                   |
| <i>rrawmidi</i>     | the pointer to store the new rawmidi instance |

## Description

Creates a new rawmidi instance. Use `snd_rawmidi_set_ops` to set the operators to the new instance.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_rawmidi_set_ops` — set the rawmidi operators

## Synopsis

```
void snd_rawmidi_set_ops (struct snd_rawmidi * rmidi, int stream, struct  
snd_rawmidi_ops * ops);
```

## Arguments

*rmidi*    the rawmidi instance

*stream*   the stream direction, `SNDRV_RAWMIDI_STREAM_XXX`

*ops*       the operator table

## Description

Sets the rawmidi operators for the given stream direction.

## Name

`snd_request_card` — try to load the card module

## Synopsis

```
void snd_request_card (int card);
```

## Arguments

*card* the card number

## Description

Tries to load the module “snd-card-X” for the given card number via `request_module`. Returns immediately if already loaded.

## Name

`snd_lookup_minor_data` — get user data of a registered device

## Synopsis

```
void * snd_lookup_minor_data (unsigned int minor, int type);
```

## Arguments

*minor* the minor number

*type* device type (SNDRV\_DEVICE\_TYPE\_XXX)

## Description

Checks that a minor device with the specified type is registered, and returns its user data pointer.

This function increments the reference counter of the card instance if an associated instance with the given minor number and type is found. The caller must call `snd_card_unref` appropriately later.

## Return

The user data pointer if the specified device is found. NULL otherwise.

## Name

`snd_register_device` — Register the ALSA device file for the card

## Synopsis

```
int snd_register_device (int type, struct snd_card * card, int dev,  
const struct file_operations * f_ops, void * private_data, struct device  
* device);
```

## Arguments

|                     |  |
|---------------------|--|
| <i>type</i>         | the device type, SNDRV_DEVICE_TYPE_XXX |
| <i>card</i>         | the card instance                      |
| <i>dev</i>          | the device index                       |
| <i>f_ops</i>        | the file operations                    |
| <i>private_data</i> | user pointer for <i>f_ops</i> ->open   |
| <i>device</i>       | the device to register                 |

## Description

Registers an ALSA device file for the given card. The operators have to be set in *reg* parameter.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_unregister_device` — unregister the device on the given card

## Synopsis

```
int snd_unregister_device (struct device * dev);
```

## Arguments

*dev* the device instance

## Description

Unregisters the device file already registered via `snd_register_device`.

## Return

Zero if successful, or a negative error code on failure.

## Name

`copy_to_user_fromio` — copy data from mmio-space to user-space

## Synopsis

```
int copy_to_user_fromio (void __user * dst, const volatile void __iomem  
* src, size_t count);
```

## Arguments

*dst* the destination pointer on user-space

*src* the source pointer on mmio

*count* the data size to copy in bytes

## Description

Copies the data from mmio-space to user-space.

## Return

Zero if successful, or non-zero on failure.

## Name

`copy_from_user_toio` — copy data from user-space to mmio-space

## Synopsis

```
int copy_from_user_toio (volatile void __iomem * dst, const void __user  
* src, size_t count);
```

## Arguments

*dst* the destination pointer on mmio-space

*src* the source pointer on user-space

*count* the data size to copy in bytes

## Description

Copies the data from user-space to mmio-space.

## Return

Zero if successful, or non-zero on failure.

## Name

`snd_pcm_lib_preallocate_free_for_all` — release all pre-allocated buffers on the pcm

## Synopsis

```
int snd_pcm_lib_preallocate_free_for_all (struct snd_pcm * pcm);
```

## Arguments

*pcm* the pcm instance

## Description

Releases all the pre-allocated buffers on the given pcm.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_lib_preallocate_pages` — pre-allocation for the given DMA type

## Synopsis

```
int snd_pcm_lib_preallocate_pages (struct snd_pcm_substream * sub-  
stream, int type, struct device * data, size_t size, size_t max);
```

## Arguments

|               |  |
|---------------|--|
| <i>stream</i> | the pcm substream instance                 |
| <i>type</i>   | DMA type (SNDRV_DMA_TYPE_*)                |
| <i>data</i>   | DMA type dependent data                    |
| <i>size</i>   | the requested pre-allocation size in bytes |
| <i>max</i>    | the max. allowed pre-allocation size       |

## Description

Do pre-allocation for the given DMA buffer type.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_lib_preallocate_pages_for_all` — pre-allocation for continuous memory type (all substreams)

## Synopsis

```
int snd_pcm_lib_preallocate_pages_for_all (struct snd_pcm * pcm, int
type, void * data, size_t size, size_t max);
```

## Arguments

*pcm* the pcm instance

*type* DMA type (SNDRV\_DMA\_TYPE\_\*)

*data* DMA type dependent data

*size* the requested pre-allocation size in bytes

*max* the max. allowed pre-allocation size

## Description

Do pre-allocation to all substreams of the given pcm for the specified DMA type.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_sgbuf_ops_page` — get the page struct at the given offset

## Synopsis

```
struct page * snd_pcm_sgbuf_ops_page (struct snd_pcm_substream * sub-  
stream, unsigned long offset);
```

## Arguments

*substream* the pcm substream instance

*offset* the buffer offset

## Description

Used as the page callback of PCM ops.

## Return

The page struct at the given buffer offset. NULL on failure.

## Name

`snd_pcm_lib_malloc_pages` — allocate the DMA buffer

## Synopsis

```
int snd_pcm_lib_malloc_pages (struct snd_pcm_substream * substream,
size_t size);
```

## Arguments

*substream* the substream to allocate the DMA buffer to

*size* the requested buffer size in bytes

## Description

Allocates the DMA buffer on the BUS type given earlier to `snd_pcm_lib_preallocate_XXX_pages`.

## Return

1 if the buffer is changed, 0 if not changed, or a negative code on failure.

## Name

`snd_pcm_lib_free_pages` — release the allocated DMA buffer.

## Synopsis

```
int snd_pcm_lib_free_pages (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the substream to release the DMA buffer

## Description

Releases the DMA buffer allocated via `snd_pcm_lib_malloc_pages`.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_lib_free_vmalloc_buffer` — free vmalloc buffer

## Synopsis

```
int snd_pcm_lib_free_vmalloc_buffer (struct snd_pcm_substream * sub-  
stream);
```

## Arguments

*substream* the substream with a buffer allocated by `snd_pcm_lib_alloc_vmalloc_buffer`

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_lib_get_vmalloc_page` — map vmalloc buffer offset to page struct

## Synopsis

```
struct page * snd_pcm_lib_get_vmalloc_page (struct snd_pcm_substream *  
substream, unsigned long offset);
```

## Arguments

*substream* the substream with a buffer allocated by `snd_pcm_lib_alloc_vmalloc_buffer`

*offset* offset in the buffer

## Description

This function is to be used as the page callback in the PCM ops.

## Return

The page struct, or NULL on failure.

## Name

`snd_device_initialize` — Initialize struct device for sound devices

## Synopsis

```
void snd_device_initialize (struct device * dev, struct snd_card * card);
```

## Arguments

*dev* device to initialize

*card* card to assign, optional

## Name

`snd_card_new` — create and initialize a soundcard structure

## Synopsis

```
int snd_card_new (struct device * parent, int idx, const char * xid,  
struct module * module, int extra_size, struct snd_card ** card_ret);
```

## Arguments

|                   |   |
|-------------------|---|
| <i>parent</i>     | the parent device object                                    |
| <i>idx</i>        | card index (address) [0 ... (SNDRV_CARDS-1)]                |
| <i>xid</i>        | card identification (ASCII string)                          |
| <i>module</i>     | top level module for locking                                |
| <i>extra_size</i> | allocate this extra size after the main soundcard structure |
| <i>card_ret</i>   | the pointer to store the created card instance              |

## Description

Creates and initializes a soundcard structure.

The function allocates `snd_card` instance via `kzalloc` with the given space for the driver to use freely. The allocated struct is stored in the given `card_ret` pointer.

## Return

Zero if successful or a negative error code.

## Name

`snd_card_disconnect` — disconnect all APIs from the file-operations (user space)

## Synopsis

```
int snd_card_disconnect (struct snd_card * card);
```

## Arguments

*card* soundcard structure

## Description

Disconnects all APIs from the file-operations (user space).

## Return

Zero, otherwise a negative error code.

## Note

The current implementation replaces all active `file->f_op` with special dummy file operations (they do nothing except release).

## Name

`snd_card_free_when_closed` — Disconnect the card, free it later eventually

## Synopsis

```
int snd_card_free_when_closed (struct snd_card * card);
```

## Arguments

*card* soundcard structure

## Description

Unlike `snd_card_free`, this function doesn't try to release the card resource immediately, but tries to disconnect at first. When the card is still in use, the function returns before freeing the resources. The card resources will be freed when the refcount gets to zero.

## Name

`snd_card_free` — frees given soundcard structure

## Synopsis

```
int snd_card_free (struct snd_card * card);
```

## Arguments

*card* soundcard structure

## Description

This function releases the soundcard structure and the all assigned devices automatically. That is, you don't have to release the devices by yourself.

This function waits until the all resources are properly released.

## Return

Zero. Frees all associated devices and frees the control interface associated to given soundcard.

## Name

`snd_card_set_id` — set card identification name

## Synopsis

```
void snd_card_set_id (struct snd_card * card, const char * nid);
```

## Arguments

*card* soundcard structure

*nid* new identification string

## Description

This function sets the card identification and checks for name collisions.

## Name

`snd_card_add_dev_attr` — Append a new sysfs attribute group to card

## Synopsis

```
int snd_card_add_dev_attr (struct snd_card * card, const struct
attribute_group * group);
```

## Arguments

*card* card instance

*group* attribute group to append

## Name

`snd_card_register` — register the soundcard

## Synopsis

```
int snd_card_register (struct snd_card * card);
```

## Arguments

*card* soundcard structure

## Description

This function registers all the devices assigned to the soundcard. Until calling this, the ALSA control interface is blocked from the external accesses. Thus, you should call this function at the end of the initialization of the card.

## Return

Zero otherwise a negative error code if the registration failed.

## Name

`snd_component_add` — add a component string

## Synopsis

```
int snd_component_add (struct snd_card * card, const char * component);
```

## Arguments

*card*            soundcard structure

*component*    the component id string

## Description

This function adds the component id string to the supported list. The component can be referred from the `alsa-lib`.

## Return

Zero otherwise a negative error code.

## Name

`snd_card_file_add` — add the file to the file list of the card

## Synopsis

```
int snd_card_file_add (struct snd_card * card, struct file * file);
```

## Arguments

*card* soundcard structure

*file* file pointer

## Description

This function adds the file to the file linked-list of the card. This linked-list is used to keep tracking the connection state, and to avoid the release of busy resources by hotplug.

## Return

zero or a negative error code.

## Name

`snd_card_file_remove` — remove the file from the file list

## Synopsis

```
int snd_card_file_remove (struct snd_card * card, struct file * file);
```

## Arguments

*card* soundcard structure

*file* file pointer

## Description

This function removes the file formerly added to the card via `snd_card_file_add` function. If all files are removed and `snd_card_free_when_closed` was called beforehand, it processes the pending release of resources.

## Return

Zero or a negative error code.

## Name

`snd_power_wait` — wait until the power-state is changed.

## Synopsis

```
int snd_power_wait (struct snd_card * card, unsigned int power_state);
```

## Arguments

*card*            soundcard structure

*power\_state*    expected power state

## Description

Waits until the power-state is changed.

## Return

Zero if successful, or a negative error code.

## Note

the power lock must be active before call.

## Name

`snd_dma_program` — program an ISA DMA transfer

## Synopsis

```
void snd_dma_program (unsigned long dma, unsigned long addr, unsigned  
int size, unsigned short mode);
```

## Arguments

*dma* the dma number

*addr* the physical address of the buffer

*size* the DMA transfer size

*mode* the DMA transfer mode, `DMA_MODE_XXX`

## Description

Programs an ISA DMA transfer for the given buffer.

## Name

`snd_dma_disable` — stop the ISA DMA transfer

## Synopsis

```
void snd_dma_disable (unsigned long dma);
```

## Arguments

*dma* the dma number

## Description

Stops the ISA DMA transfer.

## Name

`snd_dma_pointer` — return the current pointer to DMA transfer buffer in bytes

## Synopsis

```
unsigned int snd_dma_pointer (unsigned long dma, unsigned int size);
```

## Arguments

*dma* the dma number

*size* the dma transfer size

## Return

The current pointer in DMA transfer buffer in bytes.

## Name

`snd_ctl_notify` — Send notification to user-space for a control change

## Synopsis

```
void snd_ctl_notify (struct snd_card * card, unsigned int mask, struct
snd_ctl_elem_id * id);
```

## Arguments

*card* the card to send notification

*mask* the event mask, `SNDRV_CTL_EVENT_*`

*id* the ctl element id to send notification

## Description

This function adds an event record with the given id and mask, appends to the list and wakes up the user-space for notification. This can be called in the atomic context.

## Name

`snd_ctl_new1` — create a control instance from the template

## Synopsis

```
struct snd_kcontrol * snd_ctl_new1 (const struct snd_kcontrol_new *  
ncontrol, void * private_data);
```

## Arguments

*ncontrol*            the initialization record

*private\_data*    the private data to set

## Description

Allocates a new struct `snd_kcontrol` instance and initialize from the given template. When the access field of `ncontrol` is 0, it's assumed as READWRITE access. When the count field is 0, it's assumes as one.

## Return

The pointer of the newly generated instance, or NULL on failure.

## Name

`snd_ctl_free_one` — release the control instance

## Synopsis

```
void snd_ctl_free_one (struct snd_kcontrol * kcontrol);
```

## Arguments

*kcontrol* the control instance

## Description

Releases the control instance created via `snd_ctl_new` or `snd_ctl_new1`. Don't call this after the control was added to the card.

## Name

`snd_ctl_add` — add the control instance to the card

## Synopsis

```
int snd_ctl_add (struct snd_card * card, struct snd_kcontrol * kcontrol);
```

## Arguments

*card*            the card instance

*kcontrol*       the control instance to add

## Description

Adds the control instance created via `snd_ctl_new` or `snd_ctl_new1` to the given card. Assigns also an unique numid used for fast search.

It frees automatically the control which cannot be added.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_ctl_replace` — replace the control instance of the card

## Synopsis

```
int snd_ctl_replace (struct snd_card * card, struct snd_kcontrol *  
kcontrol, bool add_on_replace);
```

## Arguments

|                       |                                      |
|-----------------------|--------------------------------------|
| <i>card</i>           | the card instance                    |
| <i>kcontrol</i>       | the control instance to replace      |
| <i>add_on_replace</i> | add the control if not already added |

## Description

Replaces the given control. If the given control does not exist and the `add_on_replace` flag is set, the control is added. If the control exists, it is destroyed first.

It frees automatically the control which cannot be added or replaced.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_ctl_remove` — remove the control from the card and release it

## Synopsis

```
int snd_ctl_remove (struct snd_card * card, struct snd_kcontrol * kcontrol);
```

## Arguments

*card*            the card instance

*kcontrol*       the control instance to remove

## Description

Removes the control from the card and then releases the instance. You don't need to call `snd_ctl_free_one`. You must be in the write lock - `down_write(card->controls_rwsem)`.

## Return

0 if successful, or a negative error code on failure.

## Name

`snd_ctl_remove_id` — remove the control of the given id and release it

## Synopsis

```
int snd_ctl_remove_id (struct snd_card * card, struct snd_ctl_elem_id  
* id);
```

## Arguments

*card* the card instance

*id* the control id to remove

## Description

Finds the control instance with the given id, removes it from the card list and releases it.

## Return

0 if successful, or a negative error code on failure.

## Name

`snd_ctl_activate_id` — activate/inactivate the control of the given id

## Synopsis

```
int snd_ctl_activate_id (struct snd_card * card, struct snd_ctl_elem_id  
* id, int active);
```

## Arguments

*card*     the card instance

*id*       the control id to activate/inactivate

*active*   non-zero to activate

## Description

Finds the control instance with the given id, and activate or inactivate the control together with notification, if changed. The given ID data is filled with full information.

## Return

0 if unchanged, 1 if changed, or a negative error code on failure.

## Name

`snd_ctl_rename_id` — replace the id of a control on the card

## Synopsis

```
int snd_ctl_rename_id (struct snd_card * card, struct snd_ctl_elem_id
* src_id, struct snd_ctl_elem_id * dst_id);
```

## Arguments

*card* the card instance

*src\_id* the old id

*dst\_id* the new id

## Description

Finds the control with the old id from the card, and replaces the id with the new one.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_ctl_find_numid` — find the control instance with the given number-id

## Synopsis

```
struct snd_kcontrol * snd_ctl_find_numid (struct snd_card * card, unsigned int numid);
```

## Arguments

*card* the card instance

*numid* the number-id to search

## Description

Finds the control instance with the given number-id from the card.

The caller must down `card->controls_rwsem` before calling this function (if the race condition can happen).

## Return

The pointer of the instance if found, or `NULL` if not.

## Name

`snd_ctl_find_id` — find the control instance with the given id

## Synopsis

```
struct snd_kcontrol * snd_ctl_find_id (struct snd_card * card, struct
snd_ctl_elem_id * id);
```

## Arguments

*card* the card instance

*id* the id to search

## Description

Finds the control instance with the given id from the card.

The caller must down `card->controls_rwsem` before calling this function (if the race condition can happen).

## Return

The pointer of the instance if found, or `NULL` if not.

## Name

`snd_ctl_register_ioctl` — register the device-specific control-ioctl

## Synopsis

```
int snd_ctl_register_ioctl (snd_kctl_ioctl_func_t fcn);
```

## Arguments

*fcn* ioctl callback function

## Description

called from each device manager like pcm.c, hwdep.c, etc.

## Name

`snd_ctl_register_ioctl_compat` — register the device-specific 32bit compat control-ioctls

## Synopsis

```
int snd_ctl_register_ioctl_compat (snd_kctl_ioctl_func_t fcn);
```

## Arguments

*fcn* ioctl callback function

## Name

`snd_ctl_unregister_ioctl` — de-register the device-specific control-ioctl

## Synopsis

```
int snd_ctl_unregister_ioctl (snd_kctl_ioctl_func_t fcn);
```

## Arguments

*fcn* ioctl callback function to unregister

## Name

`snd_ctl_unregister_ioctl_compat` — de-register the device-specific compat 32bit control-ioctls

## Synopsis

```
int snd_ctl_unregister_ioctl_compat (snd_kctl_ioctl_func_t fcn);
```

## Arguments

*fcn* ioctl callback function to unregister

## Name

`snd_ctl_boolean_mono_info` — Helper function for a standard boolean info callback with a mono channel

## Synopsis

```
int snd_ctl_boolean_mono_info (struct snd_kcontrol * kcontrol, struct
snd_ctl_elem_info * uinfo);
```

## Arguments

*kcontrol* the kcontrol instance

*uinfo* info to store

## Description

This is a function that can be used as info callback for a standard boolean control with a single mono channel.

## Name

`snd_ctl_boolean_stereo_info` — Helper function for a standard boolean info callback with stereo two channels

## Synopsis

```
int snd_ctl_boolean_stereo_info (struct snd_kcontrol * kcontrol, struct
snd_ctl_elem_info * uinfo);
```

## Arguments

*kcontrol* the kcontrol instance

*uinfo* info to store

## Description

This is a function that can be used as info callback for a standard boolean control with stereo two channels.

## Name

`snd_ctl_enum_info` — fills the info structure for an enumerated control

## Synopsis

```
int snd_ctl_enum_info (struct snd_ctl_elem_info * info, unsigned int
channels, unsigned int items, const char *const names[]);
```

## Arguments

*info*            the structure to be filled

*channels*       the number of the control's channels; often one

*items*           the number of control values; also the size of *names*

*names*[]        an array containing the names of all control values

## Description

Sets all required fields in *info* to their appropriate values. If the control's accessibility is not the default (readable and writable), the caller has to fill *info->access*.

## Return

Zero.

## Name

`snd_pcm_set_ops` — set the PCM operators

## Synopsis

```
void snd_pcm_set_ops (struct snd_pcm * pcm, int direction, const struct  
snd_pcm_ops * ops);
```

## Arguments

*pcm*            the pcm instance

*direction*    stream direction, SNDRV\_PCM\_STREAM\_XXX

*ops*            the operator table

## Description

Sets the given PCM operators to the pcm instance.

## Name

`snd_pcm_set_sync` — set the PCM sync id

## Synopsis

```
void snd_pcm_set_sync (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the pcm substream

## Description

Sets the PCM sync identifier for the card.

## Name

`snd_interval_refine` — refine the interval value of configurator

## Synopsis

```
int snd_interval_refine (struct snd_interval * i, const struct
snd_interval * v);
```

## Arguments

*i* the interval value to refine

*v* the interval value to refer to

## Description

Refines the interval value with the reference value. The interval is changed to the range satisfying both intervals. The interval status (min, max, integer, etc.) are evaluated.

## Return

Positive if the value is changed, zero if it's not changed, or a negative error code.

## Name

`snd_interval_ratnum` — refine the interval value

## Synopsis

```
int snd_interval_ratnum (struct snd_interval * i, unsigned int
rats_count, struct snd_ratnum * rats, unsigned int * nump, unsigned
int * denp);
```

## Arguments

|                   |  |
|-------------------|--|
| <i>i</i>          | interval to refine                         |
| <i>rats_count</i> | number of <code>ratnum_t</code>            |
| <i>rats</i>       | <code>ratnum_t</code> array                |
| <i>nump</i>       | pointer to store the resultant numerator   |
| <i>denp</i>       | pointer to store the resultant denominator |

## Return

Positive if the value is changed, zero if it's not changed, or a negative error code.

## Name

`snd_interval_list` — refine the interval value from the list

## Synopsis

```
int snd_interval_list (struct snd_interval * i, unsigned int count,  
const unsigned int * list, unsigned int mask);
```

## Arguments

*i*        the interval value to refine

*count*   the number of elements in the list

*list*    the value list

*mask*    the bit-mask to evaluate

## Description

Refines the interval value from the list. When mask is non-zero, only the elements corresponding to bit 1 are evaluated.

