Embedded Systems Programming

ISR and Work Queue
(Module 15)

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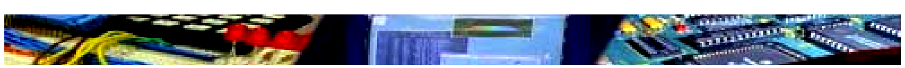
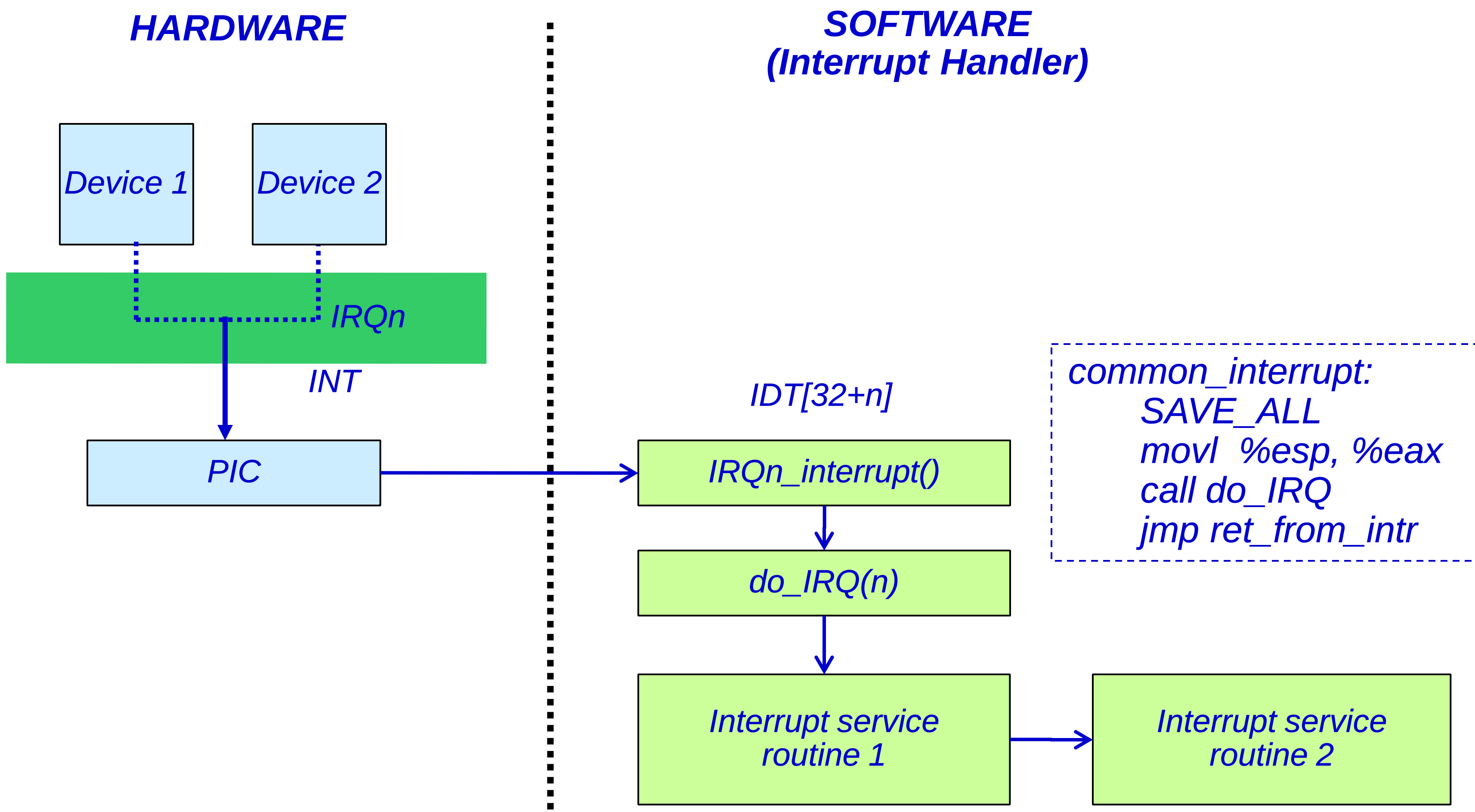


Interrupt Handling

- **Depends on the type of interrupts**
  - *I/O interrupts*
  - *Timer interrupts*
  - *Interprocessor interrupts*
- **Unlike exceptions, interrupts are “out of context” events**
- **Generally associated with a specific device that delivers a signal on a specific IRQ**
  - IRQs can be shared and several ISRs may be registered for a single IRQ
- **ISRs is unable to sleep, or block**
  - *Critical:* to be executed within the ISR immediately, with maskable interrupts disabled
  - *Noncritical:* should be finished quickly, so they are executed by theISR immediately, with the interrupts enabled
  - *Noncritical deferrable:* deferrable actions are performed by means of separate functions

I/O Interrupt Handling



(D. P. Bovet and M. Cesati, "Understanding the Linux Kernel", 3rd Edition)

Execute ISRs associated with all the devices that share the IRQ.

