Hardware-Software Interfaces

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Prof. Stephen A. Edwards

Columbia University

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### Basic Processor Architecture

- **Controller**
  - Operation
  - Result
  - Latch
  - Latch (Read, Write)
- **Registers**
- **Address Reg.**
- **Memory**
- **Shared Bus**

### Typical Processor System

- **Processor**
  - Read, Write
  - Enable
  - Address
  - Data
- **Memory**
- **Peripheral**

### Simple Bus Timing

- **Read Cycle**
  - R/W
  - Enable
  - Addr
  - Data
- **Write Cycle**
  - R/W
  - Enable
  - Addr
  - Data

### Strobe vs. Handshake

- **Strobe**
  - Req
  - Data
- **Handshake**
  - Req
  - Ack
  - Data

### 1982: The IBM PC

- The ISA Bus: Memory Read
- The ISA Bus: Memory Write

### The PC/104 Form Factor: ISA Lives

- Embedded System Legos. Stack 'em and go.
Memory-Mapped I/O

- To a processor, everything is memory.
- Peripherals appear as magical memory locations.
- Status registers: when read, report state of peripheral
- Control registers: when written, change state of peripheral

A Parallel Port Driver

```c
#define DATA 0x378
#define STATUS 0x379
#define CONTROL 0x37A
#define NBSY 0x80
#define NACK 0x40
#define OUT 0x20
#define SEL 0x00
#define STROBE 0x01
#define INVERT (NBSY | NACK | OUT | SEL | NERR)
#define NOT_READY(x) ((inb(x) ^ INVERT) & MASK)

void write_single_character(char c) {
    while (NOT_READY(STATUS)) ;
    outb(DATA, c);
    outb(CONTROL, control | STROBE); /* Assert STROBE */
    outb(CONTROL, control ); /* Clear STROBE */
}
```

Interrupts and Polling

Two ways to get data from a peripheral:
- Polling: “Are we there yet?”
- Interrupts: Ringing Telephone

Interrupts

Basic idea:
1. Peripheral asserts a processor's interrupt input
2. Processor temporarily transfers control to interrupt service routine
3. ISR gathers data from peripheral and acknowledges interrupt
4. ISR returns control to previously-executing program

Many Different Interrupts

What's a processor to do?

Processor receives interrupt
ISR polls all potential interrupt sources

Intel 8259 PIC

Prioritizes incoming requests & notifies processor
ISR reads 8-bit interrupt vector number of winner
IBM PC/AT: two 8259s; became standard