Interrupts and Signals

CMSC421

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But first

- My dog ate my homework
- Computer have moving parts and humans that write software, and stuff happens.
- With your Google drive, you have one terabyte of storage

Interrupts

- Source:
    - Angela Demke Brown, University of Toronto

Summary

- Difference between interrupts and signals
- Polling vs. interrupts
  - Polling might be better for real time device
- Hardware interrupt handling and software interrupt handling

Interrupts

- An interrupt is an event external to the currently executing process that causes a change in the normal flow of instruction execution. This is usually generated by hardware devices.
  - From “Design and Implementation of the FreeBSD Operating System”, Glossary
- Key point: interrupts are asynchronous with respect to the current process. This means the process cannot determine when the next interrupt will happen.
  - This could be a disk drive has some data ready for your process
  - Perhaps a network has some data
- Signals are generated by processes running in the computer.

Why do we have interrupts?

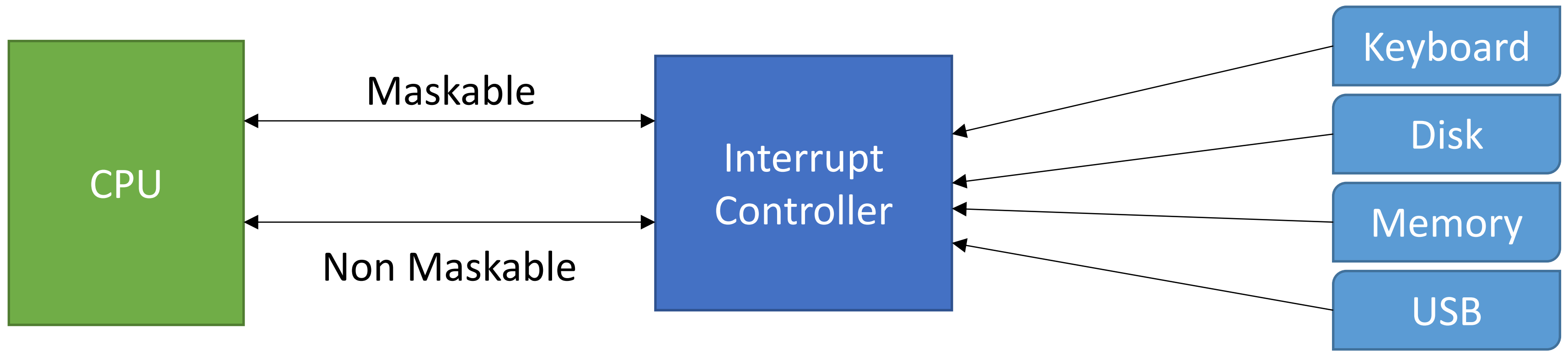
- We have so many external devices connected to our computer
  - How many different ways can a user change the operation of an iPhone?
    - For example, the power button, Class exercise, …
  - Keyboard, mouse, screen, diskdrive
  - Camera
- These devices occasionally need CPU service
  - However, we cannot predict when.
  - External events typically happen infrequently
- But, we want the expensive CPU to stay busy.

Possible Solution: Polling

- CPU periodically checks each device to see if it needs service
- Issues
  - It could take the CPU time to ask **each** device if it has anything ready
  - It ask fewer times, but the response time will be reduced
  - This could be efficient if events arrive rapidly because the CPU is always polling
- "Polling is like picking up your phone every few seconds to see if you have a call…"

