Interrupt Controller Driver

ECEN 330

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Interrupts

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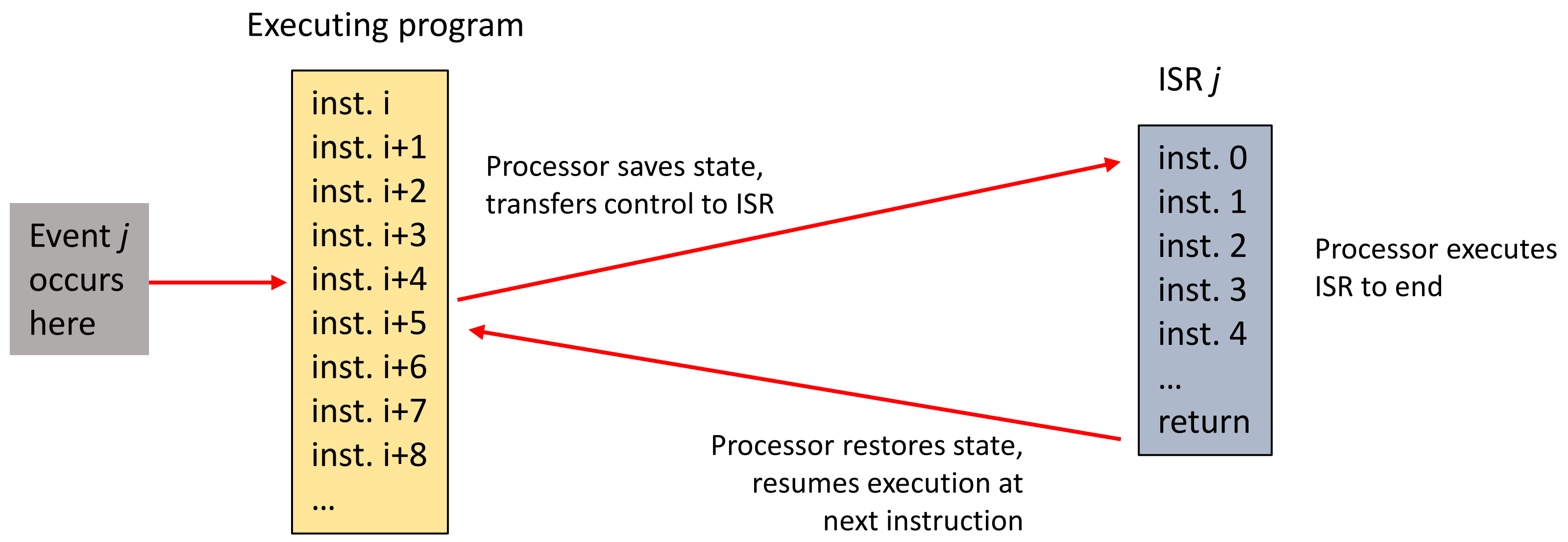
- A signal to the processor that an event occurred requiring a response
- The processor responds by:
  - Saving the state of the code that was running
  - Transferring control to a function written specifically to deal with that event