Why ISR Bottom Half?

- **To have low interrupt latency -- to split interrupt routines into**
  - a `top half', which receives the hardware interrupt and
  - a `bottom half', which does the lengthy processing.
- **Top halves have following properties (requirements)**
  - need to run as quickly as possible
  - run with some (or all) interrupt levels disabled
  - are often time-critical and they deal with HW
  - do not run in process context and cannot block
- **Bottom halves are to defer work later**
  - “Later” is often simply “not now”
  - Often, bottom halves run immediately after interrupt returns
  - They run with all interrupts enabled
- **Code in the Linux kernel runs in one of three contexts:**
  - Process context, kernel thread context, and Interrupt.

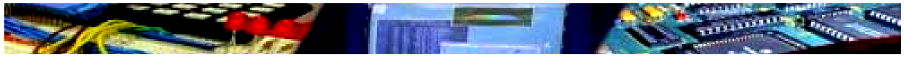
A World of Bottom Halves

- **Multiple mechanisms are available for bottom halves**
- **softirq: (available since 2.3)**
  - A set of 32 statically defined bottom halves that can run simultaneously on any processor
    - Even 2 of the same type can run concurrently
  - Used when performance is critical
  - Must be registered statically at compile-time
- **tasklet: (available since 2.3)**
  - Are built on top of softirqs
  - Two different tasklets can run simultaneously on different processors
    - But 2 of the same type cannot run simultaneously
  - Used most of the time for its ease and flexibility
  - Code can dynamically register tasklets
- **work queues: (available since 2.5)**
  - Queueing work to be performed in process context

WorkQueues

- **To request that a function be called at some future time.**
  - tasklets execute quickly, for a short period of time, and in atomic mode
  - workqueue functions may have higher latency but need not be atomic
- **Run in the context of a special kernel process (worker thread)**
  - more flexibility and workqueue functions can sleep.
  - they are allowed to block (unlike deferred routines)
  - No access to user space
- ***A workqueue (****workqueue_struct)* ***must be explicitly created***
- **Each workqueue has one or more dedicated "kernel threads", which run functions submitted to the queue via *queue_work()*.**
  - work_struct structure to submit a task to a workqueue

    *DECLARE_WORK(name, void (*function)(void *), void *data);*
- **The kernel offers a predefined work queue called *events*, which can be freely used by every kernel developer**



Example of Work Structure and Handler

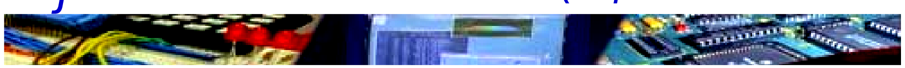
```
#include <linux/kernel.h>
#include <linux/module.h>
#include <linux/workqueue.h>
MODULE_LICENSE("GPL");

static struct workqueue_struct *my_wq;                    // work queue
typedef struct {                                          // work
        struct work_struct  my_work;
        int x;
} my_work_t;

my_work_t  *work, *work2;

static void my_wq_function( struct work_struct *work)  // function to be call
{
        my_work_t  *my_work = (my_work_t *)work;
        printk( "my_work.x %d\n", my_work->x );
        kfree( (void *)work );
        return;
}
```

(http://www.ibm.com/developerworks/linux/library/l-tasklets/index.html)

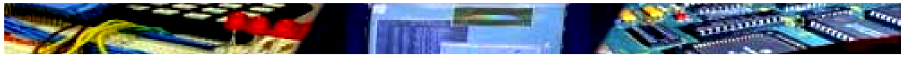


Example of Work and WorkQueue Creation

```
int init_module( void )
{
    int ret;
    my_wq = create_workqueue("my_queue");      // create work queue
    if (my_wq) {
        work = (my_work_t *)kmalloc(sizeof(my_work_t), GFP_KERNEL);
        if (work) {                              // Queue work (item 1)
            INIT_WORK( (struct work_struct *)work, my_wq_function );
            work->x = 1;
            ret = queue_work( my_wq, (struct work_struct *)work );
        }

        work2 = (my_work_t *)kmalloc(sizeof(my_work_t), GFP_KERNEL);
        if (work2) {                        // Queue work (item 2)
            INIT_WORK( (struct work_struct *)work2, my_wq_function );
            work2->x = 2;
            ret = queue_work( my_wq, (struct work_struct *)work2 );
        }
    }
    return 0;    }
```

(http://www.ibm.com/developerworks/linux/library/l-tasklets/index.html)



Linux Kernel Thread

- **A way to implement background tasks inside the kernel**

```
static struct task_struct *tsk;
static int thread_function(void *data) {
    int time_count = 0;
    do {
        printk(KERN_INFO "thread_function: %d times", ++time_count);
        msleep(1000);
     }while(!kthread_should_stop() && time_count<=30);
return time_count;
}

static int hello_init(void)  {
tsk = kthread_run(thread_function, NULL, "mythread%d", 1);
if (IS_ERR(tsk)) {  …. }
}
```