Hardware-Software Interfaces

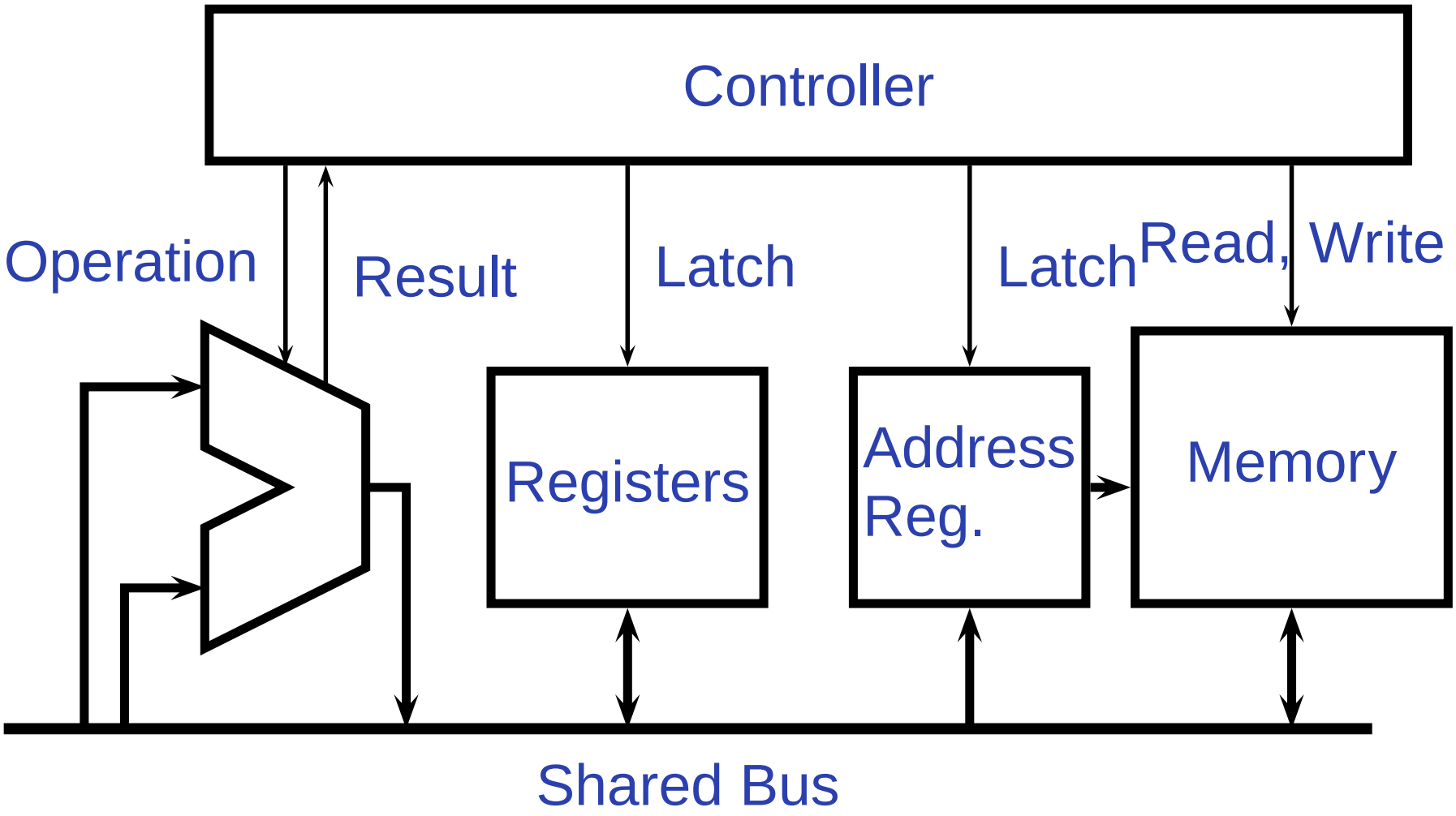
CSEE W4840

Prof. Stephen A. Edwards

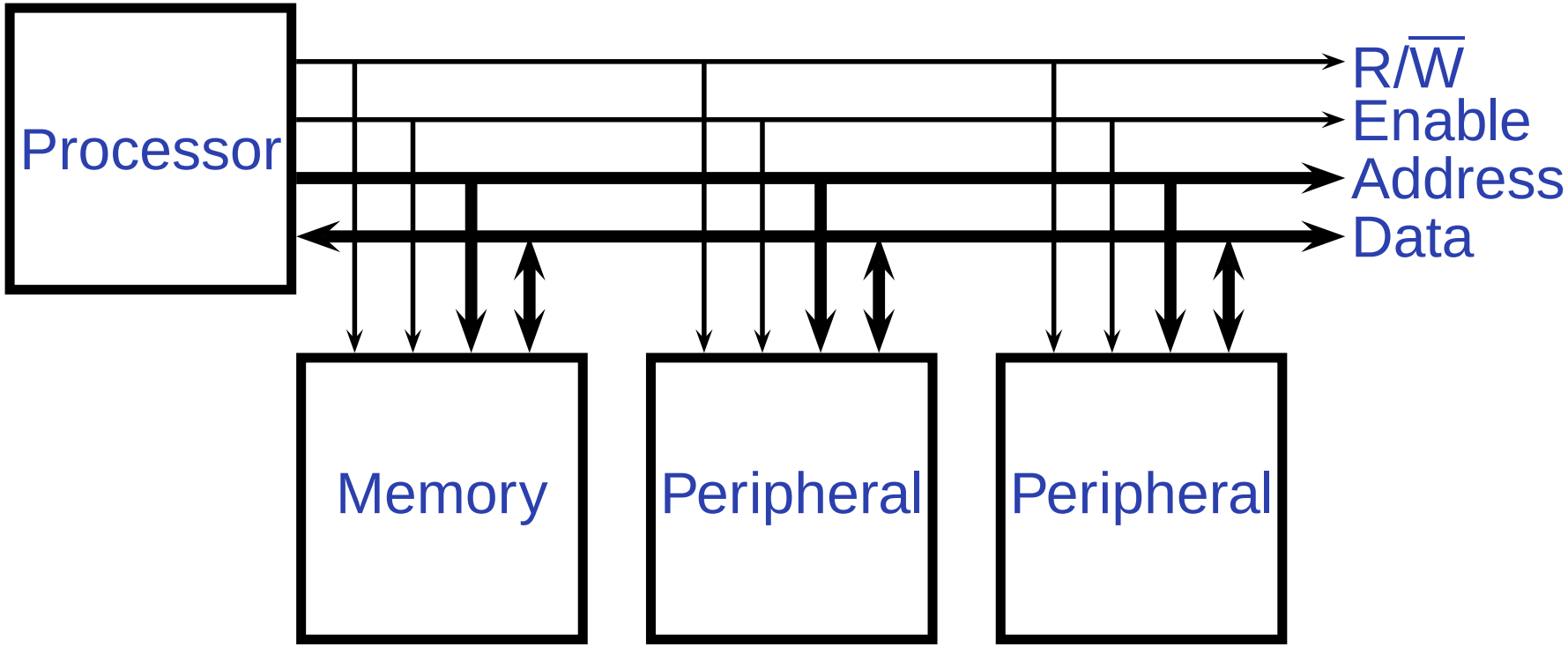
Columbia University

Spring 2008

Basic Processor Architecture

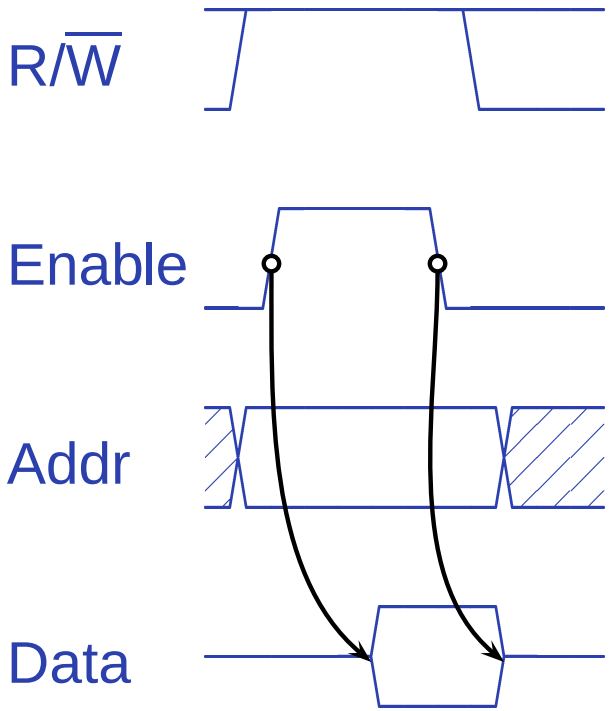