Interrupt Hardware

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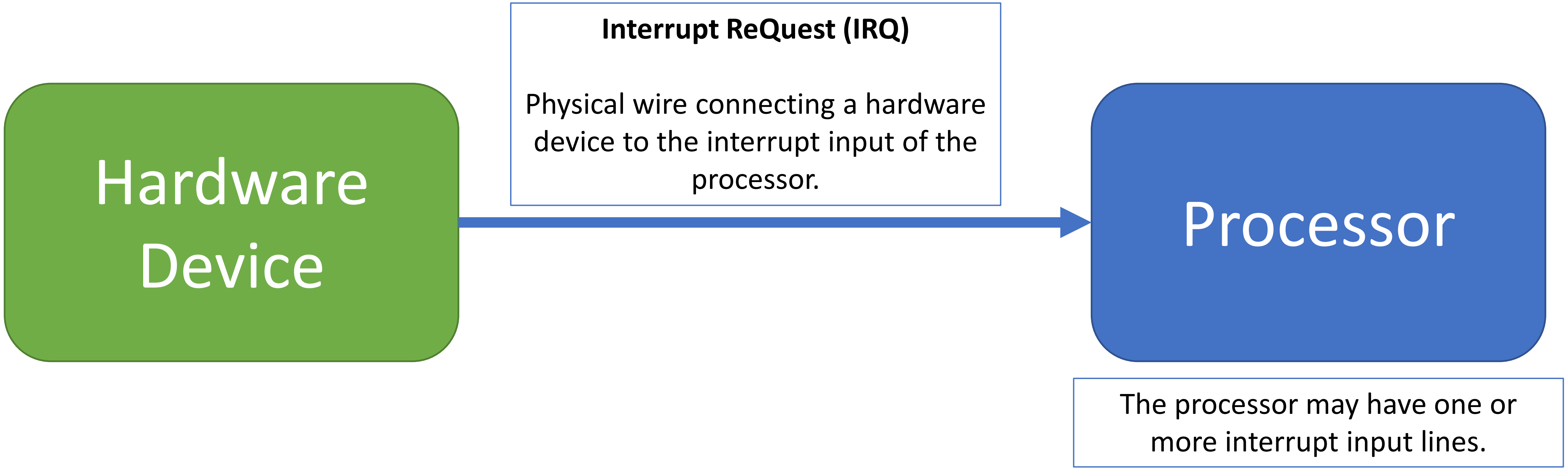
What does the hardware look like?



Interrupt ReQuest (IRQ)

Physical wire connecting a hardware device to the interrupt input of the processor.

The processor may have one or more interrupt input lines.

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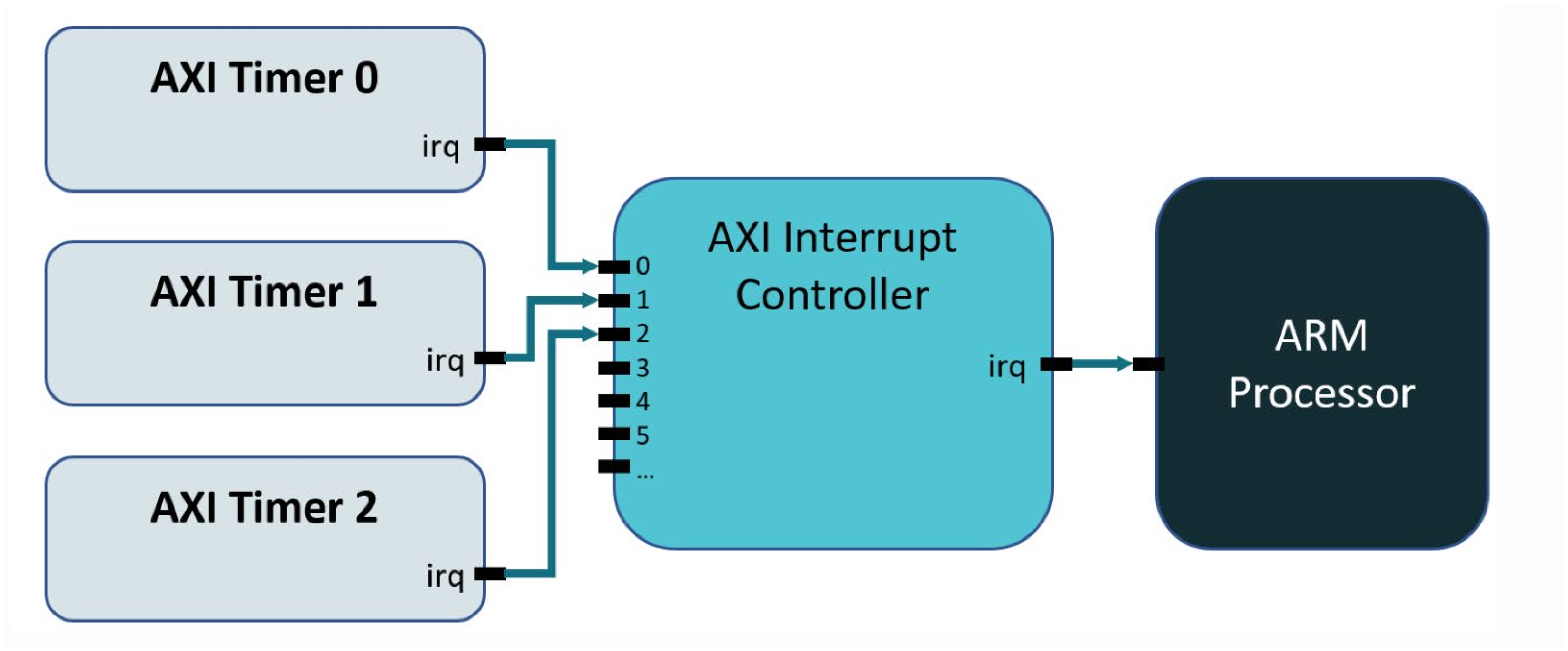
What happens if there are more devices than CPU interrupt inputs?