## Return

Positive if the value is changed, zero if it's not changed, or a negative error code.

## Name

`snd_interval_ranges` — refine the interval value from the list of ranges

## Synopsis

```
int snd_interval_ranges (struct snd_interval * i, unsigned int count,  
const struct snd_interval * ranges, unsigned int mask);
```

## Arguments

*i*            the interval value to refine

*count*       the number of elements in the list of ranges

*ranges*      the ranges list

*mask*        the bit-mask to evaluate

## Description

Refines the interval value from the list of ranges. When mask is non-zero, only the elements corresponding to bit 1 are evaluated.

## Return

Positive if the value is changed, zero if it's not changed, or a negative error code.

## Name

`snd_pcm_hw_rule_add` — add the hw-constraint rule

## Synopsis

```
int snd_pcm_hw_rule_add (struct snd_pcm_runtime * runtime, unsigned int cond, int var, snd_pcm_hw_rule_func_t func, void * private, int dep, ...);
```

## Arguments

*runtime* the pcm runtime instance

*cond* condition bits

*var* the variable to evaluate

*func* the evaluation function

*private* the private data pointer passed to function

*dep* the dependent variables

... variable arguments

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_hw_constraint_mask64` — apply the given bitmap mask constraint

## Synopsis

```
int snd_pcm_hw_constraint_mask64 (struct snd_pcm_runtime * runtime,  
snd_pcm_hw_param_t var, u_int64_t mask);
```

## Arguments

*runtime*    PCM runtime instance

*var*        hw\_params variable to apply the mask

*mask*        the 64bit bitmap mask

## Description

Apply the constraint of the given bitmap mask to a 64-bit mask parameter.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_hw_constraint_integer` — apply an integer constraint to an interval

## Synopsis

```
int snd_pcm_hw_constraint_integer (struct snd_pcm_runtime * runtime,  
snd_pcm_hw_param_t var);
```

## Arguments

*runtime* PCM runtime instance

*var* hw\_params variable to apply the integer constraint

## Description

Apply the constraint of integer to an interval parameter.

## Return

Positive if the value is changed, zero if it's not changed, or a negative error code.

## Name

`snd_pcm_hw_constraint_minmax` — apply a min/max range constraint to an interval

## Synopsis

```
int snd_pcm_hw_constraint_minmax (struct snd_pcm_runtime * runtime,  
snd_pcm_hw_param_t var, unsigned int min, unsigned int max);
```

## Arguments

|                |                                       |
|----------------|---------------------------------------|
| <i>runtime</i> | PCM runtime instance                  |
| <i>var</i>     | hw_params variable to apply the range |
| <i>min</i>     | the minimal value                     |
| <i>max</i>     | the maximal value                     |

## Description

Apply the min/max range constraint to an interval parameter.

## Return

Positive if the value is changed, zero if it's not changed, or a negative error code.

## Name

`snd_pcm_hw_constraint_list` — apply a list of constraints to a parameter

## Synopsis

```
int snd_pcm_hw_constraint_list (struct snd_pcm_runtime * runtime, unsigned int cond, snd_pcm_hw_param_t var, const struct snd_pcm_hw_constraint_list * l);
```

## Arguments

|                |   |
|----------------|---|
| <i>runtime</i> | PCM runtime instance                            |
| <i>cond</i>    | condition bits                                  |
| <i>var</i>     | hw_params variable to apply the list constraint |
| <i>l</i>       | list  |

## Description

Apply the list of constraints to an interval parameter.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_hw_constraint_ranges` — apply list of range constraints to a parameter

## Synopsis

```
int snd_pcm_hw_constraint_ranges (struct snd_pcm_runtime * runtime,
    unsigned int cond, snd_pcm_hw_param_t var, const struct
    snd_pcm_hw_constraint_ranges * r);
```

## Arguments

*runtime* PCM runtime instance

*cond* condition bits

*var* hw\_params variable to apply the list of range constraints

*r* ranges

## Description

Apply the list of range constraints to an interval parameter.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_hw_constraint_ratnums` — apply ratnums constraint to a parameter

## Synopsis

```
int snd_pcm_hw_constraint_ratnums (struct snd_pcm_runtime * runtime,
    unsigned int cond, snd_pcm_hw_param_t var, struct
    snd_pcm_hw_constraint_ratnums * r);
```

## Arguments

*runtime* PCM runtime instance

*cond* condition bits

*var* hw\_params variable to apply the ratnums constraint

*r* struct `snd_ratnums` constraints

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_hw_constraint_ratdens` — apply ratdens constraint to a parameter

## Synopsis

```
int snd_pcm_hw_constraint_ratdens (struct snd_pcm_runtime * runtime,
    unsigned int cond, snd_pcm_hw_param_t var, struct
    snd_pcm_hw_constraint_ratdens * r);
```

## Arguments

*runtime* PCM runtime instance

*cond* condition bits

*var* hw\_params variable to apply the ratdens constraint

*r* struct `snd_ratdens` constraints

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_hw_constraint_msbits` — add a hw constraint msbits rule

## Synopsis

```
int snd_pcm_hw_constraint_msbits (struct snd_pcm_runtime * runtime, unsigned int cond, unsigned int width, unsigned int msbits);
```

## Arguments

*runtime* PCM runtime instance

*cond* condition bits

*width* sample bits width

*msbits* msbits width

## Description

This constraint will set the number of most significant bits (msbits) if a sample format with the specified width has been select. If width is set to 0 the msbits will be set for any sample format with a width larger than the specified msbits.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_hw_constraint_step` — add a hw constraint step rule

## Synopsis

```
int snd_pcm_hw_constraint_step (struct snd_pcm_runtime * runtime, unsigned int cond, snd_pcm_hw_param_t var, unsigned long step);
```

## Arguments

*runtime* PCM runtime instance

*cond* condition bits

*var* hw\_params variable to apply the step constraint

*step* step size

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_hw_constraint_pow2` — add a hw constraint power-of-2 rule

## Synopsis

```
int snd_pcm_hw_constraint_pow2 (struct snd_pcm_runtime * runtime, unsigned int cond, snd_pcm_hw_param_t var);
```

## Arguments

*runtime*    PCM runtime instance

*cond*        condition bits

*var*         hw\_params variable to apply the power-of-2 constraint

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_hw_rule_noresample` — add a rule to allow disabling hw resampling

## Synopsis

```
int snd_pcm_hw_rule_noresample (struct snd_pcm_runtime * runtime, unsigned int base_rate);
```

## Arguments

*runtime*     PCM runtime instance

*base\_rate*   the rate at which the hardware does not resample

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_hw_param_value` — return *params* field *var* value

## Synopsis

```
int snd_pcm_hw_param_value (const struct snd_pcm_hw_params * params,  
snd_pcm_hw_param_t var, int * dir);
```

## Arguments

*params* the hw\_params instance

*var* parameter to retrieve

*dir* pointer to the direction (-1,0,1) or NULL

## Return

The value for field *var* if it's fixed in configuration space defined by *params*. -EINVAL otherwise.

## Name

`snd_pcm_hw_param_first` — refine config space and return minimum value

## Synopsis

```
int snd_pcm_hw_param_first (struct snd_pcm_substream * pcm, struct
snd_pcm_hw_params * params, snd_pcm_hw_param_t var, int * dir);
```

## Arguments

*pcm*        PCM instance

*params*    the `hw_params` instance

*var*        parameter to retrieve

*dir*        pointer to the direction (-1,0,1) or NULL

## Description

Inside configuration space defined by *params* remove from *var* all values > minimum. Reduce configuration space accordingly.

## Return

The minimum, or a negative error code on failure.

## Name

`snd_pcm_hw_param_last` — refine config space and return maximum value

## Synopsis

```
int snd_pcm_hw_param_last (struct snd_pcm_substream * pcm, struct
snd_pcm_hw_params * params, snd_pcm_hw_param_t var, int * dir);
```

## Arguments

*pcm*        PCM instance

*params*    the `hw_params` instance

*var*        parameter to retrieve

*dir*        pointer to the direction (-1,0,1) or NULL

## Description

Inside configuration space defined by *params* remove from *var* all values < maximum. Reduce configuration space accordingly.

## Return

The maximum, or a negative error code on failure.

## Name

`snd_pcm_lib_ioctl` — a generic PCM ioctl callback

## Synopsis

```
int snd_pcm_lib_ioctl (struct snd_pcm_substream * substream, unsigned
int cmd, void * arg);
```

## Arguments

*substream* the pcm substream instance

*cmd* ioctl command

*arg* ioctl argument

## Description

Processes the generic ioctl commands for PCM. Can be passed as the ioctl callback for PCM ops.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_period_elapsed` — update the pcm status for the next period

## Synopsis

```
void snd_pcm_period_elapsed (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the pcm substream instance

## Description

This function is called from the interrupt handler when the PCM has processed the period size. It will update the current pointer, wake up sleepers, etc.

Even if more than one periods have elapsed since the last call, you have to call this only once.

## Name

`snd_pcm_add_chmap_ctls` — create channel-mapping control elements

## Synopsis

```
int snd_pcm_add_chmap_ctls (struct snd_pcm * pcm, int stream, const struct snd_pcm_chmap_elem * chmap, int max_channels, unsigned long private_value, struct snd_pcm_chmap ** info_ret);
```

## Arguments

|                      |  |
|----------------------|--|
| <i>pcm</i>           | the assigned PCM instance  |
| <i>stream</i>        | stream direction   |
| <i>chmap</i>         | channel map elements (for query)                                     |
| <i>max_channels</i>  | the max number of channels for the stream                            |
| <i>private_value</i> | the value passed to each kcontrol's <code>private_value</code> field |
| <i>info_ret</i>      | store struct <code>snd_pcm_chmap</code> instance if non-NULL         |

## Description

Create channel-mapping control elements assigned to the given PCM stream(s).

## Return

Zero if successful, or a negative error value.

## Name

`snd_hwdep_new` — create a new hwdep instance

## Synopsis

```
int snd_hwdep_new (struct snd_card * card, char * id, int device, struct
snd_hwdep ** rhwdep);
```

## Arguments

*card*     the card instance

*id*       the id string

*device*   the device index (zero-based)

*rhwdep*   the pointer to store the new hwdep instance

## Description

Creates a new hwdep instance with the given index on the card. The callbacks (`hwdep->ops`) must be set on the returned instance after this call manually by the caller.

## Return

Zero if successful, or a negative error code on failure.

## Name

`snd_pcm_stream_lock` — Lock the PCM stream

## Synopsis

```
void snd_pcm_stream_lock (struct snd_pcm_substream * substream);
```

## Arguments

*substream* PCM substream

## Description

This locks the PCM stream's spinlock or mutex depending on the nonatomic flag of the given substream. This also takes the global link rw lock (or rw sem), too, for avoiding the race with linked streams.

## Name

`snd_pcm_stream_unlock` — Unlock the PCM stream

## Synopsis

```
void snd_pcm_stream_unlock (struct snd_pcm_substream * substream);
```

## Arguments

*substream* PCM substream

## Description

This unlocks the PCM stream that has been locked via `snd_pcm_stream_lock`.

## Name

`snd_pcm_stream_lock_irq` — Lock the PCM stream

## Synopsis

```
void snd_pcm_stream_lock_irq (struct snd_pcm_substream * substream);
```

## Arguments

*substream* PCM substream

## Description

This locks the PCM stream like `snd_pcm_stream_lock` and disables the local IRQ (only when `nonatomic` is false). In nonatomic case, this is identical as `snd_pcm_stream_lock`.

## Name

`snd_pcm_stream_unlock_irq` — Unlock the PCM stream

## Synopsis

```
void snd_pcm_stream_unlock_irq (struct snd_pcm_substream * substream);
```

## Arguments

*substream* PCM substream

## Description

This is a counter-part of `snd_pcm_stream_lock_irq`.

## Name

`snd_pcm_stream_unlock_irqrestore` — Unlock the PCM stream

## Synopsis

```
void snd_pcm_stream_unlock_irqrestore (struct snd_pcm_substream * sub-  
stream, unsigned long flags);
```

## Arguments

*substream* PCM substream

*flags* irq flags

## Description

This is a counter-part of `snd_pcm_stream_lock_irqsave`.

## Name

`snd_pcm_stop` — try to stop all running streams in the substream group

## Synopsis

```
int snd_pcm_stop (struct snd_pcm_substream * substream, snd_pcm_state_t
state);
```

## Arguments

*substream* the PCM substream instance

*state* PCM state after stopping the stream

## Description

The state of each stream is then changed to the given state unconditionally.

## Return

Zero if successful, or a negative error code.

## Name

`snd_pcm_stop_xrun` — stop the running streams as XRUN

## Synopsis

```
int snd_pcm_stop_xrun (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the PCM substream instance

## Description

This stops the given running substream (and all linked substreams) as XRUN. Unlike `snd_pcm_stop`, this function takes the substream lock by itself.

## Return

Zero if successful, or a negative error code.

## Name

`snd_pcm_suspend` — trigger SUSPEND to all linked streams

## Synopsis

```
int snd_pcm_suspend (struct snd_pcm_substream * substream);
```

## Arguments

*substream* the PCM substream

## Description

After this call, all streams are changed to SUSPENDED state.

## Return

Zero if successful (or *substream* is NULL), or a negative error code.

## Name

`snd_pcm_suspend_all` — trigger SUSPEND to all substreams in the given `pcm`

## Synopsis

```
int snd_pcm_suspend_all (struct snd_pcm * pcm);
```

## Arguments

*pcm* the PCM instance

## Description

After this call, all streams are changed to SUSPENDED state.

## Return

Zero if successful (or *pcm* is NULL), or a negative error code.

## Name

`snd_pcm_lib_default_mmap` — Default PCM data mmap function

## Synopsis

```
int snd_pcm_lib_default_mmap (struct snd_pcm_substream * substream,
struct vm_area_struct * area);
```

## Arguments

*substream* PCM substream

*area* VMA

## Description

This is the default mmap handler for PCM data. When `mmap_pcm_ops` is NULL, this function is invoked implicitly.

## Name

`snd_pcm_lib_mmap_iomem` — Default PCM data mmap function for I/O mem

## Synopsis

```
int snd_pcm_lib_mmap_iomem (struct snd_pcm_substream * substream, struct
vm_area_struct * area);
```

## Arguments

*substream* PCM substream

*area* VMA

## Description

When your hardware uses the iomapped pages as the hardware buffer and wants to mmap it, pass this function as `mmap_pcm_ops`. Note that this is supposed to work only on limited architectures.

## Name

`snd_malloc_pages` — allocate pages with the given size

## Synopsis

```
void * snd_malloc_pages (size_t size, gfp_t gfp_flags);
```

## Arguments

*size*            the size to allocate in bytes

*gfp\_flags*    the allocation conditions, GFP\_XXX

## Description

Allocates the physically contiguous pages with the given size.

## Return

The pointer of the buffer, or NULL if no enough memory.

## Name

`snd_free_pages` — release the pages

## Synopsis

```
void snd_free_pages (void * ptr, size_t size);
```

## Arguments

*ptr* the buffer pointer to release

*size* the allocated buffer size

## Description

Releases the buffer allocated via `snd_malloc_pages`.

## Name

`snd_dma_alloc_pages` — allocate the buffer area according to the given type

## Synopsis

```
int snd_dma_alloc_pages (int type, struct device * device, size_t size,  
struct snd_dma_buffer * dmab);
```

## Arguments

*type*     the DMA buffer type

*device*   the device pointer

*size*     the buffer size to allocate

*dmab*     buffer allocation record to store the allocated data

## Description

Calls the memory-allocator function for the corresponding buffer type.

## Return

Zero if the buffer with the given size is allocated successfully, otherwise a negative value on error.

## Name

`snd_dma_alloc_pages_fallback` — allocate the buffer area according to the given type with fallback

## Synopsis

```
int snd_dma_alloc_pages_fallback (int type, struct device * device,  
size_t size, struct snd_dma_buffer * dmab);
```

## Arguments

*type*     the DMA buffer type

*device*   the device pointer

*size*     the buffer size to allocate

*dmab*     buffer allocation record to store the allocated data

## Description

Calls the memory-allocator function for the corresponding buffer type. When no space is left, this function reduces the size and tries to allocate again. The size actually allocated is stored in `res_size` argument.

## Return

Zero if the buffer with the given size is allocated successfully, otherwise a negative value on error.

## Name

`snd_dma_free_pages` — release the allocated buffer

## Synopsis

```
void snd_dma_free_pages (struct snd_dma_buffer * dmab);
```

## Arguments

*dmab* the buffer allocation record to release

## Description

Releases the allocated buffer via `snd_dma_alloc_pages`.

---

# Chapter 6. 16x50 UART Driver

## Name

`uart_update_timeout` — update per-port FIFO timeout.

## Synopsis

```
void uart_update_timeout (struct uart_port * port, unsigned int cflag,  
unsigned int baud);
```

## Arguments

*port* `uart_port` structure describing the port

*cflag* `termios cflag` value

*baud* speed of the port

## Description

Set the port FIFO timeout value. The *cflag* value should reflect the actual hardware settings.

## Name

`uart_get_baud_rate` — return baud rate for a particular port

## Synopsis

```
unsigned int uart_get_baud_rate (struct uart_port * port, struct
ktermios * termios, struct ktermios * old, unsigned int min, unsigned
int max);
```

## Arguments

*port*        `uart_port` structure describing the port in question.

*termios*    desired termios settings.

*old*        old termios (or NULL)

*min*        minimum acceptable baud rate

*max*        maximum acceptable baud rate

## Description

Decode the termios structure into a numeric baud rate, taking account of the magic 38400 baud rate (with `spd_*` flags), and mapping the B0 rate to 9600 baud.

If the new baud rate is invalid, try the old termios setting. If it's still invalid, we try 9600 baud.

Update the *termios* structure to reflect the baud rate we're actually going to be using. Don't do this for the case where B0 is requested (“hang up”).

## Name

`uart_get_divisor` — return uart clock divisor

## Synopsis

```
unsigned int uart_get_divisor (struct uart_port * port, unsigned int  
baud);
```

## Arguments

*port* `uart_port` structure describing the port.

*baud* desired baud rate

## Description

Calculate the uart clock divisor for the port.

## Name

`uart_console_write` — write a console message to a serial port

## Synopsis

```
void uart_console_write (struct uart_port * port, const char * s, unsigned int count, void (*putchar) (struct uart_port *, int));
```

## Arguments

|                |   |
|----------------|---|
| <i>port</i>    | the port to write the message           |
| <i>s</i>       | array of characters                     |
| <i>count</i>   | number of characters in string to write |
| <i>putchar</i> | function to write character to port     |

## Name

uart\_parse\_earlycon — Parse earlycon options

## Synopsis

```
int uart_parse_earlycon (char * p, unsigned char * iotype, unsigned long  
* addr, char ** options);
```

## Arguments

*p* ptr to 2nd field (ie., just beyond '<name>,')  
*iotype* ptr for decoded iotype (out)  
*addr* ptr for decoded mapbase/iobase (out)  
*options* ptr for <options> field; NULL if not present (out)

## Description

Decodes earlycon kernel command line parameters of the form earlycon=<name>,io|mmio|mmio32,<addr>,<options> console=<name>,io|mmio|mmio32,<addr>,<options>

The optional form earlycon=<name>,0x<addr>,<options> console=<name>,0x<addr>,<options> is also accepted; the returned *iotype* will be UPIO\_MEM.

Returns 0 on success or -EINVAL on failure

## Name

`uart_parse_options` — Parse serial port baud/parity/bits/flow control.

## Synopsis

```
void uart_parse_options (char * options, int * baud, int * parity, int * bits, int * flow);
```

## Arguments

*options* pointer to option string

*baud* pointer to an 'int' variable for the baud rate.

*parity* pointer to an 'int' variable for the parity.

*bits* pointer to an 'int' variable for the number of data bits.

*flow* pointer to an 'int' variable for the flow control character.

## Description

`uart_parse_options` decodes a string containing the serial console options. The format of the string is `<baud><parity><bits><flow>`,

## eg

115200n8r

## Name

`uart_set_options` — setup the serial console parameters

## Synopsis

```
int uart_set_options (struct uart_port * port, struct console * co, int baud, int parity, int bits, int flow);
```

## Arguments

|               |  |
|---------------|--|
| <i>port</i>   | pointer to the serial ports <code>uart_port</code> structure |
| <i>co</i>     | console pointer  |
| <i>baud</i>   | baud rate  |
| <i>parity</i> | parity character - 'n' (none), 'o' (odd), 'e' (even)         |
| <i>bits</i>   | number of data bits  |
| <i>flow</i>   | flow control character - 'r' (rts)                           |

## Name

`uart_register_driver` — register a driver with the uart core layer

## Synopsis

```
int uart_register_driver (struct uart_driver * drv);
```

## Arguments

*drv* low level driver structure

## Description

Register a uart driver with the core driver. We in turn register with the tty layer, and initialise the core driver per-port state.

We have a proc file in `/proc/tty/driver` which is named after the normal driver.

`drv->port` should be NULL, and the per-port structures should be registered using `uart_add_one_port` after this call has succeeded.

## Name

`uart_unregister_driver` — remove a driver from the uart core layer

## Synopsis

```
void uart_unregister_driver (struct uart_driver * drv);
```

## Arguments

*drv* low level driver structure

## Description

Remove all references to a driver from the core driver. The low level driver must have removed all its ports via the `uart_remove_one_port` if it registered them with `uart_add_one_port`. (ie, `drv->port == NULL`)

## Name

`uart_add_one_port` — attach a driver-defined port structure

## Synopsis

```
int uart_add_one_port (struct uart_driver * drv, struct uart_port *  
uport);
```

## Arguments

*drv* pointer to the uart low level driver structure for this port

*uport* uart port structure to use for this port.

## Description

This allows the driver to register its own `uart_port` structure with the core driver. The main purpose is to allow the low level uart drivers to expand `uart_port`, rather than having yet more levels of structures.