Typical Processor System

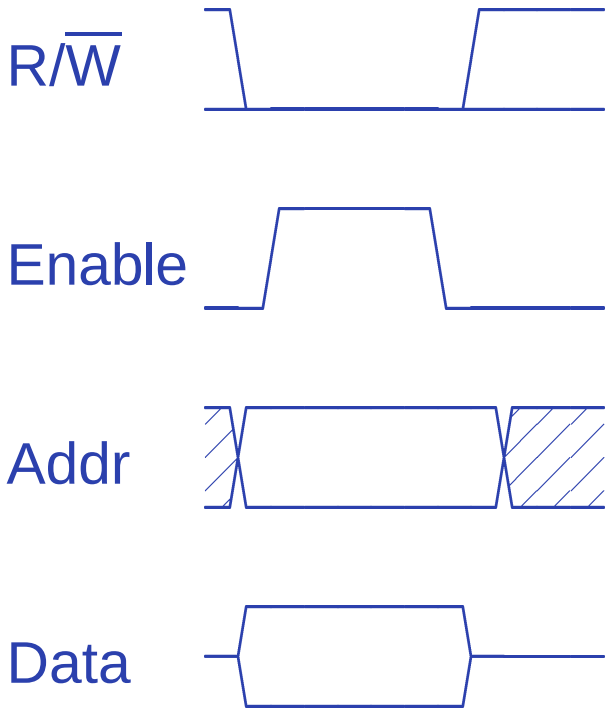


Simple Bus Timing

Read Cycle

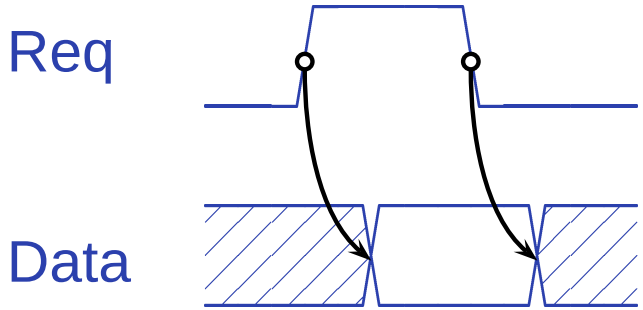


Write Cycle

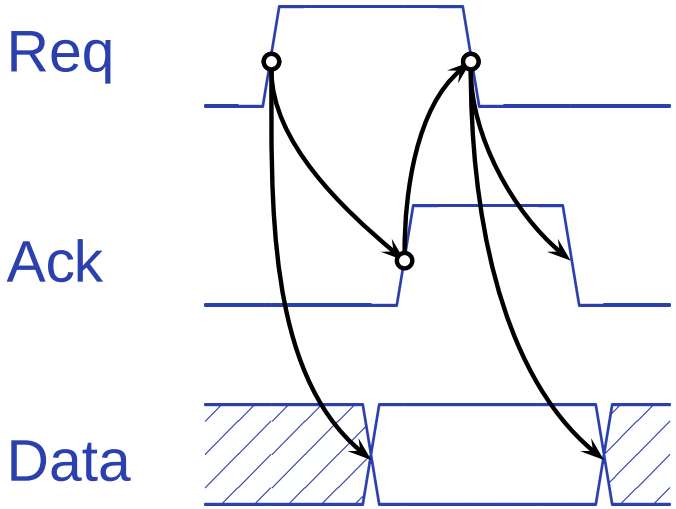


Strobe vs. Handshake

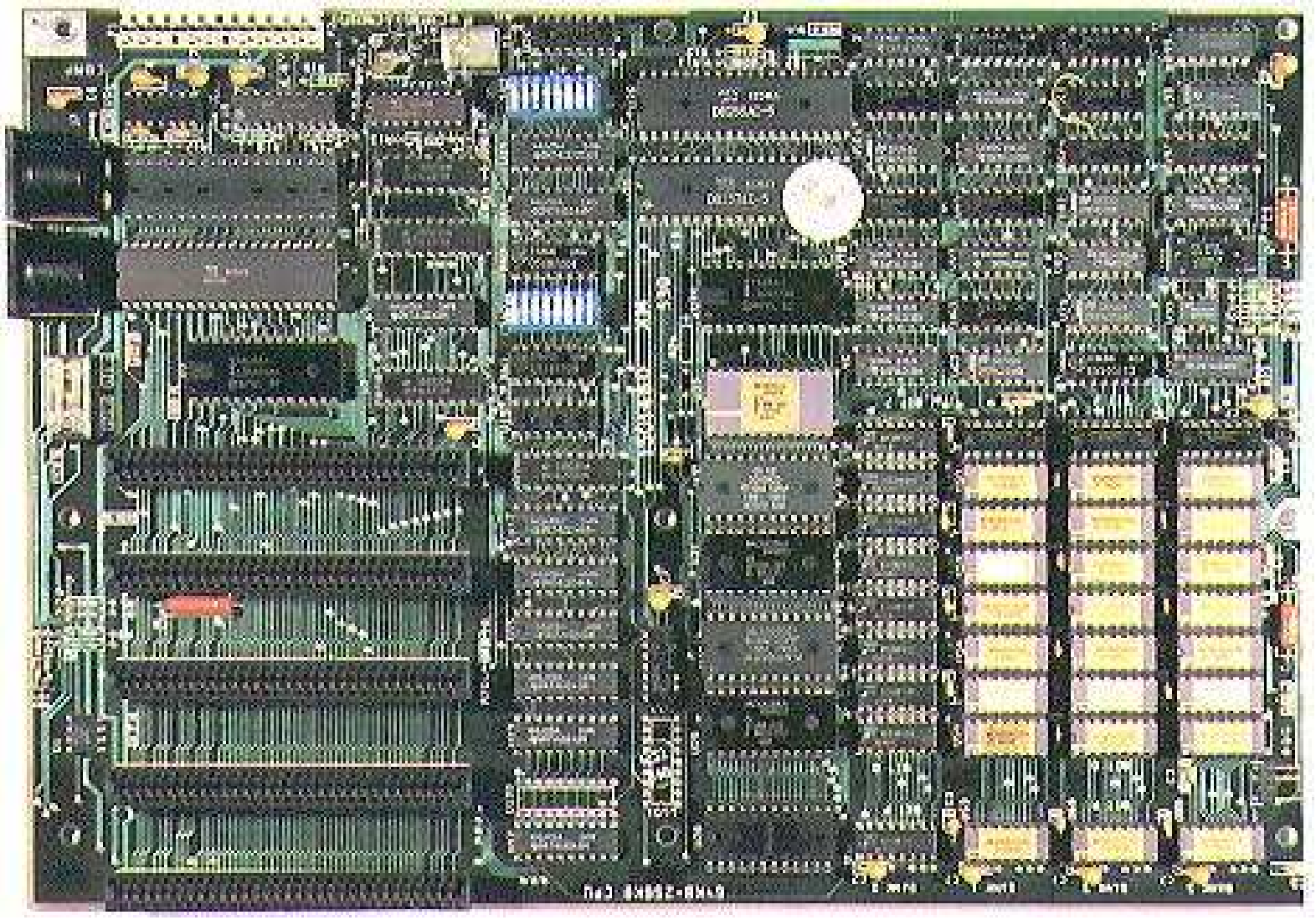