Interrupt Controller



When a hardware device sends an IRQ to the interrupt controller,
the interrupt controller sends an IRQ to the processor.
(assuming appropriate things are enabled)

Setting Up the Interrupt Controller

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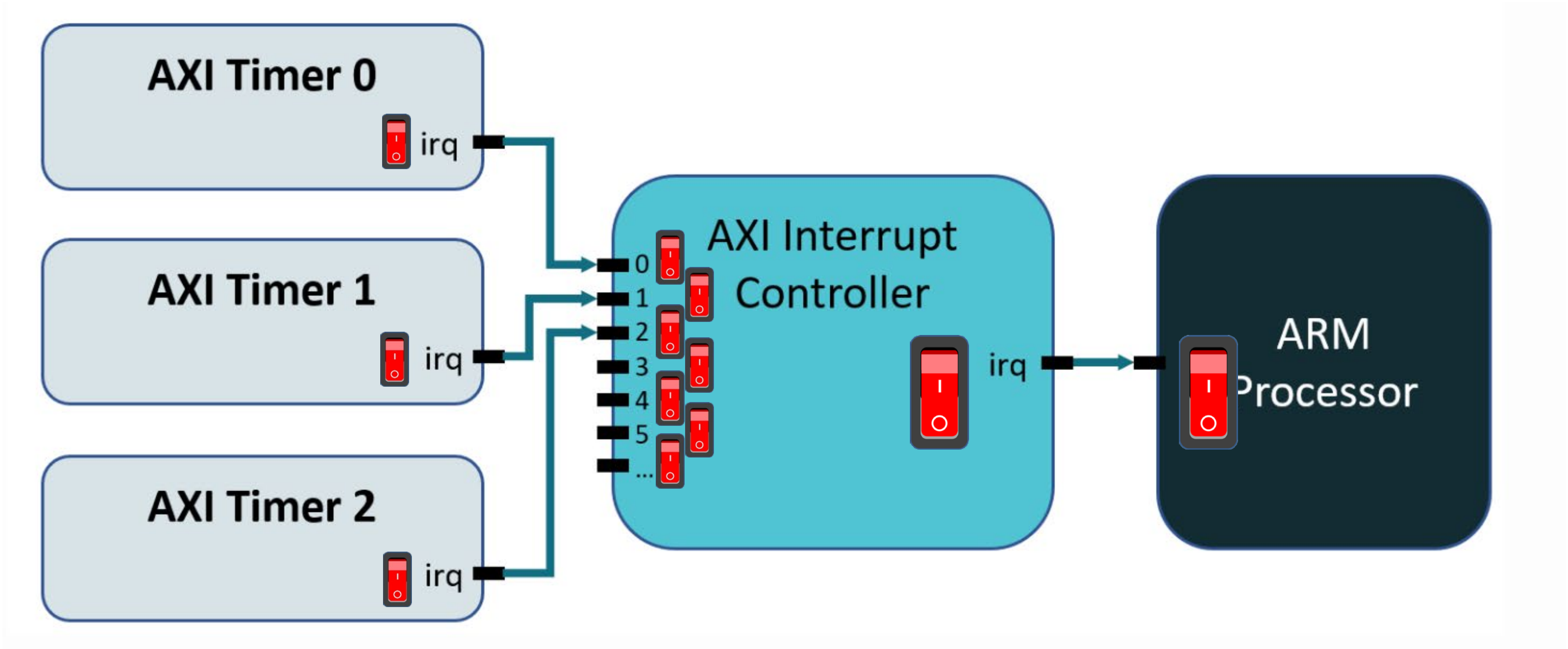
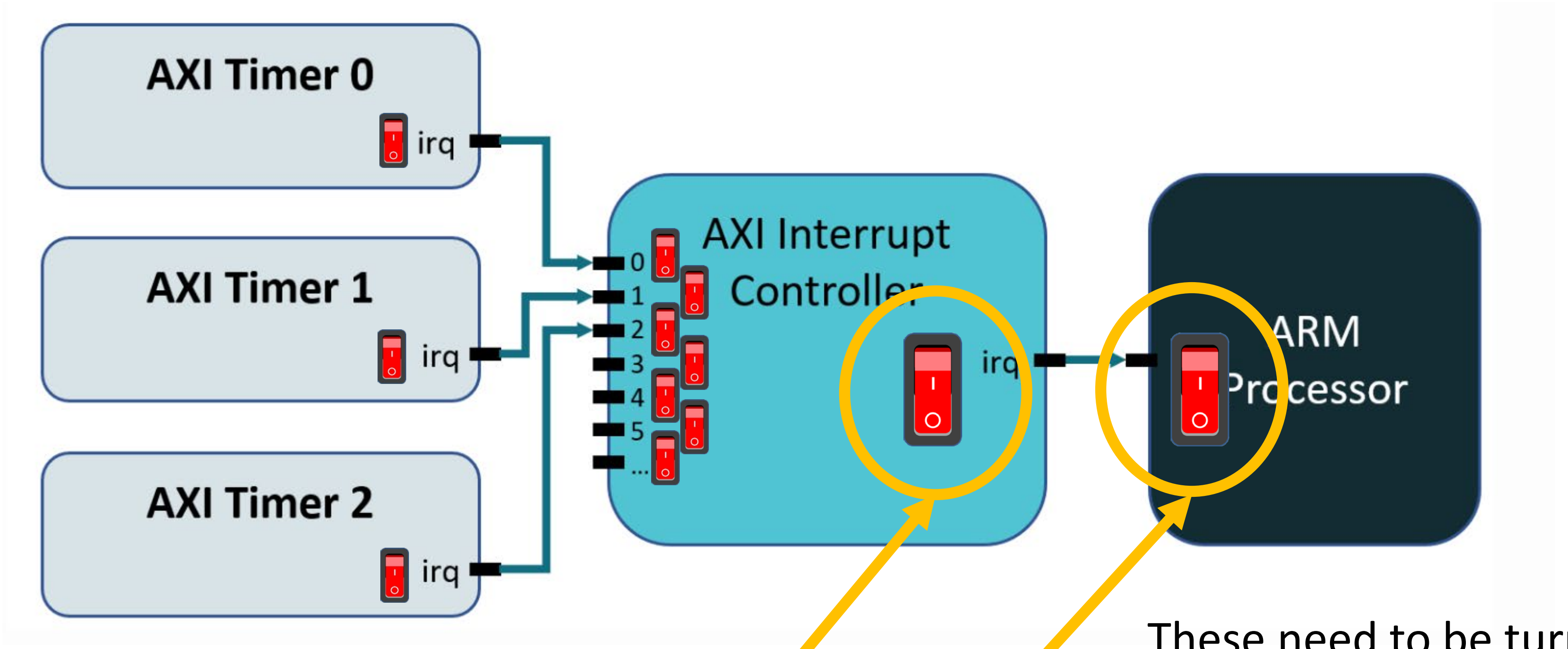
For interrupts to function, they have to be enabled:



