Run/Wait Queues

W4118 Operating Systems I

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Credits to Jae

Process States

```
/* Used in tsk->state: */
#define TASK_RUNNING             0x0000
#define TASK_INTERRUPTIBLE       0x0001
#define TASK_UNINTERRUPTIBLE     0x0002
```

`TASK_RUNNING`: the task is runnable – either currently running or on a run queue waiting to run

`TASK_INTERRUPTIBLE`: the task is sleeping waiting for some condition to exist - can be awakened prematurely if it receives a signal

`TASK_UNINTERRUPTIBLE`: the task is sleeping waiting for some condition to exist - cannot be awakened prematurely if it receives a signal

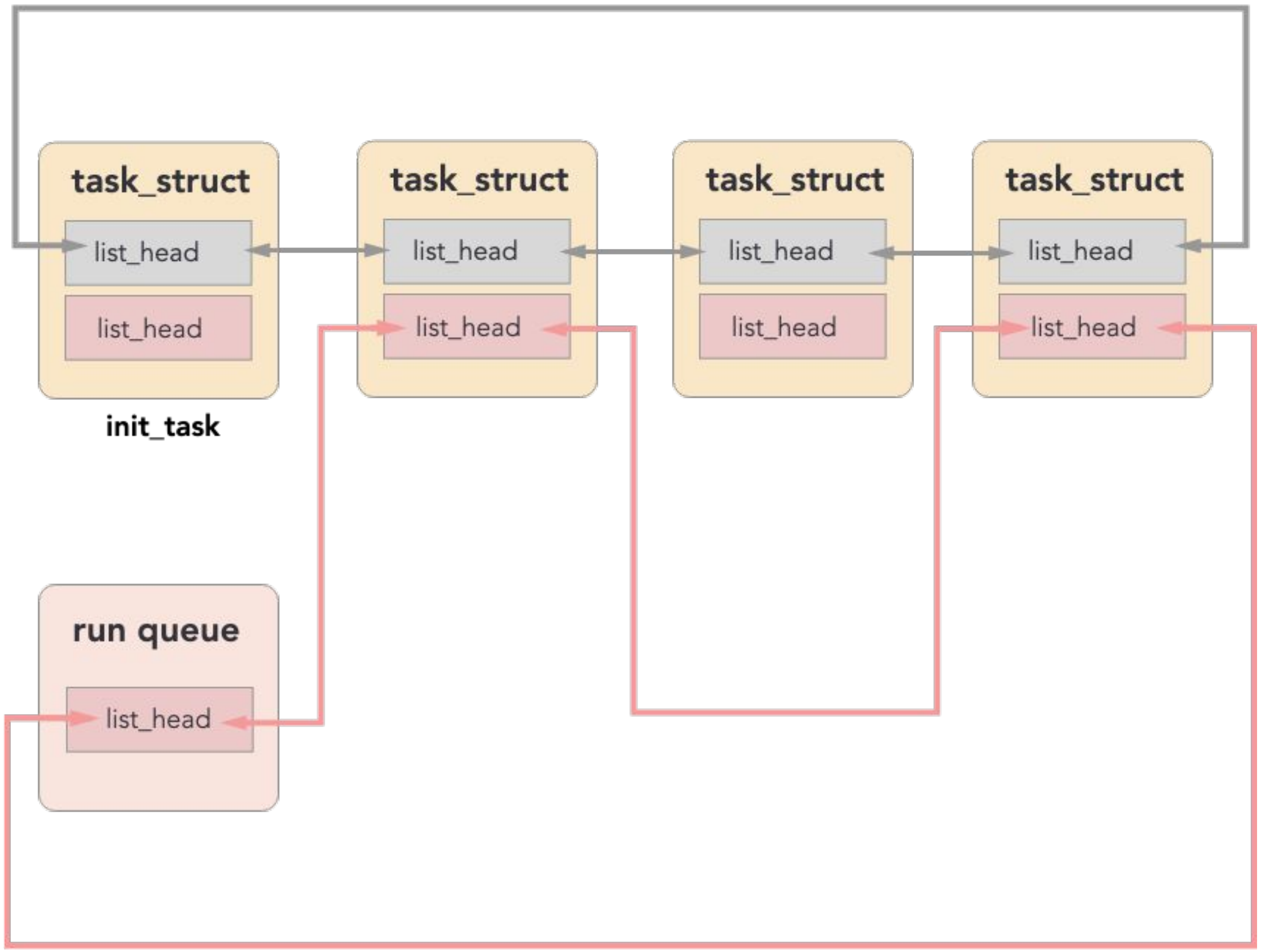
Run Queue

`task_structs` are linked via `children/sibling` list_heads

Per-CPU `run_queue` links tasks with state `TASK_RUNNING`

Why need a separate `list_head` for the run queue?