## Name

`uart_remove_one_port` — detach a driver defined port structure

## Synopsis

```
int uart_remove_one_port (struct uart_driver * drv, struct uart_port  
* uport);
```

## Arguments

*drv* pointer to the uart low level driver structure for this port

*uport* uart port structure for this port

## Description

This unhooks (and hangs up) the specified port structure from the core driver. No further calls will be made to the low-level code for this port.

## Name

`uart_handle_dcd_change` — handle a change of carrier detect state

## Synopsis

```
void uart_handle_dcd_change (struct uart_port * uport, unsigned int  
status);
```

## Arguments

*uport* uart\_port structure for the open port

*status* new carrier detect status, nonzero if active

## Description

Caller must hold `uport->lock`

## Name

`uart_handle_cts_change` — handle a change of clear-to-send state

## Synopsis

```
void uart_handle_cts_change (struct uart_port * uport, unsigned int
status);
```

## Arguments

*uport* uart\_port structure for the open port

*status* new clear to send status, nonzero if active

## Description

Caller must hold `uport->lock`

## Name

`uart_insert_char` — push a char to the uart layer

## Synopsis

```
void uart_insert_char (struct uart_port * port, unsigned int status,  
unsigned int overrun, unsigned int ch, unsigned int flag);
```

## Arguments

*port*        corresponding port

*status*     state of the serial port RX buffer (LSR for 8250)

*overrun*    mask of overrun bits in *status*

*ch*         character to push

*flag*        flag for the character (see TTY\_NORMAL and friends)

## Description

User is responsible to call `tty_flip_buffer_push` when they are done with insertion.

## Name

`serial8250_get_port` — retrieve struct `uart_8250_port`

## Synopsis

```
struct uart_8250_port * serial8250_get_port (int line);
```

## Arguments

*line* serial line number

## Description

This function retrieves struct `uart_8250_port` for the specific line. This struct *must not* be used to perform a 8250 or serial core operation which is not accessible otherwise. Its only purpose is to make the struct accessible to the runtime-pm callbacks for context suspend/restore. The lock assumption made here is none because runtime-pm suspend/resume callbacks should not be invoked if there is any operation performed on the port.

## Name

`serial8250_suspend_port` — suspend one serial port

## Synopsis

```
void serial8250_suspend_port (int line);
```

## Arguments

*line* serial line number

## Description

Suspend one serial port.

## Name

`serial8250_resume_port` — resume one serial port

## Synopsis

```
void serial8250_resume_port (int line);
```

## Arguments

*line* serial line number

## Description

Resume one serial port.

## Name

`serial8250_register_8250_port` — register a serial port

## Synopsis

```
int serial8250_register_8250_port (struct uart_8250_port * up);
```

## Arguments

*up* serial port template

## Description

Configure the serial port specified by the request. If the port exists and is in use, it is hung up and unregistered first.

The port is then probed and if necessary the IRQ is autodetected. If this fails an error is returned.

On success the port is ready to use and the line number is returned.

## Name

`serial8250_unregister_port` — remove a 16x50 serial port at runtime

## Synopsis

```
void serial8250_unregister_port (int line);
```

## Arguments

*line* serial line number

## Description

Remove one serial port. This may not be called from interrupt context. We hand the port back to the our control.

---

# Chapter 7. Frame Buffer Library

The frame buffer drivers depend heavily on four data structures. These structures are declared in `include/linux/fb.h`. They are `fb_info`, `fb_var_screeninfo`, `fb_fix_screeninfo` and `fb_monospecs`. The last three can be made available to and from userland.

`fb_info` defines the current state of a particular video card. Inside `fb_info`, there exists a `fb_ops` structure which is a collection of needed functions to make `fbdev` and `fbcon` work. `fb_info` is only visible to the kernel.

`fb_var_screeninfo` is used to describe the features of a video card that are user defined. With `fb_var_screeninfo`, things such as depth and the resolution may be defined.

The next structure is `fb_fix_screeninfo`. This defines the properties of a card that are created when a mode is set and can't be changed otherwise. A good example of this is the start of the frame buffer memory. This "locks" the address of the frame buffer memory, so that it cannot be changed or moved.

The last structure is `fb_monospecs`. In the old API, there was little importance for `fb_monospecs`. This allowed for forbidden things such as setting a mode of 800x600 on a fix frequency monitor. With the new API, `fb_monospecs` prevents such things, and if used correctly, can prevent a monitor from being cooked. `fb_monospecs` will not be useful until kernels 2.5.x.

## Frame Buffer Memory

## Name

`register_framebuffer` — registers a frame buffer device

## Synopsis

```
int register_framebuffer (struct fb_info * fb_info);
```

## Arguments

*fb\_info* frame buffer info structure

## Description

Registers a frame buffer device *fb\_info*.

Returns negative errno on error, or zero for success.

## Name

`unregister_framebuffer` — releases a frame buffer device

## Synopsis

```
int unregister_framebuffer (struct fb_info * fb_info);
```

## Arguments

*fb\_info* frame buffer info structure

## Description

Unregisters a frame buffer device *fb\_info*.

Returns negative `errno` on error, or zero for success.

This function will also notify the framebuffer console to release the driver.

This is meant to be called within a driver's `module_exit` function. If this is called outside `module_exit`, ensure that the driver implements `fb_open` and `fb_release` to check that no processes are using the device.

## Name

`fb_set_suspend` — low level driver signals suspend

## Synopsis

```
void fb_set_suspend (struct fb_info * info, int state);
```

## Arguments

*info* framebuffer affected

*state* 0 = resuming, !=0 = suspending

## Description

This is meant to be used by low level drivers to signal suspend/resume to the core & clients. It must be called with the console semaphore held

# Frame Buffer Colormap

## Name

`fb_dealloc_cmap` — deallocate a colormap

## Synopsis

```
void fb_dealloc_cmap (struct fb_cmap * cmap);
```

## Arguments

*cmap* frame buffer colormap structure

## Description

Deallocates a colormap that was previously allocated with `fb_alloc_cmap`.

## Name

`fb_copy_cmap` — copy a colormap

## Synopsis

```
int fb_copy_cmap (const struct fb_cmap * from, struct fb_cmap * to);
```

## Arguments

*from* frame buffer colormap structure

*to* frame buffer colormap structure

## Description

Copy contents of colormap from *from* to *to*.

## Name

`fb_set_cmap` — set the colormap

## Synopsis

```
int fb_set_cmap (struct fb_cmap * cmap, struct fb_info * info);
```

## Arguments

*cmap* frame buffer colormap structure

*info* frame buffer info structure

## Description

Sets the colormap *cmap* for a screen of device *info*.

Returns negative `errno` on error, or zero on success.

## Name

`fb_default_cmap` — get default colormap

## Synopsis

```
const struct fb_cmap * fb_default_cmap (int len);
```

## Arguments

*len* size of palette for a depth

## Description

Gets the default colormap for a specific screen depth. *len* is the size of the palette for a particular screen depth.

Returns pointer to a frame buffer colormap structure.

## Name

`fb_invert_cmaps` — invert all defaults colormaps

## Synopsis

```
void fb_invert_cmaps ( void );
```

## Arguments

*void* no arguments

## Description

Invert all default colormaps.

# Frame Buffer Video Mode Database

## Name

`fb_try_mode` — test a video mode

## Synopsis

```
int fb_try_mode (struct fb_var_screeninfo * var, struct fb_info * info,  
const struct fb_videomode * mode, unsigned int bpp);
```

## Arguments

*var* frame buffer user defined part of display

*info* frame buffer info structure

*mode* frame buffer video mode structure

*bpp* color depth in bits per pixel

## Description

Tries a video mode to test it's validity for device *info*.

Returns 1 on success.

## Name

`fb_delete_videomode` — removed videomode entry from modelist

## Synopsis

```
void fb_delete_videomode (const struct fb_videomode * mode, struct  
list_head * head);
```

## Arguments

*mode* videomode to remove

*head* struct list\_head of modelist

## NOTES

Will remove all matching mode entries

## Name

`fb_find_mode` — finds a valid video mode

## Synopsis

```
int fb_find_mode (struct fb_var_screeninfo * var, struct fb_info * info,
const char * mode_option, const struct fb_videomode * db, unsigned
int dbsize, const struct fb_videomode * default_mode, unsigned int
default_bpp);
```

## Arguments

|                     |   |
|---------------------|---|
| <i>var</i>          | frame buffer user defined part of display |
| <i>info</i>         | frame buffer info structure               |
| <i>mode_option</i>  | string video mode to find                 |
| <i>db</i>           | video mode database                       |
| <i>dbsize</i>       | size of <i>db</i>                         |
| <i>default_mode</i> | default video mode to fall back to        |
| <i>default_bpp</i>  | default color depth in bits per pixel     |

## Description

Finds a suitable video mode, starting with the specified mode in *mode\_option* with fallback to *default\_mode*. If *default\_mode* fails, all modes in the video mode database will be tried.

Valid mode specifiers for *mode\_option*:

```
<xres>x<yres>[M][R][-<bpp>][@<refresh>][i][m] or <name>[-<bpp>][@<refresh>]
```

with *<xres>*, *<yres>*, *<bpp>* and *<refresh>* decimal numbers and *<name>* a string.

If 'M' is present after yres (and before refresh/bpp if present), the function will compute the timings using VESA(tm) Coordinated Video Timings (CVT). If 'R' is present after 'M', will compute with reduced blanking (for flatpanels). If 'i' is present, compute interlaced mode. If 'm' is present, add margins equal to 1.8% of xres rounded down to 8 pixels, and 1.8% of yres. The char 'i' and 'm' must be after 'M' and 'R'. Example:

```
1024x768MR-860m - Reduced blank with margins at 60Hz.
```

## NOTE

The passed struct *var* is *\_not\_* cleared! This allows you to supply values for e.g. the grayscale and *accel\_flags* fields.

Returns zero for failure, 1 if using specified *mode\_option*, 2 if using specified *mode\_option* with an ignored refresh rate, 3 if default mode is used, 4 if fall back to any valid mode.

## Name

`fb_var_to_videomode` — convert `fb_var_screeninfo` to `fb_videomode`

## Synopsis

```
void fb_var_to_videomode (struct fb_videomode * mode, const struct
fb_var_screeninfo * var);
```

## Arguments

*mode* pointer to struct `fb_videomode`

*var* pointer to struct `fb_var_screeninfo`

## Name

`fb_videomode_to_var` — convert `fb_videomode` to `fb_var_screeninfo`

## Synopsis

```
void fb_videomode_to_var (struct fb_var_screeninfo * var, const struct  
fb_videomode * mode);
```

## Arguments

*var* pointer to struct `fb_var_screeninfo`

*mode* pointer to struct `fb_videomode`

## Name

`fb_mode_is_equal` — compare 2 videomodes

## Synopsis

```
int fb_mode_is_equal (const struct fb_videomode * mode1, const struct
fb_videomode * mode2);
```

## Arguments

*mode1* first videomode

*mode2* second videomode

## RETURNS

1 if equal, 0 if not

## Name

`fb_find_best_mode` — find best matching videomode

## Synopsis

```
const struct fb_videomode * fb_find_best_mode (const struct
fb_var_screeninfo * var, struct list_head * head);
```

## Arguments

*var* pointer to struct `fb_var_screeninfo`

*head* pointer to struct `list_head` of modelist

## RETURNS

struct `fb_videomode`, NULL if none found

## IMPORTANT

This function assumes that all modelist entries in `info->modelist` are valid.

## NOTES

Finds best matching videomode which has an equal or greater dimension than `var->xres` and `var->yres`. If more than 1 videomode is found, will return the videomode with the highest refresh rate

## Name

`fb_find_nearest_mode` — find closest videomode

## Synopsis

```
const struct fb_videomode * fb_find_nearest_mode (const struct
fb_videomode * mode, struct list_head * head);
```

## Arguments

*mode* pointer to struct fb\_videomode

*head* pointer to modelist

## Description

Finds best matching videomode, smaller or greater in dimension. If more than 1 videomode is found, will return the videomode with the closest refresh rate.

## Name

`fb_match_mode` — find a videomode which exactly matches the timings in `var`

## Synopsis

```
const struct fb_videomode * fb_match_mode (const struct
fb_var_screeninfo * var, struct list_head * head);
```

## Arguments

*var* pointer to struct `fb_var_screeninfo`

*head* pointer to struct `list_head` of modelist

## RETURNS

struct `fb_videomode`, NULL if none found

## Name

`fb_add_videomode` — adds videomode entry to modelist

## Synopsis

```
int fb_add_videomode (const struct fb_videomode * mode, struct list_head  
* head);
```

## Arguments

*mode* videomode to add

*head* struct list\_head of modelist

## NOTES

Will only add unmatched mode entries

## Name

`fb_destroy_modelist` — destroy modelist

## Synopsis

```
void fb_destroy_modelist (struct list_head * head);
```

## Arguments

*head* struct list\_head of modelist

## Name

`fb_videomode_to_modelist` — convert mode array to mode list

## Synopsis

```
void fb_videomode_to_modelist (const struct fb_videomode * modedb, int
num, struct list_head * head);
```

## Arguments

*modedb* array of struct fb\_videomode

*num* number of entries in array

*head* struct list\_head of modelist

# Frame Buffer Macintosh Video Mode Database

## Name

`mac_vmode_to_var` — converts vmode/cmode pair to var structure

## Synopsis

```
int mac_vmode_to_var (int vmode, int cmode, struct fb_var_screeninfo  
* var);
```

## Arguments

*vmode* MacOS video mode

*cmode* MacOS color mode

*var* frame buffer video mode structure

## Description

Converts a MacOS vmode/cmode pair to a frame buffer video mode structure.

Returns negative errno on error, or zero for success.

## Name

`mac_map_monitor_sense` — Convert monitor sense to vmode

## Synopsis

```
int mac_map_monitor_sense (int sense);
```

## Arguments

*sense* Macintosh monitor sense number

## Description

Converts a Macintosh monitor sense number to a MacOS vmode number.

Returns MacOS vmode video mode number.

## Name

`mac_find_mode` — find a video mode

## Synopsis

```
int mac_find_mode (struct fb_var_screeninfo * var, struct fb_info *
info, const char * mode_option, unsigned int default_bpp);
```

## Arguments

*var* frame buffer user defined part of display

*info* frame buffer info structure

*mode\_option* video mode name (see `mac_modedb[]`)

*default\_bpp* default color depth in bits per pixel

## Description

Finds a suitable video mode. Tries to set mode specified by *mode\_option*. If the name of the wanted mode begins with 'mac', the Mac video mode database will be used, otherwise it will fall back to the standard video mode database.

## Note

Function marked as `__init` and can only be used during system boot.

Returns error code from `fb_find_mode` (see `fb_find_mode` function).

## Frame Buffer Fonts

Refer to the file `lib/fonts/fonts.c` for more information.

---

# Chapter 8. Input Subsystem

## Input core

## Name

struct input\_value — input value representation

## Synopsis

```
struct input_value {
    __u16 type;
    __u16 code;
    __s32 value;
};
```

## Members

|       |                                     |
|-------|-------------------------------------|
| type  | type of value (EV_KEY, EV_ABS, etc) |
| code  | the value code                      |
| value | the value                           |

## Name

struct input\_dev — represents an input device

## Synopsis

```

struct input_dev {
    const char * name;
    const char * phys;
    const char * uniq;
    struct input_id id;
    unsigned long propbit[BITS_TO_LONGS(INPUT_PROP_CNT)];
    unsigned long evbit[BITS_TO_LONGS(EV_CNT)];
    unsigned long keybit[BITS_TO_LONGS(KEY_CNT)];
    unsigned long relbit[BITS_TO_LONGS(REL_CNT)];
    unsigned long absbit[BITS_TO_LONGS(ABS_CNT)];
    unsigned long mscbit[BITS_TO_LONGS(MSC_CNT)];
    unsigned long ledbit[BITS_TO_LONGS(LED_CNT)];
    unsigned long sndbit[BITS_TO_LONGS(SND_CNT)];
    unsigned long ffbit[BITS_TO_LONGS(FF_CNT)];
    unsigned long swbit[BITS_TO_LONGS(SW_CNT)];
    unsigned int hint_events_per_packet;
    unsigned int keycodemax;
    unsigned int keycodesize;
    void * keycode;
    int (* setkeycode) (struct input_dev *dev, const struct input_keymap_entry *ke, un
    int (* getkeycode) (struct input_dev *dev, struct input_keymap_entry *ke);
    struct ff_device * ff;
    unsigned int repeat_key;
    struct timer_list timer;
    int rep[REP_CNT];
    struct input_mt * mt;
    struct input_absinfo * absinfo;
    unsigned long key[BITS_TO_LONGS(KEY_CNT)];
    unsigned long led[BITS_TO_LONGS(LED_CNT)];
    unsigned long snd[BITS_TO_LONGS(SND_CNT)];
    unsigned long sw[BITS_TO_LONGS(SW_CNT)];
    int (* open) (struct input_dev *dev);
    void (* close) (struct input_dev *dev);
    int (* flush) (struct input_dev *dev, struct file *file);
    int (* event) (struct input_dev *dev, unsigned int type, unsigned int code, int
    struct input_handle __rcu * grab;
    spinlock_t event_lock;
    struct mutex mutex;
    unsigned int users;
    bool going_away;
    struct device dev;
    struct list_head h_list;
    struct list_head node;
    unsigned int num_vals;
    unsigned int max_vals;
    struct input_value * vals;
    bool devres_managed;

```

};

## Members

|  |  |
|--|--|
| name                                   | name of the device   |
| phys                                   | physical path to the device in the system hierarchy  |
| uniq                                   | unique identification code for the device (if device has it)   |
| id                                     | id of the device (struct input_id)   |
| propbit[BITS_TO_LONGS(INPUT_PROP_CNT)] | bitmap of device properties and quirks   |
| evbit[BITS_TO_LONGS(EV_CNT)]           | bitmap of types of events supported by the device (EV_KEY, EV_REL, etc.)   |
| keybit[BITS_TO_LONGS(KEY_CNT)]         | bitmap of keys/buttons this device has   |
| relbit[BITS_TO_LONGS(REL_CNT)]         | bitmap of relative axes for the device   |
| absbit[BITS_TO_LONGS(ABS_CNT)]         | bitmap of absolute axes for the device   |
| mscbit[BITS_TO_LONGS(MSC_CNT)]         | map of miscellaneous events supported by the device  |
| ledbit[BITS_TO_LONGS(LED_CNT)]         | bitmap of leds present on the device   |
| sndbit[BITS_TO_LONGS(SND_CNT)]         | bitmap of sound effects supported by the device  |
| ffbit[BITS_TO_LONGS(FF_CNT)]           | bitmap of force feedback effects supported by the device   |
| swbit[BITS_TO_LONGS(SW_CNT)]           | bitmap of switches present on the device   |
| hint_events_per_packet                 | average number of events generated by the device in a packet (between EV_SYN/SYN_REPORT events). Used by event handlers to estimate size of the buffer needed to hold events.                          |
| keycodemax                             | size of keycode table  |
| keycodesize                            | size of elements in keycode table  |
| keycode                                | map of scancodes to keycodes for this device   |
| setkeycode                             | optional method to alter current keymap, used to implement sparse keymaps. If not supplied default mechanism will be used. The method is being called while holding event_lock and thus must not sleep |
| getkeycode                             | optional legacy method to retrieve current keymap.   |
| ff                                     | force feedback structure associated with the device if device supports force feedback effects  |
| repeat_key                             | stores key code of the last key pressed; used to implement software autorepeat   |
| timer                                  | timer for software autorepeat  |

|  |  |
|--|--|
| <code>rep[REP_CNT]</code>                | current values for autorepeat parameters (delay, rate)   |
| <code>mt</code>                          | pointer to multitouch state  |
| <code>absinfo</code>                     | array of struct <code>input_absinfo</code> elements holding information about absolute axes (current value, min, max, flat, fuzz, resolution)  |
| <code>key[BITS_TO_LONGS(KEY_CNT)]</code> | reflects current state of device's keys/buttons  |
| <code>led[BITS_TO_LONGS(LED_CNT)]</code> | reflects current state of device's LEDs  |
| <code>snd[BITS_TO_LONGS(SND_CNT)]</code> | reflects current state of sound effects  |
| <code>sw[BITS_TO_LONGS(SW_CNT)]</code>   | reflects current state of device's switches  |
| <code>open</code>                        | this method is called when the very first user calls <code>input_open_device</code> . The driver must prepare the device to start generating events (start polling thread, request an IRQ, submit URB, etc.)   |
| <code>close</code>                       | this method is called when the very last user calls <code>input_close_device</code> .  |
| <code>flush</code>                       | purges the device. Most commonly used to get rid of force feedback effects loaded into the device when disconnecting from it   |
| <code>event</code>                       | event handler for events sent <code>_to_</code> the device, like <code>EV_LED</code> or <code>EV_SND</code> . The device is expected to carry out the requested action (turn on a LED, play sound, etc.) The call is protected by <code>event_lock</code> and must not sleep   |
| <code>grab</code>                        | input handle that currently has the device grabbed (via <code>EVIOC-GRAB</code> ioctl). When a handle grabs a device it becomes sole recipient for all input events coming from the device   |
| <code>event_lock</code>                  | this spinlock is taken when input core receives and processes a new event for the device (in <code>input_event</code> ). Code that accesses and/or modifies parameters of a device (such as keymap or absmin, absmax, absfuzz, etc.) after device has been registered with input core must take this lock.                       |
| <code>mutex</code>                       | serializes calls to <code>open</code> , <code>close</code> and <code>flush</code> methods  |
| <code>users</code>                       | stores number of users (input handlers) that opened this device. It is used by <code>input_open_device</code> and <code>input_close_device</code> to make sure that <code>dev-&gt;open</code> is only called when the first user opens device and <code>dev-&gt;close</code> is called when the very last user closes the device |
| <code>going_away</code>                  | marks devices that are in a middle of unregistering and causes <code>input_open_device*()</code> fail with <code>-ENODEV</code> .  |
| <code>dev</code>                         | driver model's view of this device   |
| <code>h_list</code>                      | list of input handles associated with the device. When accessing the list <code>dev-&gt;mutex</code> must be held  |

|                |  |
|----------------|--|
| node           | used to place the device onto input_dev_list   |
| num_vals       | number of values queued in the current frame   |
| max_vals       | maximum number of values queued in a frame   |
| vals           | array of values queued in the current frame  |
| devres_managed | indicates that devices is managed with devres framework and needs not be explicitly unregistered or freed. |

## Name

struct `input_handler` — implements one of interfaces for input devices

## Synopsis

```

struct input_handler {
    void * private;
    void (* event) (struct input_handle *handle, unsigned int type, unsigned int code);
    void (* events) (struct input_handle *handle, const struct input_value *vals, unsigned int type);
    bool (* filter) (struct input_handle *handle, unsigned int type, unsigned int code);
    bool (* match) (struct input_handler *handler, struct input_dev *dev);
    int (* connect) (struct input_handler *handler, struct input_dev *dev, const struct input_dev *parent);
    void (* disconnect) (struct input_handle *handle);
    void (* start) (struct input_handle *handle);
    bool legacy_minors;
    int minor;
    const char * name;
    const struct input_device_id * id_table;
    struct list_head h_list;
    struct list_head node;
};

```

## Members

|                            |  |
|----------------------------|--|
| <code>private</code>       | driver-specific data   |
| <code>event</code>         | event handler. This method is being called by input core with interrupts disabled and <code>dev-&gt;event_lock</code> spinlock held and so it may not sleep                |
| <code>events</code>        | event sequence handler. This method is being called by input core with interrupts disabled and <code>dev-&gt;event_lock</code> spinlock held and so it may not sleep       |
| <code>filter</code>        | similar to <i>event</i> ; separates normal event handlers from “filters”.  |
| <code>match</code>         | called after comparing device's id with handler's <code>id_table</code> to perform fine-grained matching between device and handler  |
| <code>connect</code>       | called when attaching a handler to an input device   |
| <code>disconnect</code>    | disconnects a handler from input device  |
| <code>start</code>         | starts handler for given handle. This function is called by input core right after <code>connect</code> method and also when a process that “grabbed” a device releases it |
| <code>legacy_minors</code> | set to <code>true</code> by drivers using legacy minor ranges  |
| <code>minor</code>         | beginning of range of 32 legacy minors for devices this driver can provide   |
| <code>name</code>          | name of the handler, to be shown in <code>/proc/bus/input/handlers</code>  |
| <code>id_table</code>      | pointer to a table of <code>input_device_ids</code> this driver can handle   |
| <code>h_list</code>        | list of input handles associated with the handler  |
| <code>node</code>          | for placing the driver onto <code>input_handler_list</code>  |

## Description

Input handlers attach to input devices and create input handles. There are likely several handlers attached to any given input device at the same time. All of them will get their copy of input event generated by the device.