Strobe



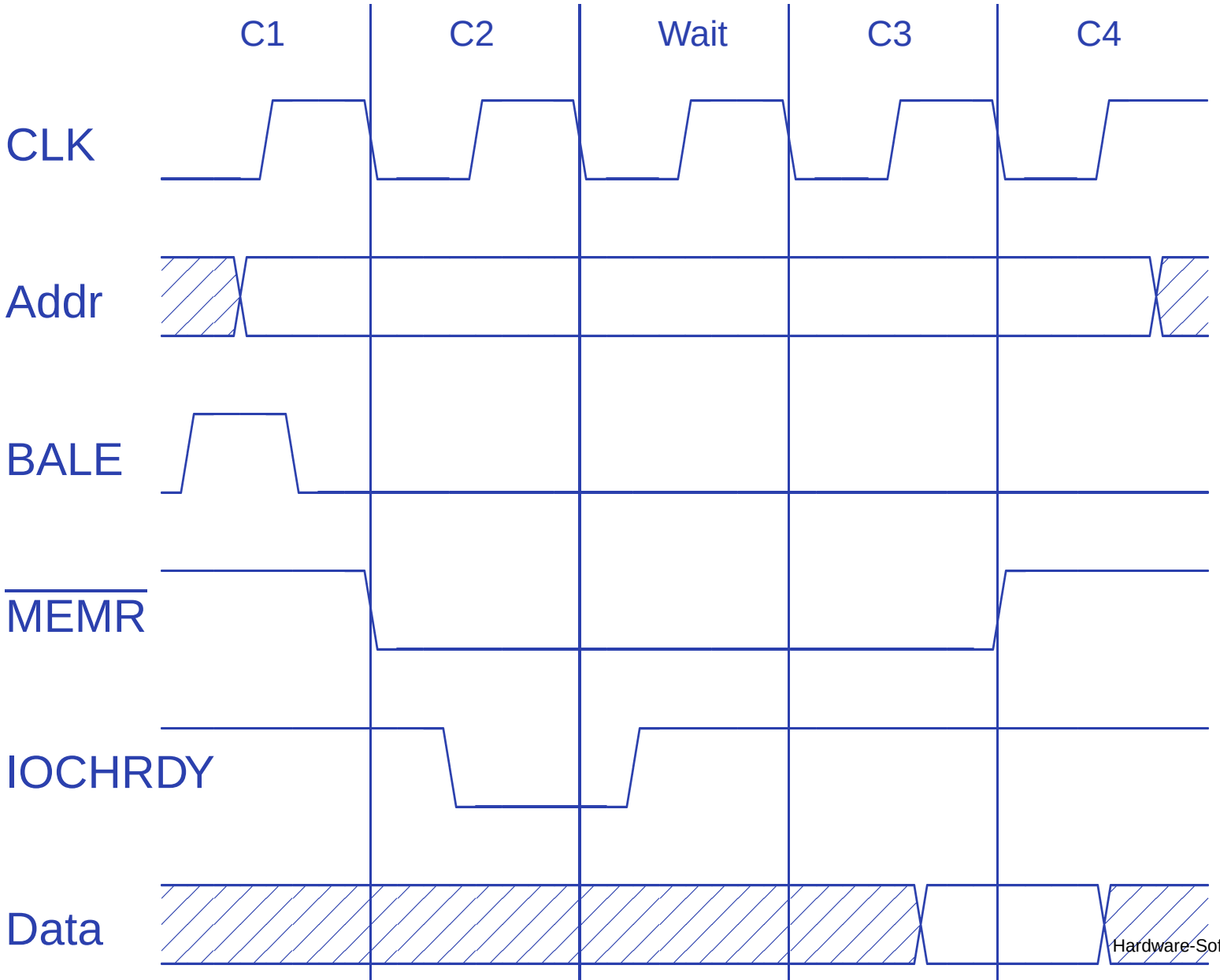
Handshake



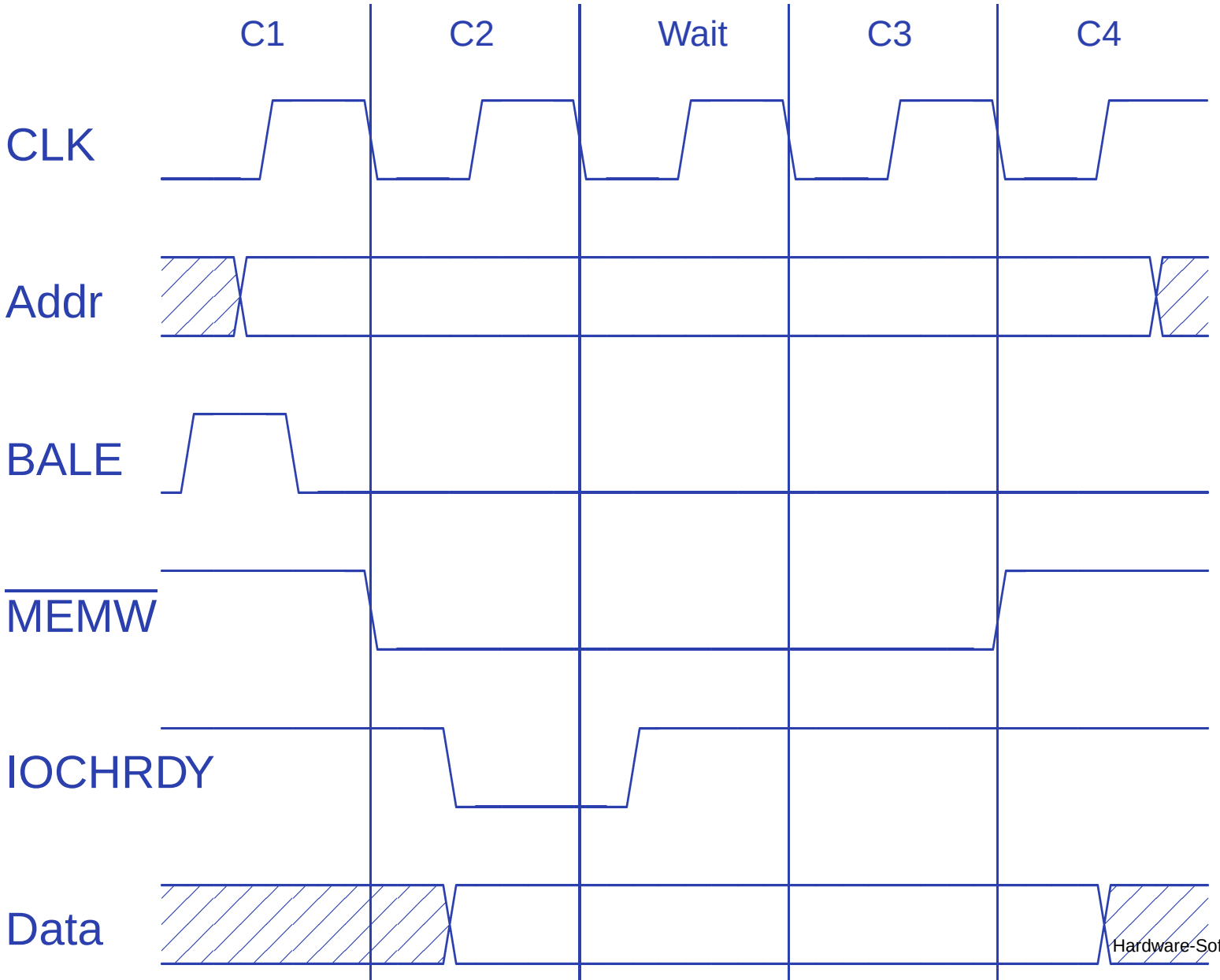
1982: The IBM PC



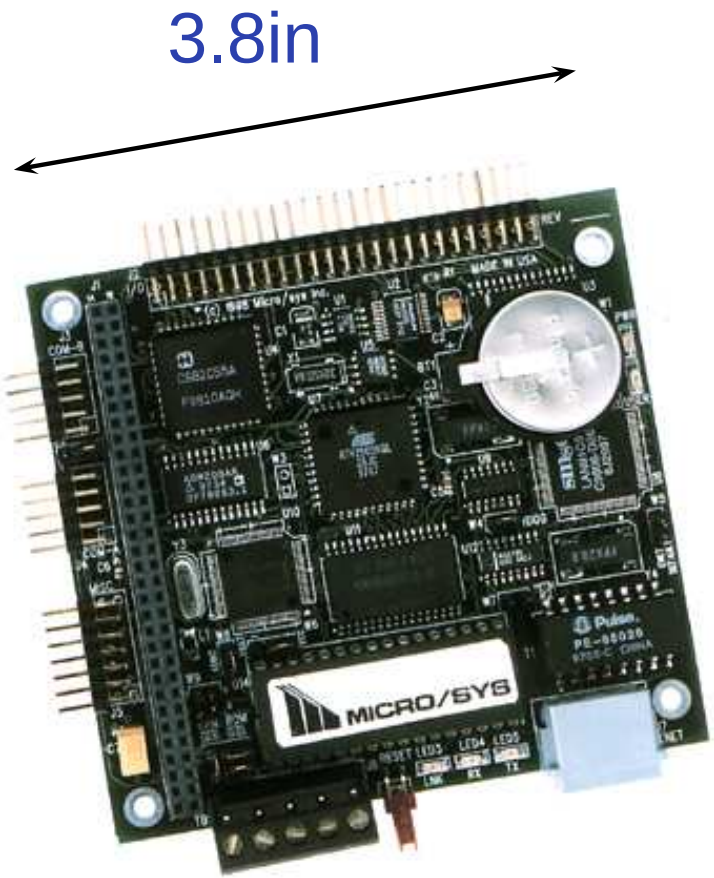
The ISA Bus: Memory Read

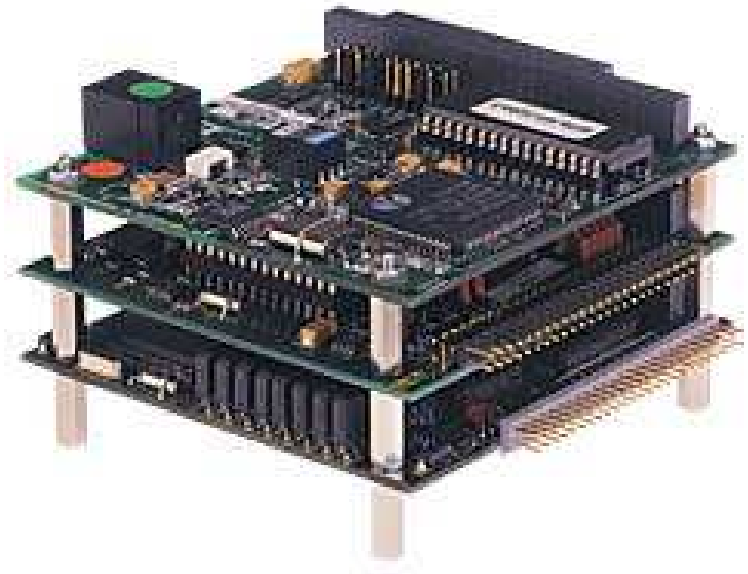


The ISA Bus: Memory Write