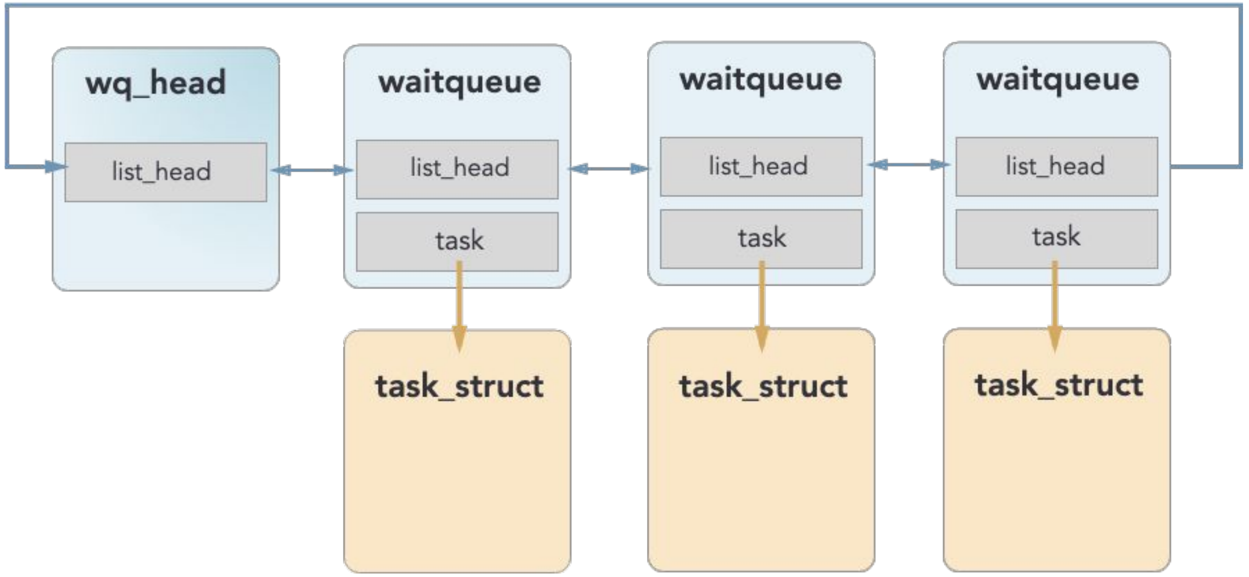
[`include/linux/sched.h`]()



Wait Queue

Per-event `wait_queue`

Wait queue entry is NOT embedded in `task_struct`



Wait Queue Data Structures

***pseudocode

```
struct wait_queue_head {
        spin_lock_t lock;
        struct list_head task_list;
};

struct waitqueue {
        struct task_struct *task;
        wait_queue_func_t func; // callback function, e.g. try_to_wake_up()
        struct list_head entry;
};
```

How to wait

`include/linux/wait.h` – (kernel 3.12.74 for simplicity)

1. **`prepare_to_wait()`**: add yourself to wait queue, change state to **`TASK_INTERRUPTIBLE`**
2. **`signal_pending()`**: check for "spurious wakeup", i.e. signal interrupted sleep before condition was met
   - break out of loop instead of sleeping
3. **`schedule()`**: put yourself to sleep
4. **`finish_wait()`**: change state to **`TASK_RUNNING`**, remove yourself from the wait queue

Perform 1-3 in a loop to handle spurious wakeups

Notes:

1. LKD page 59 is outdated and incorrect, use **`wait_event_interruptible()`**
2. **`wait_event_interruptible()`** is a generic macro, probably not appropriate to use directly
   a. Doesn't account for synchronization
   b. You may want to handle **`signal_pending()`** differently

Scheduling Basics

`kernel/sched/core.c`

1. `pick_next_task()`: choose a new task to run from the run queue
2. `context_switch()`: put current task to sleep, start running new task