The very same structure is used to implement input filters. Input core allows filters to run first and will not pass event to regular handlers if any of the filters indicate that the event should be filtered (by returning `true` from their `filter` method).

Note that input core serializes calls to `connect` and `disconnect` methods.

## Name

struct `input_handle` — links input device with an input handler

## Synopsis

```
struct input_handle {  
    void * private;  
    int open;  
    const char * name;  
    struct input_dev * dev;  
    struct input_handler * handler;  
    struct list_head d_node;  
    struct list_head h_node;  
};
```

## Members

|                      |  |
|----------------------|--|
| <code>private</code> | handler-specific data  |
| <code>open</code>    | counter showing whether the handle is 'open', i.e. should deliver events from its device |
| <code>name</code>    | name given to the handle by handler that created it                                      |
| <code>dev</code>     | input device the handle is attached to   |
| <code>handler</code> | handler that works with the device through this handle                                   |
| <code>d_node</code>  | used to put the handle on device's list of attached handles                              |
| <code>h_node</code>  | used to put the handle on handler's list of handles from which it gets events            |

## Name

`input_set_events_per_packet` — tell handlers about the driver event rate

## Synopsis

```
void input_set_events_per_packet (struct input_dev * dev, int n_events);
```

## Arguments

*dev*            the input device used by the driver

*n\_events*      the average number of events between calls to `input_sync`

## Description

If the event rate sent from a device is unusually large, use this function to set the expected event rate. This will allow handlers to set up an appropriate buffer size for the event stream, in order to minimize information loss.

## Name

struct ff\_device — force-feedback part of an input device

## Synopsis

```
struct ff_device {
    int (* upload) (struct input_dev *dev, struct ff_effect *effect, struct ff_effect
    int (* erase) (struct input_dev *dev, int effect_id);
    int (* playback) (struct input_dev *dev, int effect_id, int value);
    void (* set_gain) (struct input_dev *dev, u16 gain);
    void (* set_autocenter) (struct input_dev *dev, u16 magnitude);
    void (* destroy) (struct ff_device *);
    void * private;
    unsigned long ffbits[BITS_TO_LONGS(FF_CNT)];
    struct mutex mutex;
    int max_effects;
    struct ff_effect * effects;
    struct file * effect_owners[];
};
```

## Members

|                               |   |
|-------------------------------|---|
| upload                        | Called to upload an new effect into device  |
| erase                         | Called to erase an effect from device   |
| playback                      | Called to request device to start playing specified effect  |
| set_gain                      | Called to set specified gain  |
| set_autocenter                | Called to auto-center device  |
| destroy                       | called by input core when parent input device is being destroyed  |
| private                       | driver-specific data, will be freed automatically   |
| ffbits[BITS_TO_LONGS(FF_CNT)] | bitmap of force feedback capabilities truly supported by device (not emulated like ones in input_dev->ffbits) |
| mutex                         | mutex for serializing access to the device  |
| max_effects                   | maximum number of effects supported by device   |
| effects                       | pointer to an array of effects currently loaded into device   |
| effect_owners[]               | array of effect owners; when file handle owning an effect gets closed the effect is automatically erased      |

## Description

Every force-feedback device must implement `upload` and `playback` methods; `erase` is optional. `set_gain` and `set_autocenter` need only be implemented if driver sets up `FF_GAIN` and `FF_AUTOCENTER` bits.

Note that `playback`, `set_gain` and `set_autocenter` are called with `dev->event_lock` spinlock held and interrupts off and thus may not sleep.

## Name

`input_event` — report new input event

## Synopsis

```
void input_event (struct input_dev * dev, unsigned int type, unsigned  
int code, int value);
```

## Arguments

*dev* device that generated the event

*type* type of the event

*code* event code

*value* value of the event

## Description

This function should be used by drivers implementing various input devices to report input events. See also `input_inject_event`.

## NOTE

`input_event` may be safely used right after input device was allocated with `input_allocate_device`, even before it is registered with `input_register_device`, but the event will not reach any of the input handlers. Such early invocation of `input_event` may be used to 'seed' initial state of a switch or initial position of absolute axis, etc.

## Name

`input_inject_event` — send input event from input handler

## Synopsis

```
void input_inject_event (struct input_handle * handle, unsigned int type, unsigned int code, int value);
```

## Arguments

*handle* input handle to send event through

*type* type of the event

*code* event code

*value* value of the event

## Description

Similar to `input_event` but will ignore event if device is “grabbed” and handle injecting event is not the one that owns the device.

## Name

`input_alloc_absinfo` — allocates array of `input_absinfo` structs

## Synopsis

```
void input_alloc_absinfo (struct input_dev * dev);
```

## Arguments

*dev* the input device emitting absolute events

## Description

If the `absinfo` struct the caller asked for is already allocated, this functions will not do anything.

## Name

`input_grab_device` — grabs device for exclusive use

## Synopsis

```
int input_grab_device (struct input_handle * handle);
```

## Arguments

*handle* input handle that wants to own the device

## Description

When a device is grabbed by an input handle all events generated by the device are delivered only to this handle. Also events injected by other input handles are ignored while device is grabbed.

## Name

`input_release_device` — release previously grabbed device

## Synopsis

```
void input_release_device (struct input_handle * handle);
```

## Arguments

*handle* input handle that owns the device

## Description

Releases previously grabbed device so that other input handles can start receiving input events. Upon release all handlers attached to the device have their `start` method called so they have a change to synchronize device state with the rest of the system.

## Name

`input_open_device` — open input device

## Synopsis

```
int input_open_device (struct input_handle * handle);
```

## Arguments

*handle* handle through which device is being accessed

## Description

This function should be called by input handlers when they want to start receive events from given input device.

## Name

`input_close_device` — close input device

## Synopsis

```
void input_close_device (struct input_handle * handle);
```

## Arguments

*handle* handle through which device is being accessed

## Description

This function should be called by input handlers when they want to stop receive events from given input device.

## Name

`input_scancode_to_scalar` — converts scancode in struct `input_keymap_entry`

## Synopsis

```
int input_scancode_to_scalar (const struct input_keymap_entry * ke,
unsigned int * scancode);
```

## Arguments

*ke*            keymap entry containing scancode to be converted.

*scancode*    pointer to the location where converted scancode should be stored.

## Description

This function is used to convert scancode stored in struct `keymap_entry` into scalar form understood by legacy keymap handling methods. These methods expect scancodes to be represented as 'unsigned int'.

## Name

`input_get_keycode` — retrieve keycode currently mapped to a given scancode

## Synopsis

```
int input_get_keycode (struct input_dev * dev, struct input_keymap_entry  
* ke);
```

## Arguments

*dev* input device which keymap is being queried

*ke* keymap entry

## Description

This function should be called by anyone interested in retrieving current keymap. Presently evdev handlers use it.

## Name

`input_set_keycode` — attribute a keycode to a given scancode

## Synopsis

```
int input_set_keycode (struct input_dev * dev, const struct
input_keymap_entry * ke);
```

## Arguments

*dev* input device which keymap is being updated

*ke* new keymap entry

## Description

This function should be called by anyone needing to update current keymap. Presently keyboard and evdev handlers use it.

## Name

`input_reset_device` — reset/restore the state of input device

## Synopsis

```
void input_reset_device (struct input_dev * dev);
```

## Arguments

*dev* input device whose state needs to be reset

## Description

This function tries to reset the state of an opened input device and bring internal state and state if the hardware in sync with each other. We mark all keys as released, restore LED state, repeat rate, etc.

## Name

`input_allocate_device` — allocate memory for new input device

## Synopsis

```
struct input_dev * input_allocate_device ( void );
```

## Arguments

*void* no arguments

## Description

Returns prepared struct `input_dev` or `NULL`.

## NOTE

Use `input_free_device` to free devices that have not been registered; `input_unregister_device` should be used for already registered devices.

## Name

`devm_input_allocate_device` — allocate managed input device

## Synopsis

```
struct input_dev * devm_input_allocate_device (struct device * dev);
```

## Arguments

*dev* device owning the input device being created

## Description

Returns prepared struct `input_dev` or `NULL`.

Managed input devices do not need to be explicitly unregistered or freed as it will be done automatically when owner device unbinds from its driver (or binding fails). Once managed input device is allocated, it is ready to be set up and registered in the same fashion as regular input device. There are no special `devm_input_device_[un]register` variants, regular ones work with both managed and unmanaged devices, should you need them. In most cases however, managed input device need not be explicitly unregistered or freed.

## NOTE

the owner device is set up as parent of input device and users should not override it.

## Name

`input_free_device` — free memory occupied by `input_dev` structure

## Synopsis

```
void input_free_device (struct input_dev * dev);
```

## Arguments

*dev* input device to free

## Description

This function should only be used if `input_register_device` was not called yet or if it failed. Once device was registered use `input_unregister_device` and memory will be freed once last reference to the device is dropped.

Device should be allocated by `input_allocate_device`.

## NOTE

If there are references to the input device then memory will not be freed until last reference is dropped.

## Name

`input_set_capability` — mark device as capable of a certain event

## Synopsis

```
void input_set_capability (struct input_dev * dev, unsigned int type,  
unsigned int code);
```

## Arguments

*dev* device that is capable of emitting or accepting event

*type* type of the event (EV\_KEY, EV\_REL, etc...)

*code* event code

## Description

In addition to setting up corresponding bit in appropriate capability bitmap the function also adjusts `dev->evbit`.

## Name

`input_register_device` — register device with input core

## Synopsis

```
int input_register_device (struct input_dev * dev);
```

## Arguments

*dev* device to be registered

## Description

This function registers device with input core. The device must be allocated with `input_allocate_device` and all its capabilities set up before registering. If function fails the device must be freed with `input_free_device`. Once device has been successfully registered it can be unregistered with `input_unregister_device`; `input_free_device` should not be called in this case.

Note that this function is also used to register managed input devices (ones allocated with `devm_input_allocate_device`). Such managed input devices need not be explicitly unregistered or freed, their tear down is controlled by the devres infrastructure. It is also worth noting that tear down of managed input devices is internally a 2-step process: registered managed input device is first unregistered, but stays in memory and can still handle `input_event` calls (although events will not be delivered anywhere). The freeing of managed input device will happen later, when devres stack is unwound to the point where device allocation was made.

## Name

`input_unregister_device` — unregister previously registered device

## Synopsis

```
void input_unregister_device (struct input_dev * dev);
```

## Arguments

*dev* device to be unregistered

## Description

This function unregisters an input device. Once device is unregistered the caller should not try to access it as it may get freed at any moment.

## Name

`input_register_handler` — register a new input handler

## Synopsis

```
int input_register_handler (struct input_handler * handler);
```

## Arguments

*handler* handler to be registered

## Description

This function registers a new input handler (interface) for input devices in the system and attaches it to all input devices that are compatible with the handler.

## Name

`input_unregister_handler` — unregisters an input handler

## Synopsis

```
void input_unregister_handler (struct input_handler * handler);
```

## Arguments

*handler* handler to be unregistered

## Description

This function disconnects a handler from its input devices and removes it from lists of known handlers.

## Name

`input_handler_for_each_handle` — handle iterator

## Synopsis

```
int input_handler_for_each_handle (struct input_handler * handler, void  
* data, int (*fn) (struct input_handle *, void *));
```

## Arguments

*handler* input handler to iterate

*data* data for the callback

*fn* function to be called for each handle

## Description

Iterate over *bus*'s list of devices, and call *fn* for each, passing it *data* and stop when *fn* returns a non-zero value. The function is using RCU to traverse the list and therefore may be used in atonic contexts. The *fn* callback is invoked from RCU critical section and thus must not sleep.

## Name

`input_register_handle` — register a new input handle

## Synopsis

```
int input_register_handle (struct input_handle * handle);
```

## Arguments

*handle* handle to register

## Description

This function puts a new input handle onto device's and handler's lists so that events can flow through it once it is opened using `input_open_device`.

This function is supposed to be called from handler's `connect` method.

## Name

`input_unregister_handle` — unregister an input handle

## Synopsis

```
void input_unregister_handle (struct input_handle * handle);
```

## Arguments

*handle* handle to unregister

## Description

This function removes input handle from device's and handler's lists.

This function is supposed to be called from handler's `disconnect` method.

## Name

`input_get_new_minor` — allocates a new input minor number

## Synopsis

```
int input_get_new_minor (int legacy_base, unsigned int legacy_num, bool  
allow_dynamic);
```

## Arguments

*legacy\_base*      beginning of the legacy range to be searched

*legacy\_num*      size of legacy range

*allow\_dynamic*   whether we can also take ID from the dynamic range

## Description

This function allocates a new device minor for from input major namespace. Caller can request legacy minor by specifying *legacy\_base* and *legacy\_num* parameters and whether ID can be allocated from dynamic range if there are no free IDs in legacy range.

## Name

`input_free_minor` — release previously allocated minor

## Synopsis

```
void input_free_minor (unsigned int minor);
```

## Arguments

*minor* minor to be released

## Description

This function releases previously allocated input minor so that it can be reused later.

## Name

`input_ff_upload` — upload effect into force-feedback device

## Synopsis

```
int input_ff_upload (struct input_dev * dev, struct ff_effect * effect,  
struct file * file);
```

## Arguments

*dev*      input device

*effect*   effect to be uploaded

*file*      owner of the effect

## Name

`input_ff_erase` — erase a force-feedback effect from device

## Synopsis

```
int input_ff_erase (struct input_dev * dev, int effect_id, struct file  
* file);
```

## Arguments

*dev*           input device to erase effect from

*effect\_id*    id of the effect to be erased

*file*           purported owner of the request

## Description

This function erases a force-feedback effect from specified device. The effect will only be erased if it was uploaded through the same file handle that is requesting erase.

## Name

`input_ff_event` — generic handler for force-feedback events

## Synopsis

```
int input_ff_event (struct input_dev * dev, unsigned int type, unsigned  
int code, int value);
```

## Arguments

*dev*     input device to send the effect to

*type*    event type (anything but EV\_FF is ignored)

*code*    event code

*value*   event value

## Name

`input_ff_create` — create force-feedback device

## Synopsis

```
int input_ff_create (struct input_dev * dev, unsigned int max_effects);
```

## Arguments

*dev*                   input device supporting force-feedback

*max\_effects*       maximum number of effects supported by the device

## Description

This function allocates all necessary memory for a force feedback portion of an input device and installs all default handlers. *dev->ffbit* should be already set up before calling this function. Once ff device is created you need to setup its upload, erase, playback and other handlers before registering input device

## Name

`input_ff_destroy` — frees force feedback portion of input device

## Synopsis

```
void input_ff_destroy (struct input_dev * dev);
```

## Arguments

*dev* input device supporting force feedback

## Description

This function is only needed in error path as input core will automatically free force feedback structures when device is destroyed.

## Name

`input_ff_create_memless` — create memoryless force-feedback device

## Synopsis

```
int input_ff_create_memless (struct input_dev * dev, void * data, int  
(*play_effect) (struct input_dev *, void *, struct ff_effect *));
```

## Arguments

*dev*           input device supporting force-feedback

*data*           driver-specific data to be passed into *play\_effect*

*play\_effect*   driver-specific method for playing FF effect

## Multitouch Library

## Name

struct `input_mt_slot` — represents the state of an input MT slot

## Synopsis

```
struct input_mt_slot {  
    int abs[ABS_MT_LAST - ABS_MT_FIRST + 1];  
    unsigned int frame;  
    unsigned int key;  
};
```

## Members

|  |  |
|--|--|
| <code>abs[ABS_MT_LAST - ABS_MT_FIRST + 1]</code> | holds current values of ABS_MT axes for this slot                      |
| <code>frame</code>                               | last frame at which <code>input_mt_report_slot_state</code> was called |
| <code>key</code>                                 | optional driver designation of this slot                               |

## Name

struct `input_mt` — state of tracked contacts

## Synopsis

```
struct input_mt {
    int trkid;
    int num_slots;
    int slot;
    unsigned int flags;
    unsigned int frame;
    int * red;
    struct input_mt_slot slots[];
};
```

## Members

|                        |   |
|------------------------|---|
| <code>trkid</code>     | stores MT tracking ID for the next contact                      |
| <code>num_slots</code> | number of MT slots the device uses                              |
| <code>slot</code>      | MT slot currently being transmitted                             |
| <code>flags</code>     | <code>input_mt</code> operation flags                           |
| <code>frame</code>     | increases every time <code>input_mt_sync_frame</code> is called |
| <code>red</code>       | reduced cost matrix for in-kernel tracking                      |
| <code>slots[]</code>   | array of slots holding current values of tracked contacts       |

## Name

struct input\_mt\_pos — contact position

## Synopsis

```
struct input_mt_pos {  
    s16 x;  
    s16 y;  
};
```

## Members

x horizontal coordinate

y vertical coordinate

## Name

`input_mt_init_slots` — initialize MT input slots

## Synopsis

```
int input_mt_init_slots (struct input_dev * dev, unsigned int num_slots,  
unsigned int flags);
```

## Arguments

*dev*           input device supporting MT events and finger tracking

*num\_slots*    number of slots used by the device

*flags*         mt tasks to handle in core

## Description

This function allocates all necessary memory for MT slot handling in the input device, prepares the `ABS_MT_SLOT` and `ABS_MT_TRACKING_ID` events for use and sets up appropriate buffers. Depending on the flags set, it also performs pointer emulation and frame synchronization.

May be called repeatedly. Returns `-EINVAL` if attempting to reinitialize with a different number of slots.

## Name

`input_mt_destroy_slots` — frees the MT slots of the input device

## Synopsis

```
void input_mt_destroy_slots (struct input_dev * dev);
```

## Arguments

*dev* input device with allocated MT slots

## Description

This function is only needed in error path as the input core will automatically free the MT slots when the device is destroyed.

## Name

`input_mt_report_slot_state` — report contact state

## Synopsis

```
void input_mt_report_slot_state (struct input_dev * dev, unsigned int  
tool_type, bool active);
```

## Arguments

*dev*           input device with allocated MT slots

*tool\_type*    the tool type to use in this slot

*active*       true if contact is active, false otherwise

## Description

Reports a contact via `ABS_MT_TRACKING_ID`, and optionally `ABS_MT_TOOL_TYPE`. If `active` is true and the slot is currently inactive, or if the tool type is changed, a new tracking id is assigned to the slot. The tool type is only reported if the corresponding `absbit` field is set.

## Name

`input_mt_report_finger_count` — report contact count

## Synopsis

```
void input_mt_report_finger_count (struct input_dev * dev, int count);
```

## Arguments

*dev* input device with allocated MT slots

*count* the number of contacts

## Description

Reports the contact count via `BTN_TOOL_FINGER`, `BTN_TOOL_DOUBLETAP`, `BTN_TOOL_TRIPLETAP` and `BTN_TOOL_QUADTAP`.

The input core ensures only the `KEY` events already setup for this device will produce output.

## Name

`input_mt_report_pointer_emulation` — common pointer emulation

## Synopsis

```
void input_mt_report_pointer_emulation (struct input_dev * dev, bool  
use_count);
```

## Arguments

*dev*           input device with allocated MT slots

*use\_count*   report number of active contacts as finger count

## Description

Performs legacy pointer emulation via `BTN_TOUCH`, `ABS_X`, `ABS_Y` and `ABS_PRESSURE`. Touchpad finger count is emulated if `use_count` is true.

The input core ensures only the `KEY` and `ABS` axes already setup for this device will produce output.