Setting Up the Interrupt Controller

For interrupts to function, they have to be enabled:



Set both bits in "Master Enable Register"

```
armInterrupts_init();
armInterrupts_enable();
```

These need to be turned on whenever you use interrupts, so turn them on in your **`interrupts_init()`** function

Setting Up the Interrupt Controller

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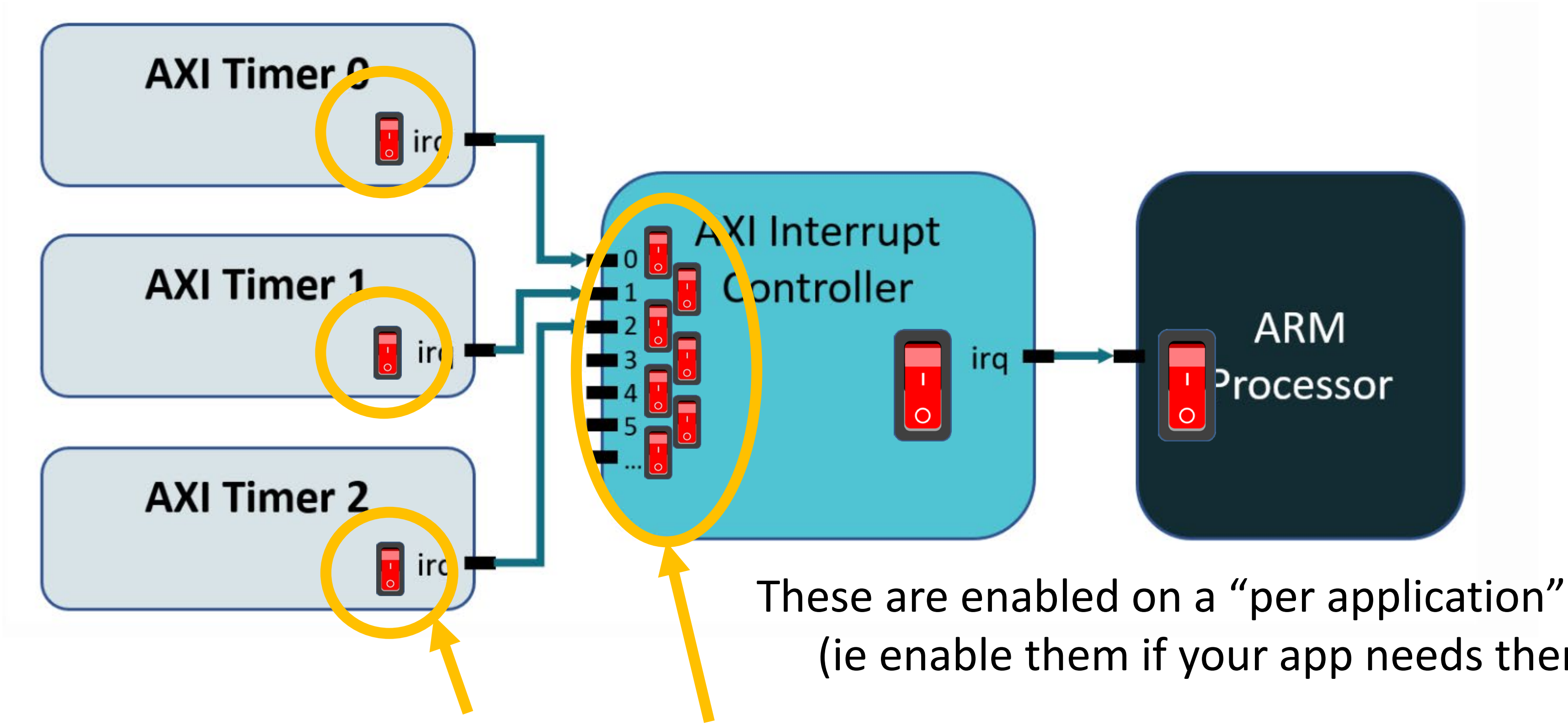
For interrupts to function, they have to be enabled:



These are enabled on a "per application" basis
(ie enable them if your app needs them)

`intervalTimer_enableInterrupt()`

`interrupts_irq_enable()` – Use IER or SIE register
`interrupts_irq_disable()` – Use IER or CIE register

Inside **`interrupts_init()`**, it's a good idea to disable all of the interrupt inputs.

Enabling the Interrupt Controller

The last setup step:

Specify an interrupt service routine (ISR).

- This is a function in your code that is called when the processor detects an interrupt.

```
static void interrupts_isr() {
    …
    …
}
```

This function will be a helper function in your Interrupt Controller Driver (inside *interrupts.c*)

How do you do this?

- Call the following and provide a function pointer:
  `armInterrupts_setupIntc(interrupts_isr);`

- Do this inside your **`interrupts_init()`** function

Now you are done setting up your interrupt controller!

At this point you should have written these functions:

`interrupts_init()`

`interrupts_irq_enable()`

`interrupts_irq_disable()`

```
static void interrupts_isr() {
    …
    …
}
```

So what should you do in your ISR function?

(Students often struggle getting this right.)