Wait Queue Walkthrough

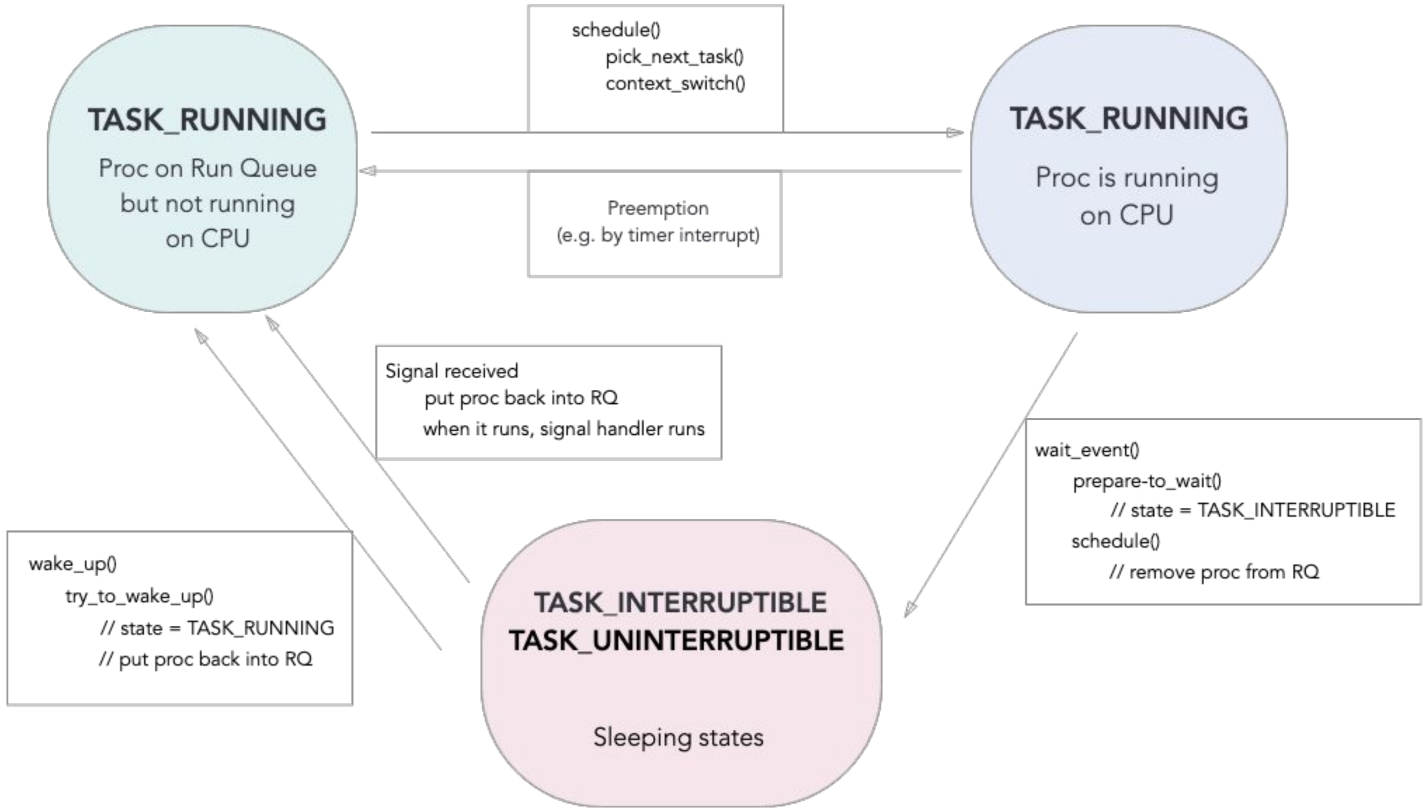
Sleeping:

1. **`wait_event()`**
2. Enqueued on wait queue
3. Remove from run queue
4. **`schedule()`**
   - **`pick_next_task()`**
   - **`context_switch`**
5. Other task runs

Waking up:

1. Task signals event: **`wake_up()`**
2. Call **`try_to_wake_up()`** on each task
3. Enqueue each task on run queue
4. Eventually other tasks calls **`schedule()`** and previously sleeping task gets chosen*
5. Previously sleeping task checks condition
   - If true, **`finish_wake()`**
   - Else, repeat 3-6 from “sleeping”

Process State Transition



Example: **`read()`**

1. Trap into kernel
    - save registers into per-proc kernel stack
2. Device driver issues an I/O request to the device
3. Put the calling process to sleep
    - **`wait_event()`** → **`schedule()`** → **`pick_next_task()`** → **`context_switch()`**
4. Another process starts running
5. The device completes the I/O request and raised a hardware interrupt
6. Trap into kernel and jump to the interrupt handler:
    - **`wake_up():`** enqueue blocked tasks back on run queue
    - Current task eventually calls **`schedule()`** → **`pick_next_task()`** → **`context_switch()`**
7. Another process starts running
    - This process may or may not be the one that called **`read()`**