Interrupts

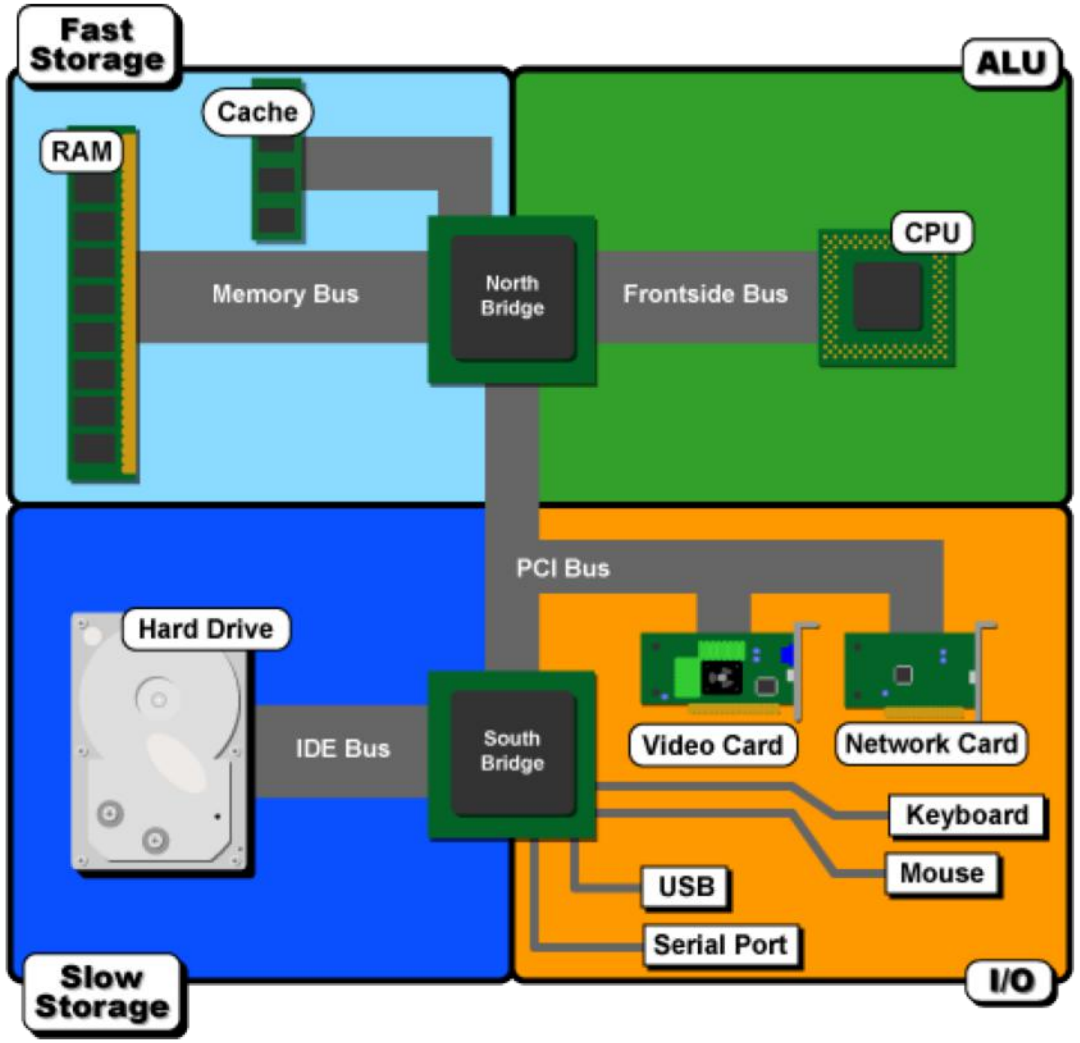
- Give each device a wire that it can use to signal the processor
  - When the interrupt signaled, processor executes an interrupt handler to deal with the interrupt.
  - The keyboard handler is going to be different than the memory handler
  - Benefit: No overhead when there are no requests pending



Intel 430HX Motherboard

- Programmable interrupt controller (PIC) part of the Southbridge chip
- 8 inputs, 1 output
- Top to bottom, fast to slow

Image: http://origin.arstechnica.com/articles/paedia/hardware/mobo-guide-1.media/430HX.png



Polling vs. Interrupts, which is better?

- **Polling**: picking up your phone every few seconds, is anyone there?
- **Interrupts**: waiting for the phone to ring

- **Interrupts** the system as a whole is faster if the processor is doing other things and response time is not critical
- **Polling** is better if the processor has to respond to a device immediately.
  - This sounds good for real time systems
  - The CPU must respond to this event in a specified time.
  - Could have a secondary controller to handle this

Hardware Interrupt Handling

- Interrupt controller signals the CPU that the interrupt has occurred and passes the interrupt number
  - Interrupts are assigned priorities to handle simultaneous interrupts
  - Lower priority interrupts may be disabled during service
- CPU checks interrupt request after every instruction: if raised, then:
  - Uses interrupt number to determine which handler to start
  - Interrupt vector associates handlers with interrupts
- Basic program state saved
- CPU jumps to interrupt handler
- When an interrupt service routine is complete, the original program state (where it left off) is reloaded and program continues.

Software Interrupt Handling

- Typically, two parts to interrupt handling
  - The part that has to be done now
    - So the device can continue working
  - The part that can be saved for later
    - To make the device respond faster
    - And, have a more convenient execution context
    - What?

Interrupt Context

- Execution of the first part of the interrupt handler uses the context of whatever was interrupted
  - The process state is saved in process structure
  - Handler uses the interrupted thread’s kernel stack
    - Careful about stack-allocated data
  - Handler is not allowed to block
    - Has no process structure of its own to save state or allow rescheduling
    - Cannot call functions that might block
- Handler must be kept fast and simple
  - Typically, set up for the second part, fast that second part needs to execute and re-enables interrupt.

Software Interrupts

- The deferred part of interrupt handling is sometimes called “software interrupts”
  - Linux calls them the “bottom halves”
- What things can be deferred?
  - Networking
    - Time critical work is 1. Copy packet off hardware 2. respond to hardware
    - Deferred work 1. process packet 2. Pass packet to the correct application
  - Timers
    - Time critical work is 1. Increment current time of day
    - Deferred – recalculate process priorities

Signals

- Software equivalent of hardware interrupts
- Allows processes to respond to asynchronous external events
    - Process may specify its own signal handlers or use OS default
    - Defaults
        - Ignore signal
        - Terminate all threads in process
        - Stop all threads in process
        - Resume all threads in process
- Used as simple Inter-process communication.

Signal Basics

- Process structure has flags for possible signals and actions to take
- When the signal is posted to process, signal pending flag is marked
- When process is next scheduled to run, pending signals are checked and action taken
  - Signal delivery is not instantaneous

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Last slide

- See subject