## Name

`input_mt_drop_unused` — Inactivate slots not seen in this frame

## Synopsis

```
void input_mt_drop_unused (struct input_dev * dev);
```

## Arguments

*dev* input device with allocated MT slots

## Description

Lift all slots not seen since the last call to this function.

## Name

`input_mt_sync_frame` — synchronize mt frame

## Synopsis

```
void input_mt_sync_frame (struct input_dev * dev);
```

## Arguments

*dev* input device with allocated MT slots

## Description

Close the frame and prepare the internal state for a new one. Depending on the flags, marks unused slots as inactive and performs pointer emulation.

## Name

`input_mt_assign_slots` — perform a best-match assignment

## Synopsis

```
int input_mt_assign_slots (struct input_dev * dev, int * slots, const
struct input_mt_pos * pos, int num_pos, int dmax);
```

## Arguments

*dev*        input device with allocated MT slots

*slots*     the slot assignment to be filled

*pos*        the position array to match

*num\_pos*   number of positions

*dmax*      maximum ABS\_MT\_POSITION displacement (zero for infinite)

## Description

Performs a best match against the current contacts and returns the slot assignment list. New contacts are assigned to unused slots.

The assignments are balanced so that all coordinate displacements are below the euclidian distance `dmax`. If no such assignment can be found, some contacts are assigned to unused slots.

Returns zero on success, or negative error in case of failure.

## Name

`input_mt_get_slot_by_key` — return slot matching key

## Synopsis

```
int input_mt_get_slot_by_key (struct input_dev * dev, int key);
```

## Arguments

*dev* input device with allocated MT slots

*key* the key of the sought slot

## Description

Returns the slot of the given key, if it exists, otherwise set the key on the first unused slot and return.

If no available slot can be found, -1 is returned. Note that for this function to work properly, `input_mt_sync_frame` has to be called at each frame.

## Polled input devices

## Name

struct `input_polled_dev` — simple polled input device

## Synopsis

```
struct input_polled_dev {
    void * private;
    void (* open) (struct input_polled_dev *dev);
    void (* close) (struct input_polled_dev *dev);
    void (* poll) (struct input_polled_dev *dev);
    unsigned int poll_interval;
    unsigned int poll_interval_max;
    unsigned int poll_interval_min;
    struct input_dev * input;
};
```

## Members

|                                |  |
|--------------------------------|--|
| <code>private</code>           | private driver data.   |
| <code>open</code>              | driver-supplied method that prepares device for polling (enabled the device and maybe flushes device state).                           |
| <code>close</code>             | driver-supplied method that is called when device is no longer being polled. Used to put device into low power mode.                   |
| <code>poll</code>              | driver-supplied method that polls the device and posts input events (mandatory).   |
| <code>poll_interval</code>     | specifies how often the <code>poll</code> method should be called. Defaults to 500 msec unless overridden when registering the device. |
| <code>poll_interval_max</code> | specifies upper bound for the poll interval. Defaults to the initial value of <i>poll_interval</i> .                                   |
| <code>poll_interval_min</code> | specifies lower bound for the poll interval. Defaults to 0.  |
| <code>input</code>             | input device structure associated with the polled device. Must be properly initialized by the driver (id, name, phys, bits).           |

## Description

Polled input device provides a skeleton for supporting simple input devices that do not raise interrupts but have to be periodically scanned or polled to detect changes in their state.

## Name

`input_allocate_polled_device` — allocate memory for polled device

## Synopsis

```
struct input_polled_dev * input_allocate_polled_device ( void );
```

## Arguments

*void* no arguments

## Description

The function allocates memory for a polled device and also for an input device associated with this polled device.

## Name

`devm_input_allocate_polled_device` — allocate managed polled device

## Synopsis

```
struct input_polled_dev * devm_input_allocate_polled_device (struct de-  
vice * dev);
```

## Arguments

*dev* device owning the polled device being created

## Description

Returns prepared struct `input_polled_dev` or `NULL`.

Managed polled input devices do not need to be explicitly unregistered or freed as it will be done automatically when owner device unbinds from \* its driver (or binding fails). Once such managed polled device is allocated, it is ready to be set up and registered in the same fashion as regular polled input devices (using `input_register_polled_device` function).

If you want to manually unregister and free such managed polled devices, it can be still done by calling `input_unregister_polled_device` and `input_free_polled_device`, although it is rarely needed.

## NOTE

the owner device is set up as parent of input device and users should not override it.

## Name

`input_free_polled_device` — free memory allocated for polled device

## Synopsis

```
void input_free_polled_device (struct input_polled_dev * dev);
```

## Arguments

*dev* device to free

## Description

The function frees memory allocated for polling device and drops reference to the associated input device.

## Name

`input_register_polled_device` — register polled device

## Synopsis

```
int input_register_polled_device (struct input_polled_dev * dev);
```

## Arguments

*dev* device to register

## Description

The function registers previously initialized polled input device with input layer. The device should be allocated with call to `input_allocate_polled_device`. Callers should also set up `poll` method and set up capabilities (`id`, `name`, `phys`, `bits`) of the corresponding `input_dev` structure.

## Name

`input_unregister_polled_device` — unregister polled device

## Synopsis

```
void input_unregister_polled_device (struct input_polled_dev * dev);
```

## Arguments

*dev* device to unregister

## Description

The function unregisters previously registered polled input device from input layer. Polling is stopped and device is ready to be freed with call to `input_free_polled_device`.

## Matrix keyboards/keypads

## Name

struct matrix\_keymap\_data — keymap for matrix keyboards

## Synopsis

```
struct matrix_keymap_data {  
    const uint32_t * keymap;  
    unsigned int keymap_size;  
};
```

## Members

|             |  |
|-------------|--|
| keymap      | pointer to array of uint32 values encoded with KEY macro representing keymap |
| keymap_size | number of entries (initialized) in this keymap                               |

## Description

This structure is supposed to be used by platform code to supply keymaps to drivers that implement matrix-like keypads/keyboards.

## Name

struct matrix\_keypad\_platform\_data — platform-dependent keypad data

## Synopsis

```
struct matrix_keypad_platform_data {
    const struct matrix_keymap_data * keymap_data;
    const unsigned int * row_gpios;
    const unsigned int * col_gpios;
    unsigned int num_row_gpios;
    unsigned int num_col_gpios;
    unsigned int col_scan_delay_us;
    unsigned int debounce_ms;
    unsigned int clustered_irq;
    unsigned int clustered_irq_flags;
    bool active_low;
    bool wakeup;
    bool no_autorepeat;
};
```

## Members

|                     |   |
|---------------------|---|
| keymap_data         | pointer to matrix_keymap_data   |
| row_gpios           | pointer to array of gpio numbers representing rows  |
| col_gpios           | pointer to array of gpio numbers representing columns   |
| num_row_gpios       | actual number of row gpios used by device   |
| num_col_gpios       | actual number of col gpios used by device   |
| col_scan_delay_us   | delay, measured in microseconds, that is needed before we can keypad after activating column gpio |
| debounce_ms         | debounce interval in milliseconds   |
| clustered_irq       | may be specified if interrupts of all row/column GPIOs are bundled to one single irq              |
| clustered_irq_flags | flags that are needed for the clustered irq   |
| active_low          | gpio polarity   |
| wakeup              | controls whether the device should be set up as wakeup source                                     |
| no_autorepeat       | disable key autorepeat  |

## Description

This structure represents platform-specific data that use used by matrix\_keypad driver to perform proper initialization.

## Name

`matrix_keypad_parse_of_params` — Read parameters from matrix-keypad node

## Synopsis

```
int matrix_keypad_parse_of_params (struct device * dev, unsigned int *  
rows, unsigned int * cols);
```

## Arguments

*dev* Device containing of\_node

*rows* Returns number of matrix rows

*cols* Returns number of matrix columns *return* 0 if OK, <0 on error

## Sparse keymap support

## Name

struct `key_entry` — keymap entry for use in sparse keymap

## Synopsis

```
struct key_entry {
    int type;
    u32 code;
    union {unnamed_union};
};
```

## Members

|                              |  |
|------------------------------|--|
| <code>type</code>            | Type of the key entry ( <code>KE_KEY</code> , <code>KE_SW</code> , <code>KE_VSW</code> , <code>KE_END</code> ); drivers are allowed to extend the list with their own private definitions. |
| <code>code</code>            | Device-specific data identifying the button/switch   |
| <code>{unnamed_union}</code> | anonymous  |

## Description

This structure defines an entry in a sparse keymap used by some input devices for which traditional table-based approach is not suitable.

## Name

`sparse_keymap_entry_from_scancode` — perform sparse keymap lookup

## Synopsis

```
struct key_entry * sparse_keymap_entry_from_scancode (struct input_dev  
* dev, unsigned int code);
```

## Arguments

*dev* Input device using sparse keymap

*code* Scan code

## Description

This function is used to perform struct `key_entry` lookup in an input device using sparse keymap.

## Name

`sparse_keymap_entry_from_keycode` — perform sparse keymap lookup

## Synopsis

```
struct key_entry * sparse_keymap_entry_from_keycode (struct input_dev  
* dev, unsigned int keycode);
```

## Arguments

*dev*        Input device using sparse keymap

*keycode*   Key code

## Description

This function is used to perform struct `key_entry` lookup in an input device using sparse keymap.

## Name

`sparse_keymap_setup` — set up sparse keymap for an input device

## Synopsis

```
int sparse_keymap_setup (struct input_dev * dev, const struct key_entry  
* keymap, int (*setup) (struct input_dev *, struct key_entry *));
```

## Arguments

*dev*      Input device

*keymap*   Keymap in form of array of `key_entry` structures ending with `KE_END` type entry

*setup*    Function that can be used to adjust keymap entries depending on device's deeds, may be `NULL`

## Description

The function calculates size and allocates copy of the original keymap after which sets up input device event bits appropriately. Before destroying input device allocated keymap should be freed with a call to `sparse_keymap_free`.

## Name

`sparse_keymap_free` — free memory allocated for sparse keymap

## Synopsis

```
void sparse_keymap_free (struct input_dev * dev);
```

## Arguments

*dev* Input device using sparse keymap

## Description

This function is used to free memory allocated by sparse keymap in an input device that was set up by `sparse_keymap_setup`.

## NOTE

It is safe to call this function while input device is still registered (however the drivers should care not to try to use freed keymap and thus have to shut off interrupts/polling before freeing the keymap).

## Name

`sparse_keymap_report_entry` — report event corresponding to given key entry

## Synopsis

```
void sparse_keymap_report_entry (struct input_dev * dev, const struct  
key_entry * ke, unsigned int value, bool autorelease);
```

## Arguments

|                    |  |
|--------------------|--|
| <i>dev</i>         | Input device for which event should be reported  |
| <i>ke</i>          | key entry describing event   |
| <i>value</i>       | Value that should be reported (ignored by KE_SW entries)   |
| <i>autorelease</i> | Signals whether release event should be emitted for KE_KEY entries right after reporting press event, ignored by all other entries |

## Description

This function is used to report input event described by given struct `key_entry`.

## Name

`sparse_keymap_report_event` — report event corresponding to given scancode

## Synopsis

```
bool sparse_keymap_report_event (struct input_dev * dev, unsigned int
code, unsigned int value, bool autorelease);
```

## Arguments

|                    |  |
|--------------------|--|
| <i>dev</i>         | Input device using sparse keymap   |
| <i>code</i>        | Scan code  |
| <i>value</i>       | Value that should be reported (ignored by KE_SW entries)   |
| <i>autorelease</i> | Signals whether release event should be emitted for KE_KEY entries right after reporting press event, ignored by all other entries |

## Description

This function is used to perform lookup in an input device using sparse keymap and report corresponding event. Returns `true` if lookup was successful and `false` otherwise.

---

# Chapter 9. Serial Peripheral Interface (SPI)

SPI is the "Serial Peripheral Interface", widely used with embedded systems because it is a simple and efficient interface: basically a multiplexed shift register. Its three signal wires hold a clock (SCK, often in the range of 1-20 MHz), a "Master Out, Slave In" (MOSI) data line, and a "Master In, Slave Out" (MISO) data line. SPI is a full duplex protocol; for each bit shifted out the MOSI line (one per clock) another is shifted in on the MISO line. Those bits are assembled into words of various sizes on the way to and from system memory. An additional chipselect line is usually active-low (nCS); four signals are normally used for each peripheral, plus sometimes an interrupt.

The SPI bus facilities listed here provide a generalized interface to declare SPI busses and devices, manage them according to the standard Linux driver model, and perform input/output operations. At this time, only "master" side interfaces are supported, where Linux talks to SPI peripherals and does not implement such a peripheral itself. (Interfaces to support implementing SPI slaves would necessarily look different.)

The programming interface is structured around two kinds of driver, and two kinds of device. A "Controller Driver" abstracts the controller hardware, which may be as simple as a set of GPIO pins or as complex as a pair of FIFOs connected to dual DMA engines on the other side of the SPI shift register (maximizing throughput). Such drivers bridge between whatever bus they sit on (often the platform bus) and SPI, and expose the SPI side of their device as a struct `spi_master`. SPI devices are children of that master, represented as a struct `spi_device` and manufactured from struct `spi_board_info` descriptors which are usually provided by board-specific initialization code. A struct `spi_driver` is called a "Protocol Driver", and is bound to a `spi_device` using normal driver model calls.

The I/O model is a set of queued messages. Protocol drivers submit one or more struct `spi_message` objects, which are processed and completed asynchronously. (There are synchronous wrappers, however.) Messages are built from one or more struct `spi_transfer` objects, each of which wraps a full duplex SPI transfer. A variety of protocol tweaking options are needed, because different chips adopt very different policies for how they use the bits transferred with SPI.

## Name

struct spi\_device — Master side proxy for an SPI slave device

## Synopsis

```

struct spi_device {
    struct device dev;
    struct spi_master * master;
    u32 max_speed_hz;
    u8 chip_select;
    u8 bits_per_word;
    u16 mode;
#define SPI_CPHA 0x01
#define SPI_CPOL 0x02
#define SPI_MODE_0 (0|0)
#define SPI_MODE_1 (0|SPI_CPHA)
#define SPI_MODE_2 (SPI_CPOL|0)
#define SPI_MODE_3 (SPI_CPOL|SPI_CPHA)
#define SPI_CS_HIGH 0x04
#define SPI_LSB_FIRST 0x08
#define SPI_3WIRE 0x10
#define SPI_LOOP 0x20
#define SPI_NO_CS 0x40
#define SPI_READY 0x80
#define SPI_TX_DUAL 0x100
#define SPI_TX_QUAD 0x200
#define SPI_RX_DUAL 0x400
#define SPI_RX_QUAD 0x800
    int irq;
    void * controller_state;
    void * controller_data;
    char modalias[SPI_NAME_SIZE];
    int cs_gpio;
};

```

## Members

|               |  |
|---------------|--|
| dev           | Driver model representation of the device.   |
| master        | SPI controller used with the device.   |
| max_speed_hz  | Maximum clock rate to be used with this chip (on this board); may be changed by the device's driver. The <code>spi_transfer.speed_hz</code> can override this for each transfer.   |
| chip_select   | Chipselect, distinguishing chips handled by <i>master</i> .  |
| bits_per_word | Data transfers involve one or more words; word sizes like eight or 12 bits are common. In-memory wordsizes are powers of two bytes (e.g. 20 bit samples use 32 bits). This may be changed by the device's driver, or left at the default (0) indicating protocol words are eight bit bytes. The <code>spi_transfer.bits_per_word</code> can override this for each transfer. |

|                                      |   |
|--------------------------------------|---|
| <code>mode</code>                    | The spi mode defines how data is clocked out and in. This may be changed by the device's driver. The “active low” default for chipselect mode can be overridden (by specifying <code>SPI_CS_HIGH</code> ) as can the “MSB first” default for each word in a transfer (by specifying <code>SPI_LSB_FIRST</code> ). |
| <code>irq</code>                     | Negative, or the number passed to <code>request_irq</code> to receive interrupts from this device.  |
| <code>controller_state</code>        | Controller's runtime state  |
| <code>controller_data</code>         | Board-specific definitions for controller, such as FIFO initialization parameters; from <code>board_info.controller_data</code>   |
| <code>modalias[SPI_NAME_SIZE]</code> | Name of the driver to use with this device, or an alias for that name. This appears in the sysfs “modalias” attribute for driver coldplugging, and in uevents used for hotplugging  |
| <code>cs_gpio</code>                 | gpio number of the chipselect line (optional, <code>-ENOENT</code> when not using a GPIO line)  |

## Description

A *spi\_device* is used to interchange data between an SPI slave (usually a discrete chip) and CPU memory.

In *dev*, the `platform_data` is used to hold information about this device that's meaningful to the device's protocol driver, but not to its controller. One example might be an identifier for a chip variant with slightly different functionality; another might be information about how this particular board wires the chip's pins.

## Name

struct spi\_driver — Host side “protocol” driver

## Synopsis

```
struct spi_driver {
    const struct spi_device_id * id_table;
    int (* probe) (struct spi_device *spi);
    int (* remove) (struct spi_device *spi);
    void (* shutdown) (struct spi_device *spi);
    struct device_driver driver;
};
```

## Members

|          |   |
|----------|---|
| id_table | List of SPI devices supported by this driver  |
| probe    | Binds this driver to the spi device. Drivers can verify that the device is actually present, and may need to configure characteristics (such as bits_per_word) which weren't needed for the initial configuration done during system setup. |
| remove   | Unbinds this driver from the spi device   |
| shutdown | Standard shutdown callback used during system state transitions such as powerdown/halt and kexec  |
| driver   | SPI device drivers should initialize the name and owner field of this structure.  |

## Description

This represents the kind of device driver that uses SPI messages to interact with the hardware at the other end of a SPI link. It's called a “protocol” driver because it works through messages rather than talking directly to SPI hardware (which is what the underlying SPI controller driver does to pass those messages). These protocols are defined in the specification for the device(s) supported by the driver.

As a rule, those device protocols represent the lowest level interface supported by a driver, and it will support upper level interfaces too. Examples of such upper levels include frameworks like MTD, networking, MMC, RTC, filesystem character device nodes, and hardware monitoring.

## Name

`spi_unregister_driver` — reverse effect of `spi_register_driver`

## Synopsis

```
void spi_unregister_driver (struct spi_driver * sdrv);
```

## Arguments

*sdrv* the driver to unregister

## Context

can sleep

## Name

`module_spi_driver` — Helper macro for registering a SPI driver

## Synopsis

```
module_spi_driver ( __spi_driver);
```

## Arguments

`__spi_driver` `spi_driver` struct

## Description

Helper macro for SPI drivers which do not do anything special in module init/exit. This eliminates a lot of boilerplate. Each module may only use this macro once, and calling it replaces `module_init` and `module_exit`

## Name

struct spi\_master — interface to SPI master controller

## Synopsis

```

struct spi_master {
    struct device dev;
    struct list_head list;
    s16 bus_num;
    u16 num_chipselect;
    u16 dma_alignment;
    u16 mode_bits;
    u32 bits_per_word_mask;
#define SPI_BPW_MASK(bits) BIT((bits) - 1)
#define SPI_BIT_MASK(bits) (((bits) == 32) ? ~0U : (BIT(bits) - 1))
#define SPI_BPW_RANGE_MASK(min# max) (SPI_BIT_MASK(max) - SPI_BIT_MASK(min - 1))
    u32 min_speed_hz;
    u32 max_speed_hz;
    u16 flags;
#define SPI_MASTER_HALF_DUPLEX BIT(0)
#define SPI_MASTER_NO_RX BIT(1)
#define SPI_MASTER_NO_TX BIT(2)
#define SPI_MASTER_MUST_RX BIT(3)
#define SPI_MASTER_MUST_TX BIT(4)
    spinlock_t bus_lock_spinlock;
    struct mutex bus_lock_mutex;
    bool bus_lock_flag;
    int (* setup) (struct spi_device *spi);
    int (* transfer) (struct spi_device *spi, struct spi_message *msg);
    void (* cleanup) (struct spi_device *spi);
    bool (* can_dma) (struct spi_master *master, struct spi_device *spi, struct spi_tr
    bool queued;
    struct kthread_worker kworker;
    struct task_struct * kworker_task;
    struct kthread_work pump_messages;
    spinlock_t queue_lock;
    struct list_head queue;
    struct spi_message * cur_msg;
    bool idling;
    bool busy;
    bool running;
    bool rt;
    bool auto_runtime_pm;
    bool cur_msg_prepared;
    bool cur_msg_mapped;
    struct completion xfer_completion;
    size_t max_dma_len;
    int (* prepare_transfer_hardware) (struct spi_master *master);
    int (* transfer_one_message) (struct spi_master *master, struct spi_message *msg);
    int (* unprepare_transfer_hardware) (struct spi_master *master);
    int (* prepare_message) (struct spi_master *master, struct spi_message *message);
    int (* unprepare_message) (struct spi_master *master, struct spi_message *message);

```

```

void (* set_cs) (struct spi_device *spi, bool enable);
int (* transfer_one) (struct spi_master *master, struct spi_device *spi, struct s
void (* handle_err) (struct spi_master *master, struct spi_message *message);
int * cs_gpios;
struct dma_chan * dma_tx;
struct dma_chan * dma_rx;
void * dummy_rx;
void * dummy_tx;
};