The PC/104 Form Factor: ISA Lives



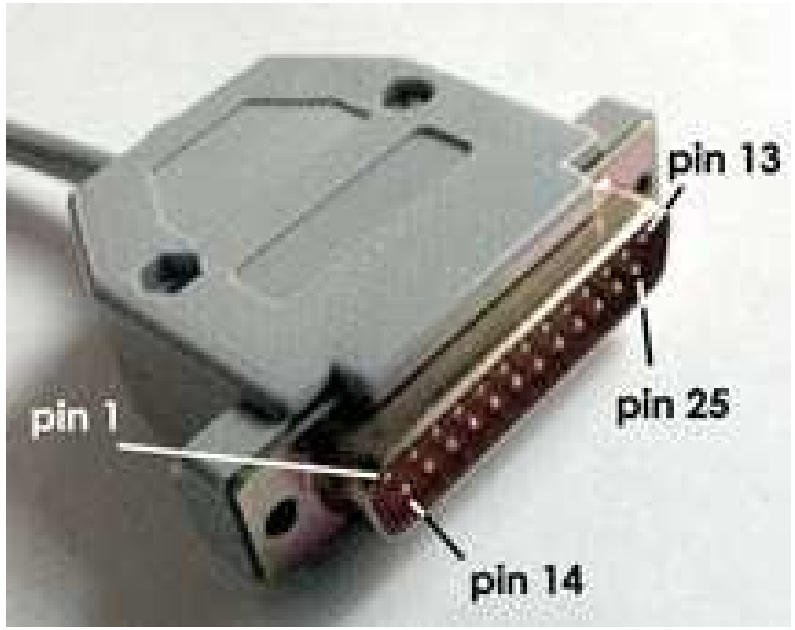


Embedded System Legos. Stack 'em and go.

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

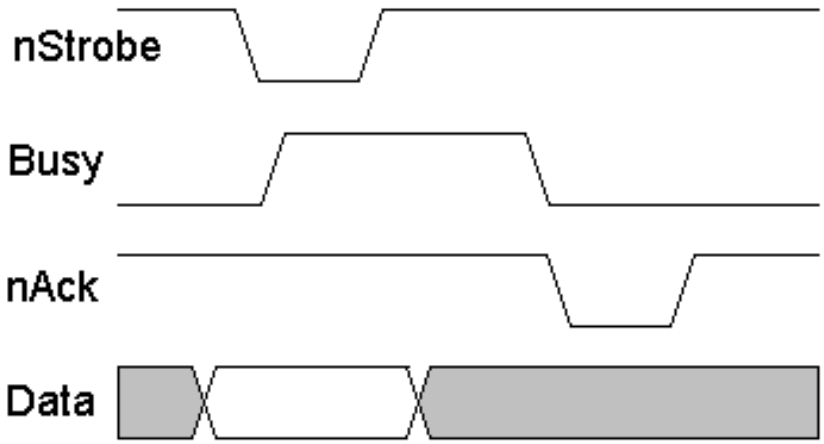
Typical Peripheral: PC Parallel Port