Key Fact:

Hardware devices don't know when it's IRQ has been handled.

- So (typically) they keep sending the IRQ until the software acknowledges/clears it.

Interrupt Controller

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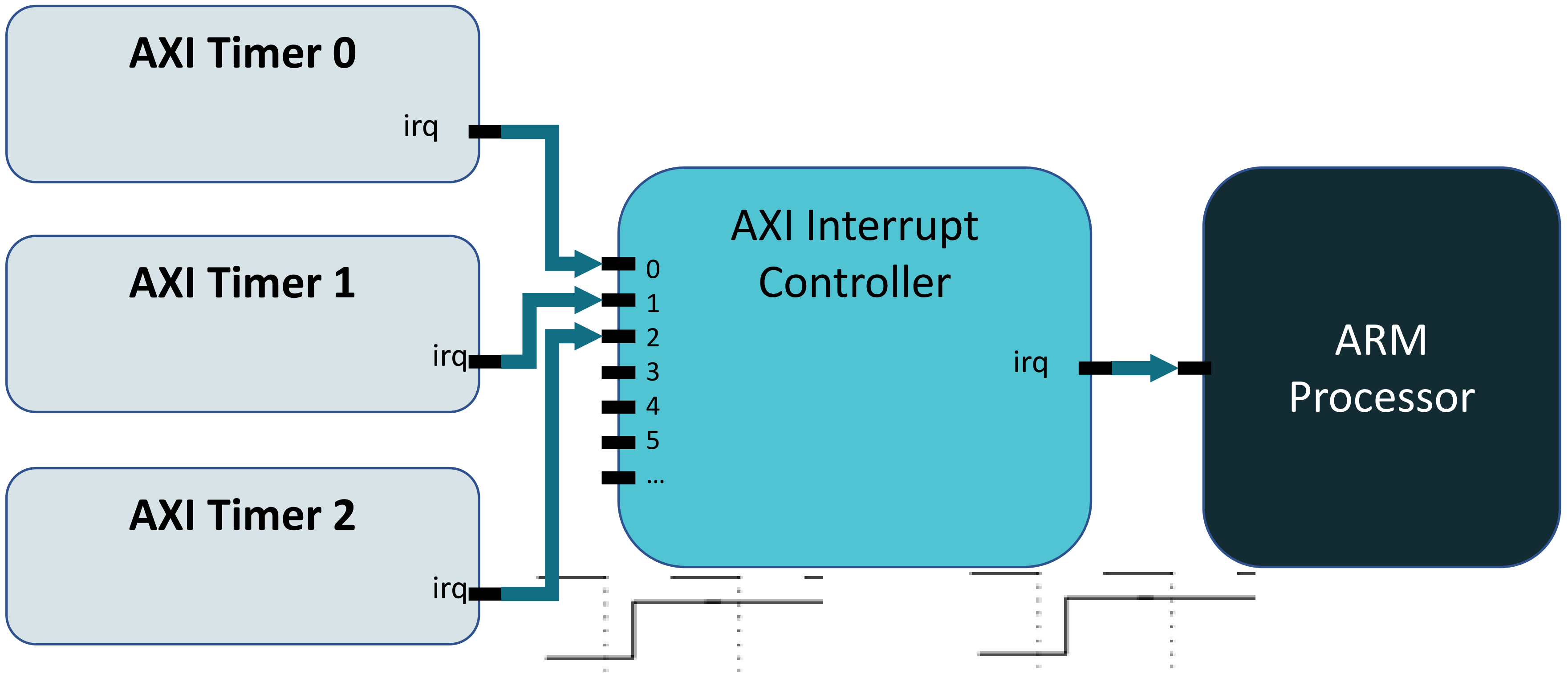

Q1: If you don’t acknowledge the IRQ on the Interrupt Controller, what will happen when your ISR function completes?

- Your ISR will immediately be called again. Infinite loop! You will never return to your program…

Q2: If you don’t acknowledge the IRQ from the Timer, what will happen?

Q3: Does it matter which you acknowledge first?