```

## Members

|                    |  |
|--------------------|--|
| dev                | device interface to this driver  |
| list               | link with the global spi_master list   |
| bus_num            | board-specific (and often SOC-specific) identifier for a given SPI controller.   |
| num_chipselect     | chipselects are used to distinguish individual SPI slaves, and are numbered from zero to num_chipselects. each slave has a chipselect signal, but it's common that not every chipselect is connected to a slave.   |
| dma_alignment      | SPI controller constraint on DMA buffers alignment.  |
| mode_bits          | flags understood by this controller driver   |
| bits_per_word_mask | A mask indicating which values of bits_per_word are supported by the driver. Bit n indicates that a bits_per_word n+1 is supported. If set, the SPI core will reject any transfer with an unsupported bits_per_word. If not set, this value is simply ignored, and it's up to the individual driver to perform any validation. |
| min_speed_hz       | Lowest supported transfer speed  |
| max_speed_hz       | Highest supported transfer speed   |
| flags              | other constraints relevant to this driver  |
| bus_lock_spinlock  | spinlock for SPI bus locking   |
| bus_lock_mutex     | mutex for SPI bus locking  |
| bus_lock_flag      | indicates that the SPI bus is locked for exclusive use   |
| setup              | updates the device mode and clocking records used by a device's SPI controller; protocol code may call this. This must fail if an unrecognized or unsupported mode is requested. It's always safe to call this unless transfers are pending on the device whose settings are being modified.                                   |
| transfer           | adds a message to the controller's transfer queue.   |
| cleanup            | frees controller-specific state  |
| can_dma            | determine whether this master supports DMA   |

|                             |   |
|-----------------------------|---|
| queued                      | whether this master is providing an internal message queue  |
| kworker                     | thread struct for message pump  |
| kworker_task                | pointer to task for message pump kworker thread   |
| pump_messages               | work struct for scheduling work to the message pump   |
| queue_lock                  | spinlock to synchronise access to message queue   |
| queue                       | message queue   |
| cur_msg                     | the currently in-flight message   |
| idling                      | the device is entering idle state   |
| busy                        | message pump is busy  |
| running                     | message pump is running   |
| rt                          | whether this queue is set to run as a realtime task   |
| auto_runtime_pm             | the core should ensure a runtime PM reference is held while the hardware is prepared, using the parent device for the spidev  |
| cur_msg_prepared            | spi_prepare_message was called for the currently in-flight message  |
| cur_msg_mapped              | message has been mapped for DMA   |
| xfer_completion             | used by core transfer_one_message   |
| max_dma_len                 | Maximum length of a DMA transfer for the device.  |
| prepare_transfer_hardware   | a message will soon arrive from the queue so the subsystem requests the driver to prepare the transfer hardware by issuing this call  |
| transfer_one_message        | the subsystem calls the driver to transfer a single message while queuing transfers that arrive in the meantime. When the driver is finished with this message, it must call spi_finalize_current_message so the subsystem can issue the next message                                   |
| unprepare_transfer_hardware | there are currently no more messages on the queue so the subsystem notifies the driver that it may relax the hardware by issuing this call  |
| prepare_message             | set up the controller to transfer a single message, for example doing DMA mapping. Called from threaded context.  |
| unprepare_message           | undo any work done by prepare_message.  |
| set_cs                      | set the logic level of the chip select line. May be called from interrupt context.  |
| transfer_one                | transfer a single spi_transfer. - return 0 if the transfer is finished, - return 1 if the transfer is still in progress. When the driver is finished with this transfer it must call spi_finalize_current_transfer so the subsystem can issue the next transfer. Note: transfer_one and |

|                         |  |
|-------------------------|--|
|                         | <code>transfer_one_message</code> are mutually exclusive; when both are set, the generic subsystem does not call your <code>transfer_one</code> callback.                              |
| <code>handle_err</code> | the subsystem calls the driver to handle an error that occurs in the generic implementation of <code>transfer_one_message</code> .   |
| <code>cs_gpios</code>   | Array of GPIOs to use as chip select lines; one per CS number. Any individual value may be <code>-ENOENT</code> for CS lines that are not GPIOs (driven by the SPI controller itself). |
| <code>dma_tx</code>     | DMA transmit channel   |
| <code>dma_rx</code>     | DMA receive channel  |
| <code>dummy_rx</code>   | dummy receive buffer for full-duplex devices   |
| <code>dummy_tx</code>   | dummy transmit buffer for full-duplex devices  |

## Description

Each SPI master controller can communicate with one or more *spi\_device* children. These make a small bus, sharing MOSI, MISO and SCK signals but not chip select signals. Each device may be configured to use a different clock rate, since those shared signals are ignored unless the chip is selected.

The driver for an SPI controller manages access to those devices through a queue of `spi_message` transactions, copying data between CPU memory and an SPI slave device. For each such message it queues, it calls the message's completion function when the transaction completes.

## Name

struct spi\_transfer — a read/write buffer pair

## Synopsis

```

struct spi_transfer {
    const void * tx_buf;
    void * rx_buf;
    unsigned len;
    dma_addr_t tx_dma;
    dma_addr_t rx_dma;
    struct sg_table tx_sg;
    struct sg_table rx_sg;
    unsigned cs_change:1;
    unsigned tx_nbits:3;
    unsigned rx_nbits:3;
#define SPI_NBITS_SINGLE 0x01
#define SPI_NBITS_DUAL 0x02
#define SPI_NBITS_QUAD 0x04
    u8 bits_per_word;
    u16 delay_usecs;
    u32 speed_hz;
    struct list_head transfer_list;
};

```

## Members

|               |   |
|---------------|---|
| tx_buf        | data to be written (dma-safe memory), or NULL   |
| rx_buf        | data to be read (dma-safe memory), or NULL  |
| len           | size of rx and tx buffers (in bytes)  |
| tx_dma        | DMA address of tx_buf, if <i>spi_message.is_dma_mapped</i>  |
| rx_dma        | DMA address of rx_buf, if <i>spi_message.is_dma_mapped</i>  |
| tx_sg         | Scatterlist for transmit, currently not for client use  |
| rx_sg         | Scatterlist for receive, currently not for client use   |
| cs_change     | affects chipselect after this transfer completes  |
| tx_nbits      | number of bits used for writing. If 0 the default (SPI_NBITS_SINGLE) is used.   |
| rx_nbits      | number of bits used for reading. If 0 the default (SPI_NBITS_SINGLE) is used.   |
| bits_per_word | select a bits_per_word other than the device default for this transfer. If 0 the default (from <i>spi_device</i> ) is used.   |
| delay_usecs   | microseconds to delay after this transfer before (optionally) changing the chipselect status, then starting the next transfer or completing this <i>spi_message</i> . |

|                            |   |
|----------------------------|---|
| <code>speed_hz</code>      | Select a speed other than the device default for this transfer. If 0 the default (from <code>spi_device</code> ) is used. |
| <code>transfer_list</code> | transfers are sequenced through <code>spi_message.transfers</code>  |

## Description

SPI transfers always write the same number of bytes as they read. Protocol drivers should always provide `rx_buf` and/or `tx_buf`. In some cases, they may also want to provide DMA addresses for the data being transferred; that may reduce overhead, when the underlying driver uses dma.

If the transmit buffer is null, zeroes will be shifted out while filling `rx_buf`. If the receive buffer is null, the data shifted in will be discarded. Only “len” bytes shift out (or in). It's an error to try to shift out a partial word. (For example, by shifting out three bytes with word size of sixteen or twenty bits; the former uses two bytes per word, the latter uses four bytes.)

In-memory data values are always in native CPU byte order, translated from the wire byte order (big-endian except with `SPI_LSB_FIRST`). So for example when `bits_per_word` is sixteen, buffers are  $2N$  bytes long ( $len = 2N$ ) and hold  $N$  sixteen bit words in CPU byte order.

When the word size of the SPI transfer is not a power-of-two multiple of eight bits, those in-memory words include extra bits. In-memory words are always seen by protocol drivers as right-justified, so the undefined (rx) or unused (tx) bits are always the most significant bits.

All SPI transfers start with the relevant chipselect active. Normally it stays selected until after the last transfer in a message. Drivers can affect the chipselect signal using `cs_change`.

(i) If the transfer isn't the last one in the message, this flag is used to make the chipselect briefly go inactive in the middle of the message. Toggling chipselect in this way may be needed to terminate a chip command, letting a single `spi_message` perform all of group of chip transactions together.

(ii) When the transfer is the last one in the message, the chip may stay selected until the next transfer. On multi-device SPI busses with nothing blocking messages going to other devices, this is just a performance hint; starting a message to another device deselects this one. But in other cases, this can be used to ensure correctness. Some devices need protocol transactions to be built from a series of `spi_message` submissions, where the content of one message is determined by the results of previous messages and where the whole transaction ends when the chipselect goes inactive.

When SPI can transfer in 1x,2x or 4x. It can get this transfer information from device through `tx_nbits` and `rx_nbits`. In Bi-direction, these two should both be set. User can set transfer mode with `SPI_NBITS_SINGLE(1x)` `SPI_NBITS_DUAL(2x)` and `SPI_NBITS_QUAD(4x)` to support these three transfer.

The code that submits an `spi_message` (and its `spi_transfers`) to the lower layers is responsible for managing its memory. Zero-initialize every field you don't set up explicitly, to insulate against future API updates. After you submit a message and its transfers, ignore them until its completion callback.

## Name

struct spi\_message — one multi-segment SPI transaction

## Synopsis

```
struct spi_message {
    struct list_head transfers;
    struct spi_device * spi;
    unsigned is_dma_mapped:1;
    void (* complete) (void *context);
    void * context;
    unsigned frame_length;
    unsigned actual_length;
    int status;
    struct list_head queue;
    void * state;
};
```

## Members

|               |  |
|---------------|--|
| transfers     | list of transfer segments in this transaction  |
| spi           | SPI device to which the transaction is queued  |
| is_dma_mapped | if true, the caller provided both dma and cpu virtual addresses for each transfer buffer |
| complete      | called to report transaction completions   |
| context       | the argument to <code>complete</code> when it's called                                   |
| frame_length  | the total number of bytes in the message   |
| actual_length | the total number of bytes that were transferred in all successful segments               |
| status        | zero for success, else negative errno  |
| queue         | for use by whichever driver currently owns the message                                   |
| state         | for use by whichever driver currently owns the message                                   |

## Description

A *spi\_message* is used to execute an atomic sequence of data transfers, each represented by a struct *spi\_transfer*. The sequence is “atomic” in the sense that no other *spi\_message* may use that SPI bus until that sequence completes. On some systems, many such sequences can execute as as single programmed DMA transfer. On all systems, these messages are queued, and might complete after transactions to other devices. Messages sent to a given *spi\_device* are always executed in FIFO order.

The code that submits an *spi\_message* (and its *spi\_transfers*) to the lower layers is responsible for managing its memory. Zero-initialize every field you don't set up explicitly, to insulate against future API updates. After you submit a message and its transfers, ignore them until its completion callback.

## Name

`spi_message_init_with_transfers` — Initialize `spi_message` and append transfers

## Synopsis

```
void spi_message_init_with_transfers (struct spi_message * m, struct  
spi_transfer * xfers, unsigned int num_xfers);
```

## Arguments

|                  |  |
|------------------|--|
| <i>m</i>         | <code>spi_message</code> to be initialized     |
| <i>xfers</i>     | An array of <code>spi_transfer</code>          |
| <i>num_xfers</i> | Number of items in the <code>xfer</code> array |

## Description

This function initializes the given `spi_message` and adds each `spi_transfer` in the given array to the message.

## Name

`spi_write` — SPI synchronous write

## Synopsis

```
int spi_write (struct spi_device * spi, const void * buf, size_t len);
```

## Arguments

*spi* device to which data will be written

*buf* data buffer

*len* data buffer size

## Context

can sleep

## Description

This writes the buffer and returns zero or a negative error code. Callable only from contexts that can sleep.

## Name

`spi_read` — SPI synchronous read

## Synopsis

```
int spi_read (struct spi_device * spi, void * buf, size_t len);
```

## Arguments

*spi* device from which data will be read

*buf* data buffer

*len* data buffer size

## Context

can sleep

## Description

This reads the buffer and returns zero or a negative error code. Callable only from contexts that can sleep.

## Name

`spi_sync_transfer` — synchronous SPI data transfer

## Synopsis

```
int spi_sync_transfer (struct spi_device * spi, struct spi_transfer *  
xfers, unsigned int num_xfers);
```

## Arguments

*spi*            device with which data will be exchanged

*xfers*         An array of `spi_transfers`

*num\_xfers*    Number of items in the xfer array

## Context

can sleep

## Description

Does a synchronous SPI data transfer of the given `spi_transfer` array.

For more specific semantics see `spi_sync`.

It returns zero on success, else a negative error code.

## Name

`spi_w8r8` — SPI synchronous 8 bit write followed by 8 bit read

## Synopsis

```
ssize_t spi_w8r8 (struct spi_device * spi, u8 cmd);
```

## Arguments

*spi* device with which data will be exchanged

*cmd* command to be written before data is read back

## Context

can sleep

## Description

This returns the (unsigned) eight bit number returned by the device, or else a negative error code. Callable only from contexts that can sleep.

## Name

`spi_w8r16` — SPI synchronous 8 bit write followed by 16 bit read

## Synopsis

```
ssize_t spi_w8r16 (struct spi_device * spi, u8 cmd);
```

## Arguments

*spi* device with which data will be exchanged

*cmd* command to be written before data is read back

## Context

can sleep

## Description

This returns the (unsigned) sixteen bit number returned by the device, or else a negative error code. Callable only from contexts that can sleep.

The number is returned in wire-order, which is at least sometimes big-endian.

## Name

`spi_w8r16be` — SPI synchronous 8 bit write followed by 16 bit big-endian read

## Synopsis

```
ssize_t spi_w8r16be (struct spi_device * spi, u8 cmd);
```

## Arguments

*spi* device with which data will be exchanged

*cmd* command to be written before data is read back

## Context

can sleep

## Description

This returns the (unsigned) sixteen bit number returned by the device in cpu endianness, or else a negative error code. Callable only from contexts that can sleep.

This function is similar to `spi_w8r16`, with the exception that it will convert the read 16 bit data word from big-endian to native endianness.

## Name

struct spi\_board\_info — board-specific template for a SPI device

## Synopsis

```
struct spi_board_info {
    char modalias[SPI_NAME_SIZE];
    const void * platform_data;
    void * controller_data;
    int irq;
    u32 max_speed_hz;
    u16 bus_num;
    u16 chip_select;
    u16 mode;
};
```

## Members

|                         |   |
|-------------------------|---|
| modalias[SPI_NAME_SIZE] | Initializes spi_device.modalias; identifies the driver.   |
| platform_data           | Initializes spi_device.platform_data; the particular data stored there is driver-specific.  |
| controller_data         | Initializes spi_device.controller_data; some controllers need hints about hardware setup, e.g. for DMA.   |
| irq                     | Initializes spi_device.irq; depends on how the board is wired.  |
| max_speed_hz            | Initializes spi_device.max_speed_hz; based on limits from the chip datasheet and board-specific signal quality issues.  |
| bus_num                 | Identifies which spi_master parents the spi_device; unused by spi_new_device, and otherwise depends on board wiring.  |
| chip_select             | Initializes spi_device.chip_select; depends on how the board is wired.  |
| mode                    | Initializes spi_device.mode; based on the chip datasheet, board wiring (some devices support both 3WIRE and standard modes), and possibly presence of an inverter in the chipselect path. |

## Description

When adding new SPI devices to the device tree, these structures serve as a partial device template. They hold information which can't always be determined by drivers. Information that `probe` can establish (such as the default transfer wordsize) is not included here.

These structures are used in two places. Their primary role is to be stored in tables of board-specific device descriptors, which are declared early in board initialization and then used (much later) to populate a controller's device tree after the that controller's driver initializes. A secondary (and atypical) role is as a parameter to `spi_new_device` call, which happens after those controller drivers are active in some dynamic board configuration models.

## Name

`spi_register_board_info` — register SPI devices for a given board

## Synopsis

```
int spi_register_board_info (struct spi_board_info const * info, unsigned n);
```

## Arguments

*info* array of chip descriptors

*n* how many descriptors are provided

## Context

can sleep

## Description

Board-specific early init code calls this (probably during `arch_initcall`) with segments of the SPI device table. Any device nodes are created later, after the relevant parent SPI controller (`bus_num`) is defined. We keep this table of devices forever, so that reloading a controller driver will not make Linux forget about these hard-wired devices.

Other code can also call this, e.g. a particular add-on board might provide SPI devices through its expansion connector, so code initializing that board would naturally declare its SPI devices.

The board info passed can safely be `__initdata` ... but be careful of any embedded pointers (`platform_data`, etc), they're copied as-is.

## Name

`spi_register_driver` — register a SPI driver

## Synopsis

```
int spi_register_driver (struct spi_driver * sdrv);
```

## Arguments

*sdrv* the driver to register

## Context

can sleep

## Name

`spi_alloc_device` — Allocate a new SPI device

## Synopsis

```
struct spi_device * spi_alloc_device (struct spi_master * master);
```

## Arguments

*master* Controller to which device is connected

## Context

can sleep

## Description

Allows a driver to allocate and initialize a `spi_device` without registering it immediately. This allows a driver to directly fill the `spi_device` with device parameters before calling `spi_add_device` on it.

Caller is responsible to call `spi_add_device` on the returned `spi_device` structure to add it to the SPI master. If the caller needs to discard the `spi_device` without adding it, then it should call `spi_dev_put` on it.

Returns a pointer to the new device, or NULL.

## Name

`spi_add_device` — Add `spi_device` allocated with `spi_alloc_device`

## Synopsis

```
int spi_add_device (struct spi_device * spi);
```

## Arguments

*spi* `spi_device` to register

## Description

Companion function to `spi_alloc_device`. Devices allocated with `spi_alloc_device` can be added onto the spi bus with this function.

Returns 0 on success; negative `errno` on failure

## Name

`spi_new_device` — instantiate one new SPI device

## Synopsis

```
struct spi_device * spi_new_device (struct spi_master * master, struct  
spi_board_info * chip);
```

## Arguments

*master* Controller to which device is connected

*chip* Describes the SPI device

## Context

can sleep

## Description

On typical mainboards, this is purely internal; and it's not needed after board init creates the hard-wired devices. Some development platforms may not be able to use `spi_register_board_info` though, and this is exported so that for example a USB or parport based adapter driver could add devices (which it would learn about out-of-band).

Returns the new device, or NULL.

## Name

`spi_finalize_current_transfer` — report completion of a transfer

## Synopsis

```
void spi_finalize_current_transfer (struct spi_master * master);
```

## Arguments

*master* the master reporting completion

## Description

Called by SPI drivers using the core `transfer_one_message` implementation to notify it that the current interrupt driven transfer has finished and the next one may be scheduled.

## Name

`spi_get_next_queued_message` — called by driver to check for queued messages

## Synopsis

```
struct spi_message * spi_get_next_queued_message (struct spi_master *  
master);
```

## Arguments

*master* the master to check for queued messages

## Description

If there are more messages in the queue, the next message is returned from this call.

## Name

`spi_finalize_current_message` — the current message is complete

## Synopsis

```
void spi_finalize_current_message (struct spi_master * master);
```

## Arguments

*master* the master to return the message to

## Description

Called by the driver to notify the core that the message in the front of the queue is complete and can be removed from the queue.

## Name

`spi_alloc_master` — allocate SPI master controller

## Synopsis

```
struct spi_master * spi_alloc_master (struct device * dev, unsigned
size);
```

## Arguments

*dev* the controller, possibly using the `platform_bus`

*size* how much zeroed driver-private data to allocate; the pointer to this memory is in the `driver_data` field of the returned device, accessible with `spi_master_get_devdata`.

## Context

can sleep

## Description

This call is used only by SPI master controller drivers, which are the only ones directly touching chip registers. It's how they allocate an `spi_master` structure, prior to calling `spi_register_master`.

This must be called from context that can sleep. It returns the SPI master structure on success, else `NULL`.

The caller is responsible for assigning the bus number and initializing the master's methods before calling `spi_register_master`; and (after errors adding the device) calling `spi_master_put` to prevent a memory leak.

## Name

`spi_register_master` — register SPI master controller

## Synopsis

```
int spi_register_master (struct spi_master * master);
```

## Arguments

*master* initialized master, originally from `spi_alloc_master`

## Context

can sleep

## Description

SPI master controllers connect to their drivers using some non-SPI bus, such as the platform bus. The final stage of `probe` in that code includes calling `spi_register_master` to hook up to this SPI bus glue.

SPI controllers use board specific (often SOC specific) bus numbers, and board-specific addressing for SPI devices combines those numbers with chip select numbers. Since SPI does not directly support dynamic device identification, boards need configuration tables telling which chip is at which address.

This must be called from context that can sleep. It returns zero on success, else a negative error code (dropping the master's refcount). After a successful return, the caller is responsible for calling `spi_unregister_master`.

## Name

`devm_spi_register_master` — register managed SPI master controller

## Synopsis

```
int devm_spi_register_master (struct device * dev, struct spi_master  
* master);
```

## Arguments

*dev* device managing SPI master

*master* initialized master, originally from `spi_alloc_master`

## Context

can sleep

## Description

Register a SPI device as with `spi_register_master` which will automatically be unregister

## Name

`spi_unregister_master` — unregister SPI master controller

## Synopsis

```
void spi_unregister_master (struct spi_master * master);
```

## Arguments

*master* the master being unregistered

## Context

can sleep

## Description

This call is used only by SPI master controller drivers, which are the only ones directly touching chip registers.

This must be called from context that can sleep.

## Name

`spi_busnum_to_master` — look up master associated with `bus_num`

## Synopsis

```
struct spi_master * spi_busnum_to_master (u16 bus_num);
```

## Arguments

*bus\_num* the master's bus number

## Context

can sleep

## Description

This call may be used with devices that are registered after arch init time. It returns a refcounted pointer to the relevant `spi_master` (which the caller must release), or NULL if there is no such master registered.

## Name

`spi_setup` — setup SPI mode and clock rate

## Synopsis

```
int spi_setup (struct spi_device * spi);
```

## Arguments

*spi* the device whose settings are being modified

## Context

can sleep, and no requests are queued to the device

## Description

SPI protocol drivers may need to update the transfer mode if the device doesn't work with its default. They may likewise need to update clock rates or word sizes from initial values. This function changes those settings, and must be called from a context that can sleep. Except for `SPI_CS_HIGH`, which takes effect immediately, the changes take effect the next time the device is selected and data is transferred to or from it. When this function returns, the spi device is deselected.

Note that this call will fail if the protocol driver specifies an option that the underlying controller or its driver does not support. For example, not all hardware supports wire transfers using nine bit words, LSB-first wire encoding, or active-high chipselects.

## Name

`spi_async` — asynchronous SPI transfer

## Synopsis

```
int spi_async (struct spi_device * spi, struct spi_message * message);
```

## Arguments

*spi* device with which data will be exchanged

*message* describes the data transfers, including completion callback

## Context

any (irqs may be blocked, etc)

## Description

This call may be used in\_irq and other contexts which can't sleep, as well as from task contexts which can sleep.