At Standard TTL Levels

	Signal Name	Adapter Pin Number	
	←— -Strobe ——	1	
E	←— +Data Bit 0 ——	2	P
X	←— +Data Bit 1 ——	3	A
T	←— +Data Bit 2 ——	4	R
E	←— +Data Bit 3 ——	5	A
R	←— +Data Bit 4 ——	6	L
N	←— +Data Bit 5 ——	7	L
A	←— +Data Bit 6 ——	8	E
L	←— +Data Bit 7 ——	9	L
	—— -Acknowledge ——	10 —→	
D	—— +Busy ——	11 —→	A
E	—— +Paper End ——	12 —→	D
V	—— +Select ——	13 —→	A
I	←— -Auto Feed ——	14	P
C	—— -Error ——	15 —→	T
E	←— -Initialize ——	16	E
	←— -Select Input ——	17	R
	—— Ground ——	18-25	

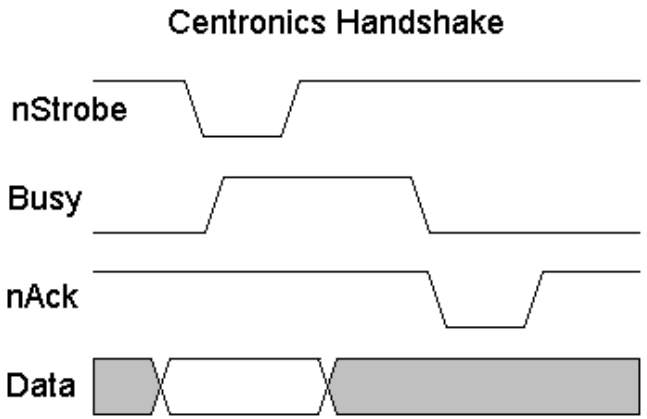
Centronics Handshake



Parallel Port Registers

D7	D6	D5	D4	D3	D2	D1	D0	
$\overline{\text{Busy}}$	Ack	Paper	Sel	Err				0x378
								0x379
				$\overline{\text{Sel}}$	Init	$\overline{\text{Auto}}$	$\overline{\text{Strobe}}$	0x37A

