Hardware-Software Interfaces
CSEE W4840
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Basic Processor Architecture

Typical Processor System

Typical Processor System

Simple Bus Timing

Strobe vs. Handshake

1982: The IBM PC

The ISA Bus: Memory Read

The ISA Bus: Memory Write

The PC/104 Form Factor: ISA Lives

1982: The IBM PC

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.

Typical Peripheral: PC Parallel Port

- Busy
- Ack
- Paper
- Sel
- Err

D7 D6 D5 D4 D3 D2 D0 0x378

<table>
<thead>
<tr>
<th>D7</th>
<th>D6</th>
<th>D5</th>
<th>D4</th>
<th>D3</th>
<th>D2</th>
<th>D0</th>
<th>0x379</th>
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</thead>
<tbody>
<tr>
<td>Sel</td>
<td>Init</td>
<td>Auto</td>
<td>Strobe</td>
<td>0x37A</td>
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1. Write Data
2. Assert Strobe
3. Wait for Busy to clear
4. Wait for Acknowledge

Parallel Port Registers

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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 INVERT (NBSY | NACK | OUT | SEL)
#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

Two ways to get data from a peripheral:

- Polling: "Are we there yet?"
- Interrupts: Ringing Telephone

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

Processor receives interrupt
ISR polls all potential interrupt sources

Interrupt Polling

Intel 8259 PIC

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