The completion callback is invoked in a context which can't sleep. Before that invocation, the value of `message->status` is undefined. When the callback is issued, `message->status` holds either zero (to indicate complete success) or a negative error code. After that callback returns, the driver which issued the transfer request may deallocate the associated memory; it's no longer in use by any SPI core or controller driver code.

Note that although all messages to a `spi_device` are handled in FIFO order, messages may go to different devices in other orders. Some device might be higher priority, or have various “hard” access time requirements, for example.

On detection of any fault during the transfer, processing of the entire message is aborted, and the device is deselected. Until returning from the associated message completion callback, no other `spi_message` queued to that device will be processed. (This rule applies equally to all the synchronous transfer calls, which are wrappers around this core asynchronous primitive.)

## Name

`spi_async_locked` — version of `spi_async` with exclusive bus usage

## Synopsis

```
int spi_async_locked (struct spi_device * spi, struct spi_message *  
message);
```

## Arguments

*spi* device with which data will be exchanged

*message* describes the data transfers, including completion callback

## Context

any (irqs may be blocked, etc)

## Description

This call may be used in `in_irq` and other contexts which can't sleep, as well as from task contexts which can sleep.

The completion callback is invoked in a context which can't sleep. Before that invocation, the value of `message->status` is undefined. When the callback is issued, `message->status` holds either zero (to indicate complete success) or a negative error code. After that callback returns, the driver which issued the transfer request may deallocate the associated memory; it's no longer in use by any SPI core or controller driver code.

Note that although all messages to a `spi_device` are handled in FIFO order, messages may go to different devices in other orders. Some device might be higher priority, or have various “hard” access time requirements, for example.

On detection of any fault during the transfer, processing of the entire message is aborted, and the device is deselected. Until returning from the associated message completion callback, no other `spi_message` queued to that device will be processed. (This rule applies equally to all the synchronous transfer calls, which are wrappers around this core asynchronous primitive.)

## Name

`spi_sync` — blocking/synchronous SPI data transfers

## Synopsis

```
int spi_sync (struct spi_device * spi, struct spi_message * message);
```

## Arguments

*spi* device with which data will be exchanged

*message* describes the data transfers

## Context

can sleep

## Description

This call may only be used from a context that may sleep. The sleep is non-interruptible, and has no timeout. Low-overhead controller drivers may DMA directly into and out of the message buffers.

Note that the SPI device's chip select is active during the message, and then is normally disabled between messages. Drivers for some frequently-used devices may want to minimize costs of selecting a chip, by leaving it selected in anticipation that the next message will go to the same chip. (That may increase power usage.)

Also, the caller is guaranteeing that the memory associated with the message will not be freed before this call returns.

It returns zero on success, else a negative error code.

## Name

`spi_sync_locked` — version of `spi_sync` with exclusive bus usage

## Synopsis

```
int spi_sync_locked (struct spi_device * spi, struct spi_message *  
message);
```

## Arguments

*spi* device with which data will be exchanged

*message* describes the data transfers

## Context

can sleep

## Description

This call may only be used from a context that may sleep. The sleep is non-interruptible, and has no timeout. Low-overhead controller drivers may DMA directly into and out of the message buffers.

This call should be used by drivers that require exclusive access to the SPI bus. It has to be preceded by a `spi_bus_lock` call. The SPI bus must be released by a `spi_bus_unlock` call when the exclusive access is over.

It returns zero on success, else a negative error code.

## Name

`spi_bus_lock` — obtain a lock for exclusive SPI bus usage

## Synopsis

```
int spi_bus_lock (struct spi_master * master);
```

## Arguments

*master* SPI bus master that should be locked for exclusive bus access

## Context

can sleep

## Description

This call may only be used from a context that may sleep. The sleep is non-interruptible, and has no timeout.

This call should be used by drivers that require exclusive access to the SPI bus. The SPI bus must be released by a `spi_bus_unlock` call when the exclusive access is over. Data transfer must be done by `spi_sync_locked` and `spi_async_locked` calls when the SPI bus lock is held.

It returns zero on success, else a negative error code.

## Name

`spi_bus_unlock` — release the lock for exclusive SPI bus usage

## Synopsis

```
int spi_bus_unlock (struct spi_master * master);
```

## Arguments

*master* SPI bus master that was locked for exclusive bus access

## Context

can sleep

## Description

This call may only be used from a context that may sleep. The sleep is non-interruptible, and has no timeout.

This call releases an SPI bus lock previously obtained by an `spi_bus_lock` call.

It returns zero on success, else a negative error code.

## Name

`spi_write_then_read` — SPI synchronous write followed by read

## Synopsis

```
int spi_write_then_read (struct spi_device * spi, const void * txbuf,  
unsigned n_tx, void * rxbuf, unsigned n_rx);
```

## Arguments

*spi* device with which data will be exchanged

*txbuf* data to be written (need not be dma-safe)

*n\_tx* size of txbuf, in bytes

*rxbuf* buffer into which data will be read (need not be dma-safe)

*n\_rx* size of rxbuf, in bytes

## Context

can sleep

## Description

This performs a half duplex MicroWire style transaction with the device, sending txbuf and then reading rxbuf. The return value is zero for success, else a negative errno status code. This call may only be used from a context that may sleep.

Parameters to this routine are always copied using a small buffer; portable code should never use this for more than 32 bytes. Performance-sensitive or bulk transfer code should instead use `spi_{async, sync}()` calls with dma-safe buffers.

---

# Chapter 10. I<sup>2</sup>C and SMBus Subsystem

I<sup>2</sup>C (or without fancy typography, "I2C") is an acronym for the "Inter-IC" bus, a simple bus protocol which is widely used where low data rate communications suffice. Since it's also a licensed trademark, some vendors use another name (such as "Two-Wire Interface", TWI) for the same bus. I2C only needs two signals (SCL for clock, SDA for data), conserving board real estate and minimizing signal quality issues. Most I2C devices use seven bit addresses, and bus speeds of up to 400 kHz; there's a high speed extension (3.4 MHz) that's not yet found wide use. I2C is a multi-master bus; open drain signaling is used to arbitrate between masters, as well as to handshake and to synchronize clocks from slower clients.

The Linux I2C programming interfaces support only the master side of bus interactions, not the slave side. The programming interface is structured around two kinds of driver, and two kinds of device. An I2C "Adapter Driver" abstracts the controller hardware; it binds to a physical device (perhaps a PCI device or platform\_device) and exposes a struct `i2c_adapter` representing each I2C bus segment it manages. On each I2C bus segment will be I2C devices represented by a struct `i2c_client`. Those devices will be bound to a struct `i2c_driver`, which should follow the standard Linux driver model. (At this writing, a legacy model is more widely used.) There are functions to perform various I2C protocol operations; at this writing all such functions are usable only from task context.

The System Management Bus (SMBus) is a sibling protocol. Most SMBus systems are also I2C conformant. The electrical constraints are tighter for SMBus, and it standardizes particular protocol messages and idioms. Controllers that support I2C can also support most SMBus operations, but SMBus controllers don't support all the protocol options that an I2C controller will. There are functions to perform various SMBus protocol operations, either using I2C primitives or by issuing SMBus commands to `i2c_adapter` devices which don't support those I2C operations.

## Name

struct `i2c_driver` — represent an I2C device driver

## Synopsis

```
struct i2c_driver {
    unsigned int class;
    int (* attach_adapter) (struct i2c_adapter *);
    int (* probe) (struct i2c_client *, const struct i2c_device_id *);
    int (* remove) (struct i2c_client *);
    void (* shutdown) (struct i2c_client *);
    void (* alert) (struct i2c_client *, unsigned int data);
    int (* command) (struct i2c_client *client, unsigned int cmd, void *arg);
    struct device_driver driver;
    const struct i2c_device_id * id_table;
    int (* detect) (struct i2c_client *, struct i2c_board_info *);
    const unsigned short * address_list;
    struct list_head clients;
};
```

## Members

|                             |   |
|-----------------------------|---|
| <code>class</code>          | What kind of i2c device we instantiate (for detect)         |
| <code>attach_adapter</code> | Callback for bus addition (deprecated)                      |
| <code>probe</code>          | Callback for device binding                                 |
| <code>remove</code>         | Callback for device unbinding                               |
| <code>shutdown</code>       | Callback for device shutdown                                |
| <code>alert</code>          | Alert callback, for example for the SMBus alert protocol    |
| <code>command</code>        | Callback for bus-wide signaling (optional)                  |
| <code>driver</code>         | Device driver model driver                                  |
| <code>id_table</code>       | List of I2C devices supported by this driver                |
| <code>detect</code>         | Callback for device detection                               |
| <code>address_list</code>   | The I2C addresses to probe (for detect)                     |
| <code>clients</code>        | List of detected clients we created (for i2c-core use only) |

## Description

The `driver.owner` field should be set to the module owner of this driver. The `driver.name` field should be set to the name of this driver.

For automatic device detection, both `detect` and `address_list` must be defined. `class` should also be set, otherwise only devices forced with module parameters will be created. The detect function must fill

at least the name field of the `i2c_board_info` structure it is handed upon successful detection, and possibly also the flags field.

If `detect` is missing, the driver will still work fine for enumerated devices. Detected devices simply won't be supported. This is expected for the many I2C/SMBus devices which can't be detected reliably, and the ones which can always be enumerated in practice.

The `i2c_client` structure which is handed to the `detect` callback is not a real `i2c_client`. It is initialized just enough so that you can call `i2c_smbus_read_byte_data` and friends on it. Don't do anything else with it. In particular, calling `dev_dbg` and friends on it is not allowed.

## Name

struct i2c\_client — represent an I2C slave device

## Synopsis

```
struct i2c_client {
    unsigned short flags;
    unsigned short addr;
    char name[I2C_NAME_SIZE];
    struct i2c_adapter * adapter;
    struct device dev;
    int irq;
    struct list_head detected;
#ifdef IS_ENABLED(CONFIG_I2C_SLAVE)
    i2c_slave_cb_t slave_cb;
#endif
};
```

## Members

|                     |   |
|---------------------|---|
| flags               | I2C_CLIENT_TEN indicates the device uses a ten bit chip address; I2C_CLIENT_PEC indicates it uses SMBus Packet Error Checking |
| addr                | Address used on the I2C bus connected to the parent adapter.  |
| name[I2C_NAME_SIZE] | Indicates the type of the device, usually a chip name that's generic enough to hide second-sourcing and compatible revisions. |
| adapter             | manages the bus segment hosting this I2C device   |
| dev                 | Driver model device node for the slave.   |
| irq                 | indicates the IRQ generated by this device (if any)   |
| detected            | member of an i2c_driver.clients list or i2c-core's userspace_devices list   |
| slave_cb            | Callback when I2C slave mode of an adapter is used. The adapter calls it to pass on slave events to the slave driver.         |

## Description

An i2c\_client identifies a single device (i.e. chip) connected to an i2c bus. The behaviour exposed to Linux is defined by the driver managing the device.

## Name

struct i2c\_board\_info — template for device creation

## Synopsis

```
struct i2c_board_info {
    char type[I2C_NAME_SIZE];
    unsigned short flags;
    unsigned short addr;
    void * platform_data;
    struct dev_archdata * archdata;
    struct device_node * of_node;
    struct fwnode_handle * fwnode;
    int irq;
};
```

## Members

|                     |   |
|---------------------|---|
| type[I2C_NAME_SIZE] | chip type, to initialize i2c_client.name      |
| flags               | to initialize i2c_client.flags                |
| addr                | stored in i2c_client.addr                     |
| platform_data       | stored in i2c_client.dev.platform_data        |
| archdata            | copied into i2c_client.dev.archdata           |
| of_node             | pointer to OpenFirmware device node           |
| fwnode              | device node supplied by the platform firmware |
| irq                 | stored in i2c_client.irq                      |

## Description

I2C doesn't actually support hardware probing, although controllers and devices may be able to use I2C\_SMBUS\_QUICK to tell whether or not there's a device at a given address. Drivers commonly need more information than that, such as chip type, configuration, associated IRQ, and so on.

i2c\_board\_info is used to build tables of information listing I2C devices that are present. This information is used to grow the driver model tree. For mainboards this is done statically using i2c\_register\_board\_info; bus numbers identify adapters that aren't yet available. For add-on boards, i2c\_new\_device does this dynamically with the adapter already known.

## Name

I2C\_BOARD\_INFO — macro used to list an i2c device and its address

## Synopsis

```
I2C_BOARD_INFO ( dev_type, dev_addr );
```

## Arguments

*dev\_type* identifies the device type

*dev\_addr* the device's address on the bus.

## Description

This macro initializes essential fields of a struct `i2c_board_info`, declaring what has been provided on a particular board. Optional fields (such as associated `irq`, or device-specific `platform_data`) are provided using conventional syntax.

## Name

struct i2c\_algorithm — represent I2C transfer method

## Synopsis

```
struct i2c_algorithm {
    int (* master_xfer) (struct i2c_adapter *adap, struct i2c_msg *msgs,int num);
    int (* smbus_xfer) (struct i2c_adapter *adap, u16 addr,unsigned short flags, cha
    u32 (* functionality) (struct i2c_adapter *);
#ifdef IS_ENABLED(CONFIG_I2C_SLAVE)
    int (* reg_slave) (struct i2c_client *client);
    int (* unreg_slave) (struct i2c_client *client);
#endif
};
```

## Members

|               |  |
|---------------|--|
| master_xfer   | Issue a set of i2c transactions to the given I2C adapter defined by the msgs array, with num messages available to transfer via the adapter specified by adap. |
| smbus_xfer    | Issue smbus transactions to the given I2C adapter. If this is not present, then the bus layer will try and convert the SMBus calls into I2C transfers instead. |
| functionality | Return the flags that this algorithm/adapter pair supports from the I2C_FUNC_* flags.  |
| reg_slave     | Register given client to I2C slave mode of this adapter  |
| unreg_slave   | Unregister given client from I2C slave mode of this adapter  |

## The following structs are for those who like to implement new bus drivers

i2c\_algorithm is the interface to a class of hardware solutions which can be addressed using the same bus algorithms - i.e. bit-banging or the PCF8584 to name two of the most common.

The return codes from the *master\_xfer* field should indicate the type of error code that occurred during the transfer, as documented in the kernel Documentation file Documentation/i2c/fault-codes.

## Name

struct i2c\_bus\_recovery\_info — I2C bus recovery information

## Synopsis

```
struct i2c_bus_recovery_info {
    int (* recover_bus) (struct i2c_adapter *);
    int (* get_scl) (struct i2c_adapter *);
    void (* set_scl) (struct i2c_adapter *, int val);
    int (* get_sda) (struct i2c_adapter *);
    void (* prepare_recovery) (struct i2c_adapter *);
    void (* unprepare_recovery) (struct i2c_adapter *);
    int scl_gpio;
    int sda_gpio;
};
```

## Members

|                    |   |
|--------------------|---|
| recover_bus        | Recover routine. Either pass driver's <code>recover_bus</code> routine, or <code>i2c_generic_scl_recovery</code> or <code>i2c_generic_gpio_recovery</code> .  |
| get_scl            | This gets current value of SCL line. Mandatory for generic SCL recovery. Used internally for generic GPIO recovery.   |
| set_scl            | This sets/clears SCL line. Mandatory for generic SCL recovery. Used internally for generic GPIO recovery.   |
| get_sda            | This gets current value of SDA line. Optional for generic SCL recovery. Used internally, if <code>sda_gpio</code> is a valid GPIO, for generic GPIO recovery. |
| prepare_recovery   | This will be called before starting recovery. Platform may configure padmux here for SDA/SCL line or something else they want.                                |
| unprepare_recovery | This will be called after completing recovery. Platform may configure padmux here for SDA/SCL line or something else they want.                               |
| scl_gpio           | gpio number of the SCL line. Only required for GPIO recovery.   |
| sda_gpio           | gpio number of the SDA line. Only required for GPIO recovery.   |

## Name

struct `i2c_adapter_quirks` — describe flaws of an i2c adapter

## Synopsis

```
struct i2c_adapter_quirks {  
    u64 flags;  
    int max_num_msgs;  
    u16 max_write_len;  
    u16 max_read_len;  
    u16 max_comb_1st_msg_len;  
    u16 max_comb_2nd_msg_len;  
};
```

## Members

|                                   |   |
|-----------------------------------|---|
| <code>flags</code>                | see <code>I2C_AQ_*</code> for possible flags and read below |
| <code>max_num_msgs</code>         | maximum number of messages per transfer                     |
| <code>max_write_len</code>        | maximum length of a write message                           |
| <code>max_read_len</code>         | maximum length of a read message                            |
| <code>max_comb_1st_msg_len</code> | maximum length of the first msg in a combined message       |
| <code>max_comb_2nd_msg_len</code> | maximum length of the second msg in a combined message      |

## Note about combined messages

Some I2C controllers can only send one message per transfer, plus something called combined message or write-then-read. This is (usually) a small write message followed by a read message and barely enough to access register based devices like EEPROMs. There is a flag to support this mode. It implies `max_num_msg = 2` and does the length checks with `max_comb_*_len` because combined message mode usually has its own limitations. Because of HW implementations, some controllers can actually do write-then-anything or other variants. To support that, write-then-read has been broken out into smaller bits like write-first and read-second which can be combined as needed.

## Name

`module_i2c_driver` — Helper macro for registering a I2C driver

## Synopsis

```
module_i2c_driver ( __i2c_driver);
```

## Arguments

`__i2c_driver` `i2c_driver` struct

## Description

Helper macro for I2C drivers which do not do anything special in module init/exit. This eliminates a lot of boilerplate. Each module may only use this macro once, and calling it replaces `module_init` and `module_exit`

## Name

`i2c_register_board_info` — statically declare I2C devices

## Synopsis

```
int i2c_register_board_info (int busnum, struct i2c_board_info const *  
info, unsigned len);
```

## Arguments

*busnum* identifies the bus to which these devices belong

*info* vector of i2c device descriptors

*len* how many descriptors in the vector; may be zero to reserve the specified bus number.

## Description

Systems using the Linux I2C driver stack can declare tables of board info while they initialize. This should be done in board-specific init code near `arch_initcall` time, or equivalent, before any I2C adapter driver is registered. For example, mainboard init code could define several devices, as could the init code for each daughtercard in a board stack.

The I2C devices will be created later, after the adapter for the relevant bus has been registered. After that moment, standard driver model tools are used to bind “new style” I2C drivers to the devices. The bus number for any device declared using this routine is not available for dynamic allocation.

The board info passed can safely be `__initdata`, but be careful of embedded pointers (for `platform_data`, functions, etc) since that won't be copied.

## Name

`i2c_verify_client` — return parameter as `i2c_client`, or `NULL`

## Synopsis

```
struct i2c_client * i2c_verify_client (struct device * dev);
```

## Arguments

*dev* device, probably from some driver model iterator

## Description

When traversing the driver model tree, perhaps using driver model iterators like `device_for_each_child()`, you can't assume very much about the nodes you find. Use this function to avoid oopses caused by wrongly treating some non-I2C device as an `i2c_client`.

## Name

`i2c_lock_adapter` — Get exclusive access to an I2C bus segment

## Synopsis

```
void i2c_lock_adapter (struct i2c_adapter * adapter);
```

## Arguments

*adapter* Target I2C bus segment

## Name

`i2c_unlock_adapter` — Release exclusive access to an I2C bus segment

## Synopsis

```
void i2c_unlock_adapter (struct i2c_adapter * adapter);
```

## Arguments

*adapter* Target I2C bus segment

## Name

`i2c_new_device` — instantiate an i2c device

## Synopsis

```
struct i2c_client * i2c_new_device (struct i2c_adapter * adap, struct  
i2c_board_info const * info);
```

## Arguments

*adap* the adapter managing the device

*info* describes one I2C device; `bus_num` is ignored

## Context

can sleep

## Description

Create an i2c device. Binding is handled through driver model `probe/remove` methods. A driver may be bound to this device when we return from this function, or any later moment (e.g. maybe hotplugging will load the driver module). This call is not appropriate for use by mainboard initialization logic, which usually runs during an `arch_initcall` long before any `i2c_adapter` could exist.

This returns the new i2c client, which may be saved for later use with `i2c_unregister_device`; or `NULL` to indicate an error.

## Name

`i2c_unregister_device` — reverse effect of `i2c_new_device`

## Synopsis

```
void i2c_unregister_device (struct i2c_client * client);
```

## Arguments

*client* value returned from `i2c_new_device`

## Context

can sleep

## Name

`i2c_new_dummy` — return a new i2c device bound to a dummy driver

## Synopsis

```
struct i2c_client * i2c_new_dummy (struct i2c_adapter * adapter, u16  
address);
```

## Arguments

*adapter* the adapter managing the device

*address* seven bit address to be used

## Context

can sleep

## Description

This returns an I2C client bound to the “dummy” driver, intended for use with devices that consume multiple addresses. Examples of such chips include various EEPROMS (like 24c04 and 24c08 models).

These dummy devices have two main uses. First, most I2C and SMBus calls except `i2c_transfer` need a client handle; the dummy will be that handle. And second, this prevents the specified address from being bound to a different driver.

This returns the new i2c client, which should be saved for later use with `i2c_unregister_device`; or NULL to indicate an error.

## Name

`i2c_verify_adapter` — return parameter as `i2c_adapter` or `NULL`

## Synopsis

```
struct i2c_adapter * i2c_verify_adapter (struct device * dev);
```

## Arguments

*dev* device, probably from some driver model iterator

## Description

When traversing the driver model tree, perhaps using driver model iterators like `device_for_each_child()`, you can't assume very much about the nodes you find. Use this function to avoid oopses caused by wrongly treating some non-I2C device as an `i2c_adapter`.

## Name

`i2c_add_adapter` — declare i2c adapter, use dynamic bus number

## Synopsis

```
int i2c_add_adapter (struct i2c_adapter * adapter);
```

## Arguments

*adapter* the adapter to add

## Context

can sleep

## Description

This routine is used to declare an I2C adapter when its bus number doesn't matter or when its bus number is specified by an dt alias. Examples of bases when the bus number doesn't matter: I2C adapters dynamically added by USB links or PCI plugin cards.