Acknowledging Interrupts

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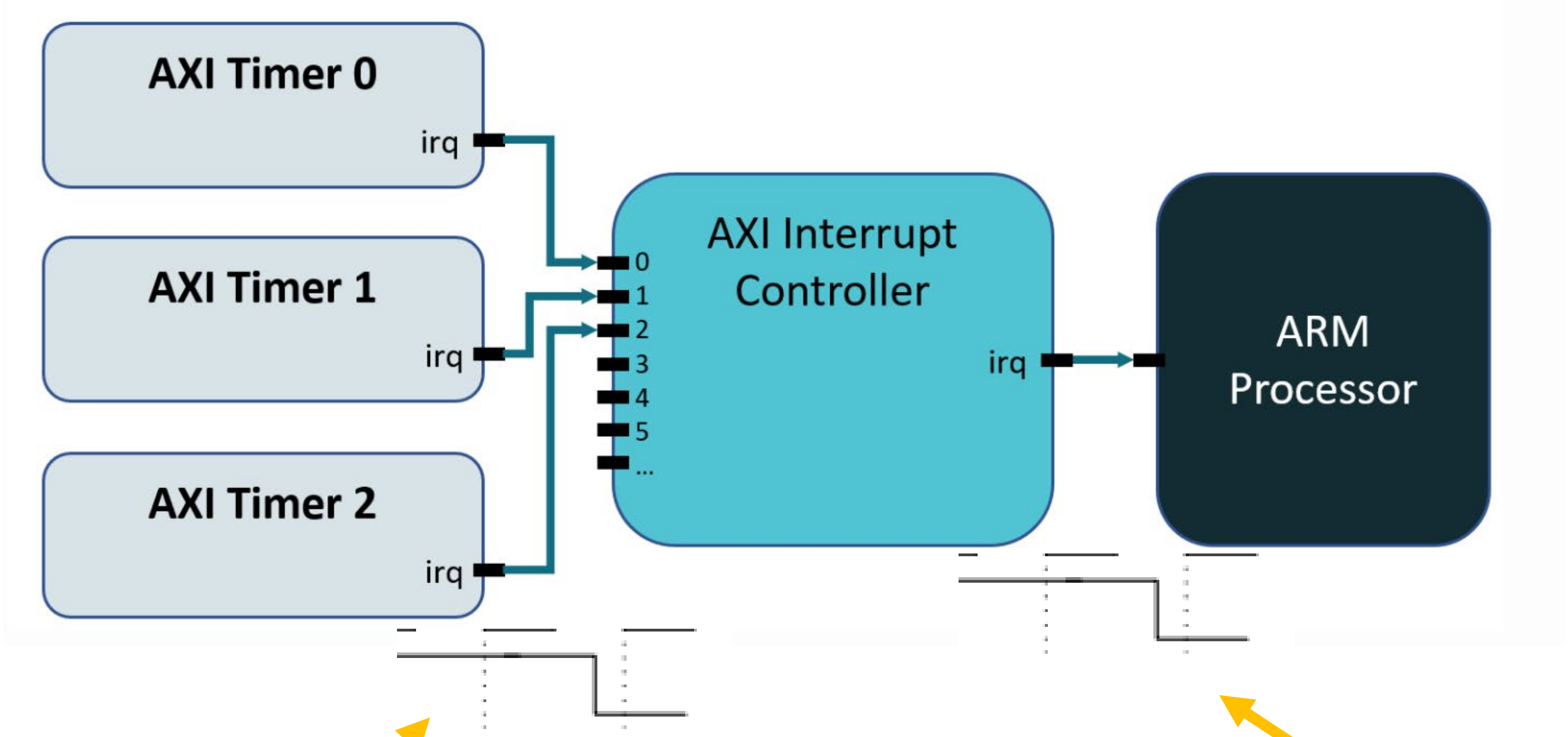

`intervalTimer_ackInterrupt()`

`interrupts_ack()`

`(Use the IAR register)`

You should now be able to handle interrupts, without your program hanging.

However, your ISR does nothing!
(aside from acknowledging the interrupt)

What would you like it to do?