When this returns zero, a new bus number was allocated and stored in `adap->nr`, and the specified adapter became available for clients. Otherwise, a negative `errno` value is returned.

## Name

`i2c_add_numbered_adapter` — declare i2c adapter, use static bus number

## Synopsis

```
int i2c_add_numbered_adapter (struct i2c_adapter * adap);
```

## Arguments

*adap* the adapter to register (with `adap->nr` initialized)

## Context

can sleep

## Description

This routine is used to declare an I2C adapter when its bus number matters. For example, use it for I2C adapters from system-on-chip CPUs, or otherwise built in to the system's mainboard, and where `i2c_board_info` is used to properly configure I2C devices.

If the requested bus number is set to -1, then this function will behave identically to `i2c_add_adapter`, and will dynamically assign a bus number.

If no devices have pre-been declared for this bus, then be sure to register the adapter before any dynamically allocated ones. Otherwise the required bus ID may not be available.

When this returns zero, the specified adapter became available for clients using the bus number provided in `adap->nr`. Also, the table of I2C devices pre-declared using `i2c_register_board_info` is scanned, and the appropriate driver model device nodes are created. Otherwise, a negative `errno` value is returned.

## Name

`i2c_del_adapter` — unregister I2C adapter

## Synopsis

```
void i2c_del_adapter (struct i2c_adapter * adap);
```

## Arguments

*adap* the adapter being unregistered

## Context

can sleep

## Description

This unregisters an I2C adapter which was previously registered by `i2c_add_adapter` or `i2c_add_numbered_adapter`.

## Name

`i2c_del_driver` — unregister I2C driver

## Synopsis

```
void i2c_del_driver (struct i2c_driver * driver);
```

## Arguments

*driver* the driver being unregistered

## Context

can sleep

## Name

`i2c_use_client` — increments the reference count of the `i2c_client` structure

## Synopsis

```
struct i2c_client * i2c_use_client (struct i2c_client * client);
```

## Arguments

*client* the client being referenced

## Description

Each live reference to a client should be refcounted. The driver model does that automatically as part of driver binding, so that most drivers don't

## need to do this explicitly

they hold a reference until they're unbound from the device.

A pointer to the client with the incremented reference counter is returned.

## Name

`i2c_release_client` — release a use of the i2c client structure

## Synopsis

```
void i2c_release_client (struct i2c_client * client);
```

## Arguments

*client* the client being no longer referenced

## Description

Must be called when a user of a client is finished with it.

## Name

`__i2c_transfer` — unlocked flavor of `i2c_transfer`

## Synopsis

```
int __i2c_transfer (struct i2c_adapter * adap, struct i2c_msg * msgs,  
int num);
```

## Arguments

*adap* Handle to I2C bus

*msgs* One or more messages to execute before STOP is issued to terminate the operation; each message begins with a START.

*num* Number of messages to be executed.

## Description

Returns negative `errno`, else the number of messages executed.

Adapter lock must be held when calling this function. No debug logging takes place. `adap->al-`  
`go->master_xfer` existence isn't checked.

## Name

`i2c_transfer` — execute a single or combined I2C message

## Synopsis

```
int i2c_transfer (struct i2c_adapter * adap, struct i2c_msg * msgs,  
int num);
```

## Arguments

*adap* Handle to I2C bus

*msgs* One or more messages to execute before STOP is issued to terminate the operation; each message begins with a START.

*num* Number of messages to be executed.

## Description

Returns negative `errno`, else the number of messages executed.

Note that there is no requirement that each message be sent to the same slave address, although that is the most common model.

## Name

`i2c_master_send` — issue a single I2C message in master transmit mode

## Synopsis

```
int i2c_master_send (const struct i2c_client * client, const char *  
buf, int count);
```

## Arguments

*client* Handle to slave device

*buf* Data that will be written to the slave

*count* How many bytes to write, must be less than 64k since `msg.len` is `u16`

## Description

Returns negative `errno`, or else the number of bytes written.

## Name

`i2c_master_recv` — issue a single I2C message in master receive mode

## Synopsis

```
int i2c_master_recv (const struct i2c_client * client, char * buf, int
count);
```

## Arguments

*client* Handle to slave device

*buf* Where to store data read from slave

*count* How many bytes to read, must be less than 64k since `msg.len` is `u16`

## Description

Returns negative `errno`, or else the number of bytes read.

## Name

`i2c_smbus_read_byte` — SMBus “receive byte” protocol

## Synopsis

```
s32 i2c_smbus_read_byte (const struct i2c_client * client);
```

## Arguments

*client* Handle to slave device

## Description

This executes the SMBus “receive byte” protocol, returning negative errno else the byte received from the device.

## Name

`i2c_smbus_write_byte` — SMBus “send byte” protocol

## Synopsis

```
s32 i2c_smbus_write_byte (const struct i2c_client * client, u8 value);
```

## Arguments

*client* Handle to slave device

*value* Byte to be sent

## Description

This executes the SMBus “send byte” protocol, returning negative `errno` else zero on success.

## Name

`i2c_smbus_read_byte_data` — SMBus “read byte” protocol

## Synopsis

```
s32 i2c_smbus_read_byte_data (const struct i2c_client * client, u8 command);
```

## Arguments

*client*    Handle to slave device

*command*    Byte interpreted by slave

## Description

This executes the SMBus “read byte” protocol, returning negative `errno` else a data byte received from the device.

## Name

`i2c_smbus_write_byte_data` — SMBus “write byte” protocol

## Synopsis

```
s32 i2c_smbus_write_byte_data (const struct i2c_client * client, u8
command, u8 value);
```

## Arguments

*client*    Handle to slave device  
*command*    Byte interpreted by slave  
*value*    Byte being written

## Description

This executes the SMBus “write byte” protocol, returning negative `errno` else zero on success.

## Name

`i2c_smbus_read_word_data` — SMBus “read word” protocol

## Synopsis

```
s32 i2c_smbus_read_word_data (const struct i2c_client * client, u8 command);
```

## Arguments

*client*    Handle to slave device

*command*    Byte interpreted by slave

## Description

This executes the SMBus “read word” protocol, returning negative `errno` else a 16-bit unsigned “word” received from the device.

## Name

`i2c_smbus_write_word_data` — SMBus “write word” protocol

## Synopsis

```
s32 i2c_smbus_write_word_data (const struct i2c_client * client, u8
command, u16 value);
```

## Arguments

*client*    Handle to slave device  
*command*    Byte interpreted by slave  
*value*    16-bit “word” being written

## Description

This executes the SMBus “write word” protocol, returning negative `errno` else zero on success.

## Name

`i2c_smbus_read_block_data` — SMBus “block read” protocol

## Synopsis

```
s32 i2c_smbus_read_block_data (const struct i2c_client * client, u8
command, u8 * values);
```

## Arguments

*client*    Handle to slave device

*command*    Byte interpreted by slave

*values*    Byte array into which data will be read; big enough to hold the data returned by the slave. SMBus allows at most 32 bytes.

## Description

This executes the SMBus “block read” protocol, returning negative `errno` else the number of data bytes in the slave's response.

Note that using this function requires that the client's adapter support the `I2C_FUNC_SMBUS_READ_BLOCK_DATA` functionality. Not all adapter drivers support this; its emulation through I2C messaging relies on a specific mechanism (`I2C_M_RECV_LEN`) which may not be implemented.

## Name

`i2c_smbus_write_block_data` — SMBus “block write” protocol

## Synopsis

```
s32 i2c_smbus_write_block_data (const struct i2c_client * client, u8
command, u8 length, const u8 * values);
```

## Arguments

*client*    Handle to slave device

*command*    Byte interpreted by slave

*length*    Size of data block; SMBus allows at most 32 bytes

*values*    Byte array which will be written.

## Description

This executes the SMBus “block write” protocol, returning negative `errno` else zero on success.

## Name

`i2c_smbus_xfer` — execute SMBus protocol operations

## Synopsis

```
s32 i2c_smbus_xfer (struct i2c_adapter * adapter, u16 addr, un-
signed short flags, char read_write, u8 command, int protocol, union
i2c_smbus_data * data);
```

## Arguments

|                   |  |
|-------------------|--|
| <i>adapter</i>    | Handle to I2C bus  |
| <i>addr</i>       | Address of SMBus slave on that bus                               |
| <i>flags</i>      | I2C_CLIENT_* flags (usually zero or I2C_CLIENT_PEC)              |
| <i>read_write</i> | I2C_SMBUS_READ or I2C_SMBUS_WRITE                                |
| <i>command</i>    | Byte interpreted by slave, for protocols which use such bytes    |
| <i>protocol</i>   | SMBus protocol operation to execute, such as I2C_SMBUS_PROC_CALL |
| <i>data</i>       | Data to be read or written                                       |

## Description

This executes an SMBus protocol operation, and returns a negative errno code else zero on success.

---

# Chapter 11. High Speed Synchronous Serial Interface (HSI)

High Speed Synchronous Serial Interface (HSI) is a serial interface mainly used for connecting application engines (APE) with cellular modem engines (CMT) in cellular handsets. HSI provides multiplexing for up to 16 logical channels, low-latency and full duplex communication.

## Name

struct hsi\_channel — channel resource used by the hsi clients

## Synopsis

```
struct hsi_channel {  
    unsigned int id;  
    const char * name;  
};
```

## Members

id     Channel number

name   Channel name

## Name

struct hsi\_config — Configuration for RX/TX HSI modules

## Synopsis

```
struct hsi_config {
    unsigned int mode;
    struct hsi_channel * channels;
    unsigned int num_channels;
    unsigned int num_hw_channels;
    unsigned int speed;
    union {unnamed_union};
};
```

## Members

|                 |  |
|-----------------|--|
| mode            | Bit transmission mode (STREAM or FRAME)                      |
| channels        | Channel resources used by the client                         |
| num_channels    | Number of channel resources                                  |
| num_hw_channels | Number of channels the transceiver is configured for [1..16] |
| speed           | Max bit transmission speed (Kbit/s)                          |
| {unnamed_union} | anonymous  |

## Name

struct hsi\_board\_info — HSI client board info

## Synopsis

```
struct hsi_board_info {  
    const char * name;  
    unsigned int hsi_id;  
    unsigned int port;  
    struct hsi_config tx_cfg;  
    struct hsi_config rx_cfg;  
    void * platform_data;  
    struct dev_archdata * archdata;  
};
```

## Members

|               |   |
|---------------|---|
| name          | Name for the HSI device                             |
| hsi_id        | HSI controller id where the client sits             |
| port          | Port number in the controller where the client sits |
| tx_cfg        | HSI TX configuration                                |
| rx_cfg        | HSI RX configuration                                |
| platform_data | Platform related data                               |
| archdata      | Architecture-dependent device data                  |

## Name

struct hsi\_client — HSI client attached to an HSI port

## Synopsis

```
struct hsi_client {  
    struct device device;  
    struct hsi_config tx_cfg;  
    struct hsi_config rx_cfg;  
};
```

## Members

|        |   |
|--------|---|
| device | Driver model representation of the device |
| tx_cfg | HSI TX configuration                      |
| rx_cfg | HSI RX configuration                      |

## Name

struct hsi\_client\_driver — Driver associated to an HSI client

## Synopsis

```
struct hsi_client_driver {  
    struct device_driver driver;  
};
```

## Members

driver     Driver model representation of the driver

## Name

struct hsi\_msg — HSI message descriptor

## Synopsis

```
struct hsi_msg {
    struct list_head link;
    struct hsi_client * cl;
    struct sg_table sgt;
    void * context;
    void (* complete) (struct hsi_msg *msg);
    void (* destructor) (struct hsi_msg *msg);
    int status;
    unsigned int actual_len;
    unsigned int channel;
    unsigned int ttype:1;
    unsigned int break_frame:1;
};
```

## Members

|             |   |
|-------------|---|
| link        | Free to use by the current descriptor owner   |
| cl          | HSI device client that issues the transfer  |
| sgt         | Head of the scatterlist array   |
| context     | Client context data associated to the transfer  |
| complete    | Transfer completion callback  |
| destructor  | Destructor to free resources when flushing  |
| status      | Status of the transfer when completed   |
| actual_len  | Actual length of data transferred on completion                                       |
| channel     | Channel were to TX/RX the message   |
| ttype       | Transfer type (TX if set, RX otherwise)   |
| break_frame | if true HSI will send/receive a break frame. Data buffers are ignored in the request. |

## Name

struct hsi\_port — HSI port device

## Synopsis

```
struct hsi_port {
    struct device device;
    struct hsi_config tx_cfg;
    struct hsi_config rx_cfg;
    unsigned int num;
    unsigned int shared:1;
    int claimed;
    struct mutex lock;
    int (* async) (struct hsi_msg *msg);
    int (* setup) (struct hsi_client *cl);
    int (* flush) (struct hsi_client *cl);
    int (* start_tx) (struct hsi_client *cl);
    int (* stop_tx) (struct hsi_client *cl);
    int (* release) (struct hsi_client *cl);
    struct atomic_notifier_head n_head;
};
```

## Members

|          |  |
|----------|--|
| device   | Driver model representation of the device                        |
| tx_cfg   | Current TX path configuration                                    |
| rx_cfg   | Current RX path configuration                                    |
| num      | Port number  |
| shared   | Set when port can be shared by different clients                 |
| claimed  | Reference count of clients which claimed the port                |
| lock     | Serialize port claim   |
| async    | Asynchronous transfer callback                                   |
| setup    | Callback to set the HSI client configuration                     |
| flush    | Callback to clean the HW state and destroy all pending transfers |
| start_tx | Callback to inform that a client wants to TX data                |
| stop_tx  | Callback to inform that a client no longer wishes to TX data     |
| release  | Callback to inform that a client no longer uses the port         |
| n_head   | Notifier chain for signaling port events to the clients.         |

## Name

struct hsi\_controller — HSI controller device

## Synopsis

```
struct hsi_controller {
    struct device device;
    struct module * owner;
    unsigned int id;
    unsigned int num_ports;
    struct hsi_port ** port;
};
```

## Members

|           |   |
|-----------|---|
| device    | Driver model representation of the device   |
| owner     | Pointer to the module owning the controller |
| id        | HSI controller ID                           |
| num_ports | Number of ports in the HSI controller       |
| port      | Array of HSI ports                          |

## Name

`hsi_id` — Get HSI controller ID associated to a client

## Synopsis

```
unsigned int hsi_id (struct hsi_client * cl);
```

## Arguments

*cl* Pointer to a HSI client

## Description

Return the controller id where the client is attached to

## Name

`hsi_port_id` — Gets the port number a client is attached to

## Synopsis

```
unsigned int hsi_port_id (struct hsi_client * cl);
```

## Arguments

*cl* Pointer to HSI client

## Description

Return the port number associated to the client

## Name

`hsi_setup` — Configure the client's port

## Synopsis

```
int hsi_setup (struct hsi_client * cl);
```

## Arguments

*cl* Pointer to the HSI client

## Description

When sharing ports, clients should either relay on a single client setup or have the same setup for all of them.

Return `-errno` on failure, `0` on success

## Name

`hsi_flush` — Flush all pending transactions on the client's port

## Synopsis

```
int hsi_flush (struct hsi_client * cl);
```

## Arguments

*cl* Pointer to the HSI client

## Description

This function will destroy all pending `hsi_msg` in the port and reset the HW port so it is ready to receive and transmit from a clean state.

Return `-errno` on failure, `0` on success

## Name

`hsi_async_read` — Submit a read transfer

## Synopsis

```
int hsi_async_read (struct hsi_client * cl, struct hsi_msg * msg);
```

## Arguments

*cl* Pointer to the HSI client

*msg* HSI message descriptor of the transfer

## Description

Return `-errno` on failure, 0 on success

## Name

`hsi_async_write` — Submit a write transfer

## Synopsis

```
int hsi_async_write (struct hsi_client * cl, struct hsi_msg * msg);
```

## Arguments

*cl* Pointer to the HSI client

*msg* HSI message descriptor of the transfer

## Description

Return `-errno` on failure, 0 on success

## Name

`hsi_start_tx` — Signal the port that the client wants to start a TX

## Synopsis

```
int hsi_start_tx (struct hsi_client * cl);
```

## Arguments

*cl* Pointer to the HSI client

## Description

Return `-errno` on failure, 0 on success

## Name

`hsi_stop_tx` — Signal the port that the client no longer wants to transmit

## Synopsis

```
int hsi_stop_tx (struct hsi_client * cl);
```

## Arguments

*cl* Pointer to the HSI client

## Description

Return `-errno` on failure, 0 on success

## Name

`hsi_port_unregister_clients` — Unregister an HSI port

## Synopsis

```
void hsi_port_unregister_clients (struct hsi_port * port);
```

## Arguments

*port* The HSI port to unregister

## Name

`hsi_unregister_controller` — Unregister an HSI controller

## Synopsis

```
void hsi_unregister_controller (struct hsi_controller * hsi);
```

## Arguments

*hsi* The HSI controller to register

## Name

`hsi_register_controller` — Register an HSI controller and its ports

## Synopsis

```
int hsi_register_controller (struct hsi_controller * hsi);
```

## Arguments

*hsi* The HSI controller to register

## Description

Returns `-errno` on failure, 0 on success.

## Name

`hsi_register_client_driver` — Register an HSI client to the HSI bus

## Synopsis

```
int hsi_register_client_driver (struct hsi_client_driver * drv);
```

## Arguments

*drv* HSI client driver to register

## Description

Returns `-errno` on failure, 0 on success.

## Name

`hsi_put_controller` — Free an HSI controller

## Synopsis

```
void hsi_put_controller (struct hsi_controller * hsi);
```

## Arguments

*hsi* Pointer to the HSI controller to freed

## Description

HSI controller drivers should only use this function if they need to free their allocated `hsi_controller` structures before a successful call to `hsi_register_controller`. Other use is not allowed.

## Name

`hsi_alloc_controller` — Allocate an HSI controller and its ports

## Synopsis

```
struct hsi_controller * hsi_alloc_controller (unsigned int n_ports,  
gfp_t flags);
```

## Arguments

*n\_ports* Number of ports on the HSI controller

*flags* Kernel allocation flags

## Description

Return NULL on failure or a pointer to an `hsi_controller` on success.

## Name

`hsi_free_msg` — Free an HSI message

## Synopsis

```
void hsi_free_msg (struct hsi_msg * msg);
```

## Arguments

*msg* Pointer to the HSI message

## Description

Client is responsible to free the buffers pointed by the scatterlists.

## Name

`hsi_alloc_msg` — Allocate an HSI message

## Synopsis

```
struct hsi_msg * hsi_alloc_msg (unsigned int nents, gfp_t flags);
```

## Arguments

*nents* Number of memory entries

*flags* Kernel allocation flags

## Description

*nents* can be 0. This mainly makes sense for read transfer. In that case, HSI drivers will call the complete callback when there is data to be read without consuming it.

Return NULL on failure or a pointer to an `hsi_msg` on success.

## Name

`hsi_async` — Submit an HSI transfer to the controller

## Synopsis

```
int hsi_async (struct hsi_client * cl, struct hsi_msg * msg);
```

## Arguments

*cl* HSI client sending the transfer

*msg* The HSI transfer passed to controller

## Description

The HSI message must have the channel, ttype, complete and destructor fields set beforehand. If nents > 0 then the client has to initialize also the scatterlists to point to the buffers to write to or read from.

HSI controllers relay on pre-allocated buffers from their clients and they do not allocate buffers on their own.

Once the HSI message transfer finishes, the HSI controller calls the complete callback with the status and actual\_len fields of the HSI message updated. The complete callback can be called before returning from `hsi_async`.

Returns -errno on failure or 0 on success

## Name

`hsi_claim_port` — Claim the HSI client's port

## Synopsis

```
int hsi_claim_port (struct hsi_client * cl, unsigned int share);
```

## Arguments

*cl*      HSI client that wants to claim its port

*share*   Flag to indicate if the client wants to share the port or not.

## Description

Returns `-errno` on failure, 0 on success.

## Name

`hsi_release_port` — Release the HSI client's port

## Synopsis

```
void hsi_release_port (struct hsi_client * cl);
```

## Arguments

*cl* HSI client which previously claimed its port

## Name

`hsi_register_port_event` — Register a client to receive port events

## Synopsis

```
int hsi_register_port_event (struct hsi_client * cl, void (*handler)  
(struct hsi_client *, unsigned long));
```

## Arguments

*cl*            HSI client that wants to receive port events

*handler*    Event handler callback

## Description

Clients should register a callback to be able to receive events from the ports. Registration should happen after claiming the port. The handler can be called in interrupt context.

Returns `-errno` on error, or `0` on success.

## Name

`hsi_unregister_port_event` — Stop receiving port events for a client

## Synopsis

```
int hsi_unregister_port_event (struct hsi_client * cl);
```

## Arguments

*cl* HSI client that wants to stop receiving port events

## Description

Clients should call this function before releasing their associated port.

Returns `-errno` on error, or `0` on success.

## Name

`hsi_event` — Notifies clients about port events

## Synopsis

```
int hsi_event (struct hsi_port * port, unsigned long event);
```

## Arguments

*port* Port where the event occurred

*event* The event type

## Description

Clients should not be concerned about wake line behavior. However, due to a race condition in HSI HW protocol, clients need to be notified about wake line changes, so they can implement a workaround for it.

## Events

HSI\_EVENT\_START\_RX - Incoming wake line high  
HSI\_EVENT\_STOP\_RX - Incoming wake line down

Returns -errno on error, or 0 on success.

## Name

`hsi_get_channel_id_by_name` — acquire channel id by channel name

## Synopsis

```
int hsi_get_channel_id_by_name (struct hsi_client * cl, char * name);
```

## Arguments

*cl* HSI client, which uses the channel

*name* name the channel is known under

## Description

Clients can call this function to get the hsi channel ids similar to requesting IRQs or GPIOs by name. This function assumes the same channel configuration is used for RX and TX.

Returns `-errno` on error or channel id on success.