ISR

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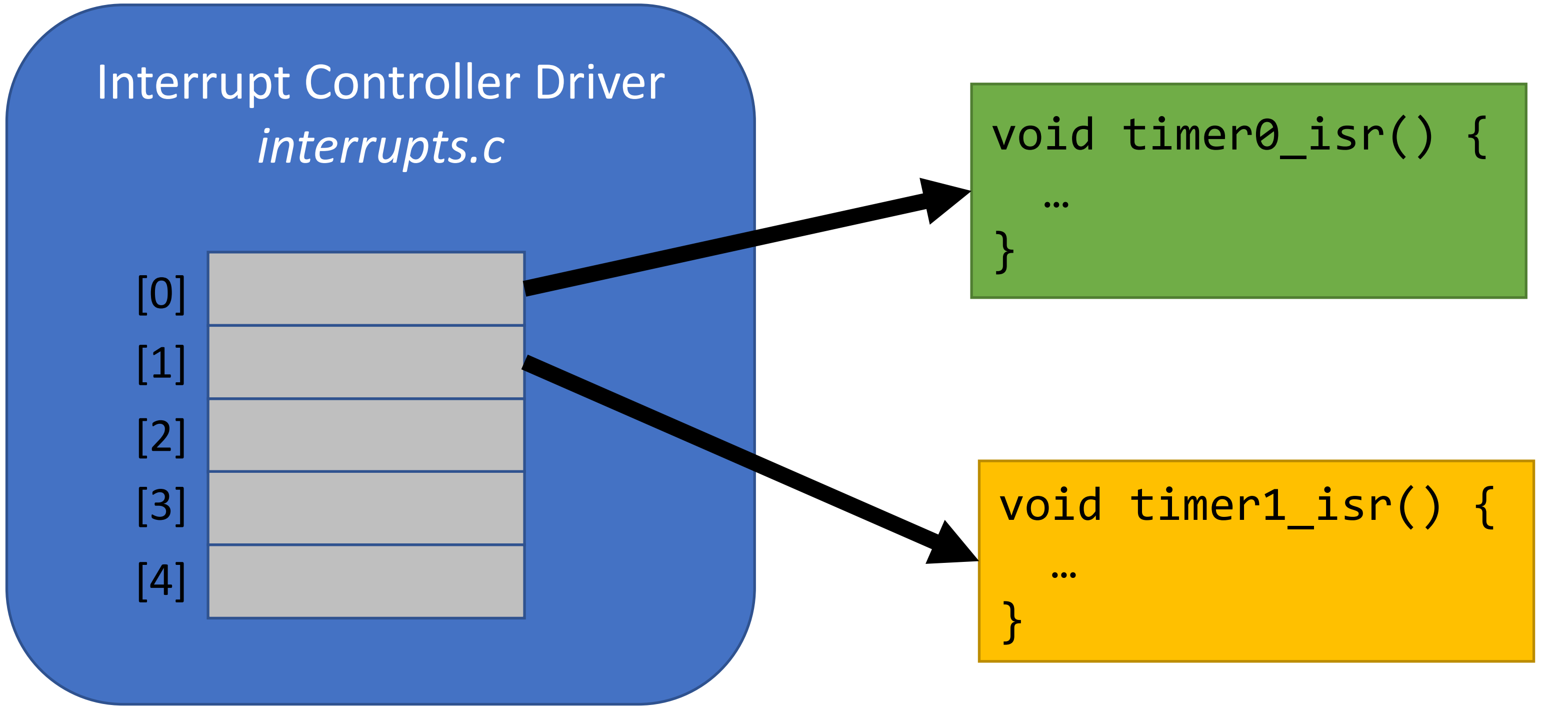
Your interrupt controller driver will allow programs to **register** a **callback function** tied to an IRQ #.

```
void interrupts_register(uint8_t irq, void (*fcn)());
```



```
void timer0_isr() {
  …
}
```

```
void timer1_isr() {
  …
}
```

```
interrupts_register(0, timer0_isr);
```

```
interrupts_register(1, timer1_isr);
```

Array of Function Pointers

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Declaring function pointer array:

```
static void (*isrFcnPtrs[3])() = {NULL};
```

Storing function pointer in array:

```
isrFcnPtrs[2] = fcn;
```

Calling a function:

```
isrFcnPtrs[2]();
```

ISR

```
static void interrupts_isr() {

        // Loop through each interrupt input
        for (i, to # interrupt inputs - 1) {

                // Check if it has an interrupt pending
                if (input i has pending interrupt) {

                // Check if there is a registered ISR and call it.
                if (isrFcnPtrs[i])
                  isrFcnPtrs[i]();

                }
        }
}
```