1. Write Data
2. Assert Strobe
3. Wait for Busy to clear
4. Wait for Acknowledge



A Parallel Port Driver

```
#define DATA    0x378
#define STATUS  0x379
#define CONTROL 0x37A

#define NBSY 0x80
#define NACK 0x40
#define OUT  0x20
#define SEL  0x10
#define NERR 0x08
#define STROBE 0x01

#define INVERT  (NBSY | NACK |       SEL | NERR)
#define MASK    (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:

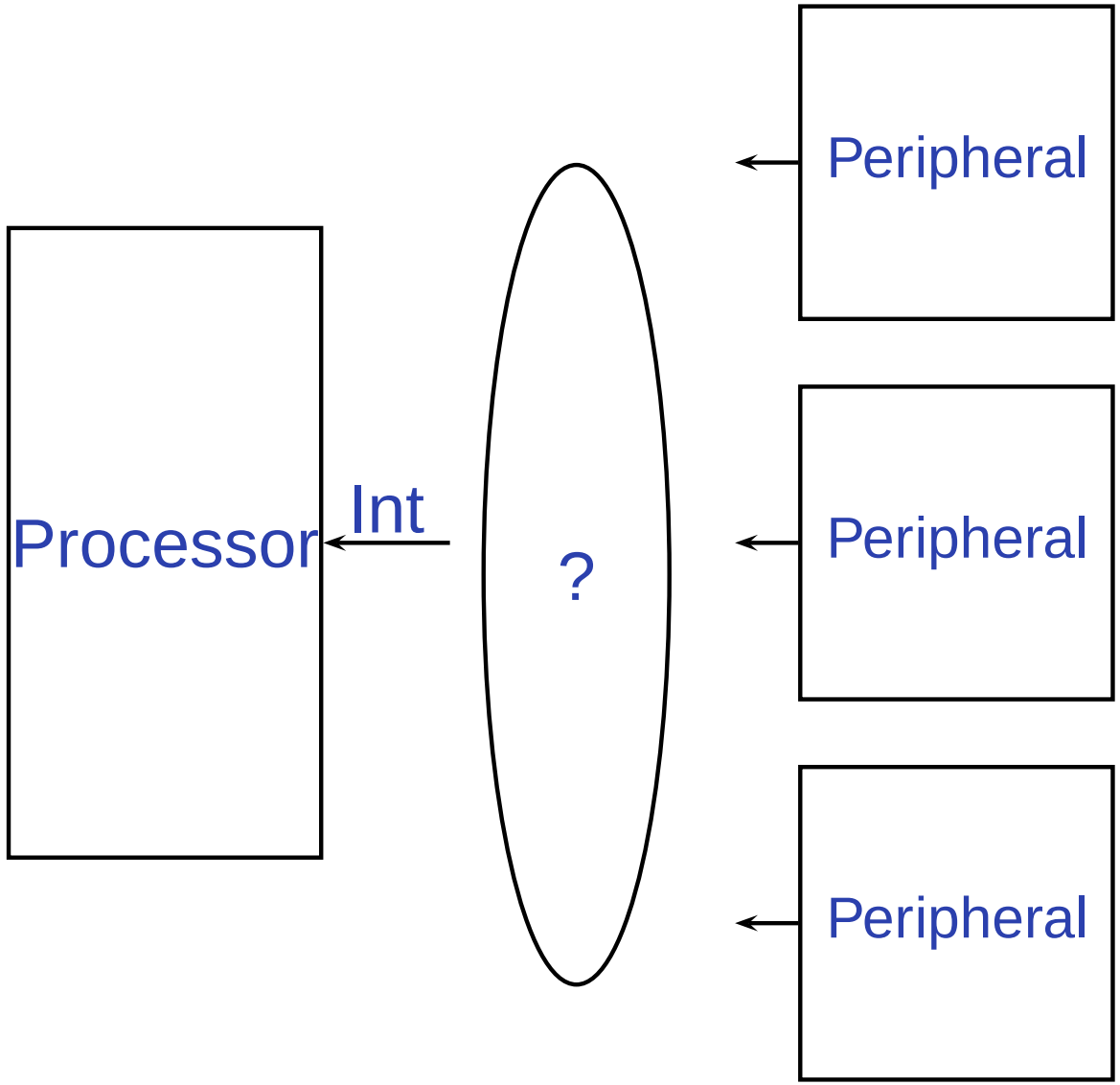
- Polling: “Are we there yet?”
- Interrupts: Ringing Telephone

Interrupts

Basic idea:

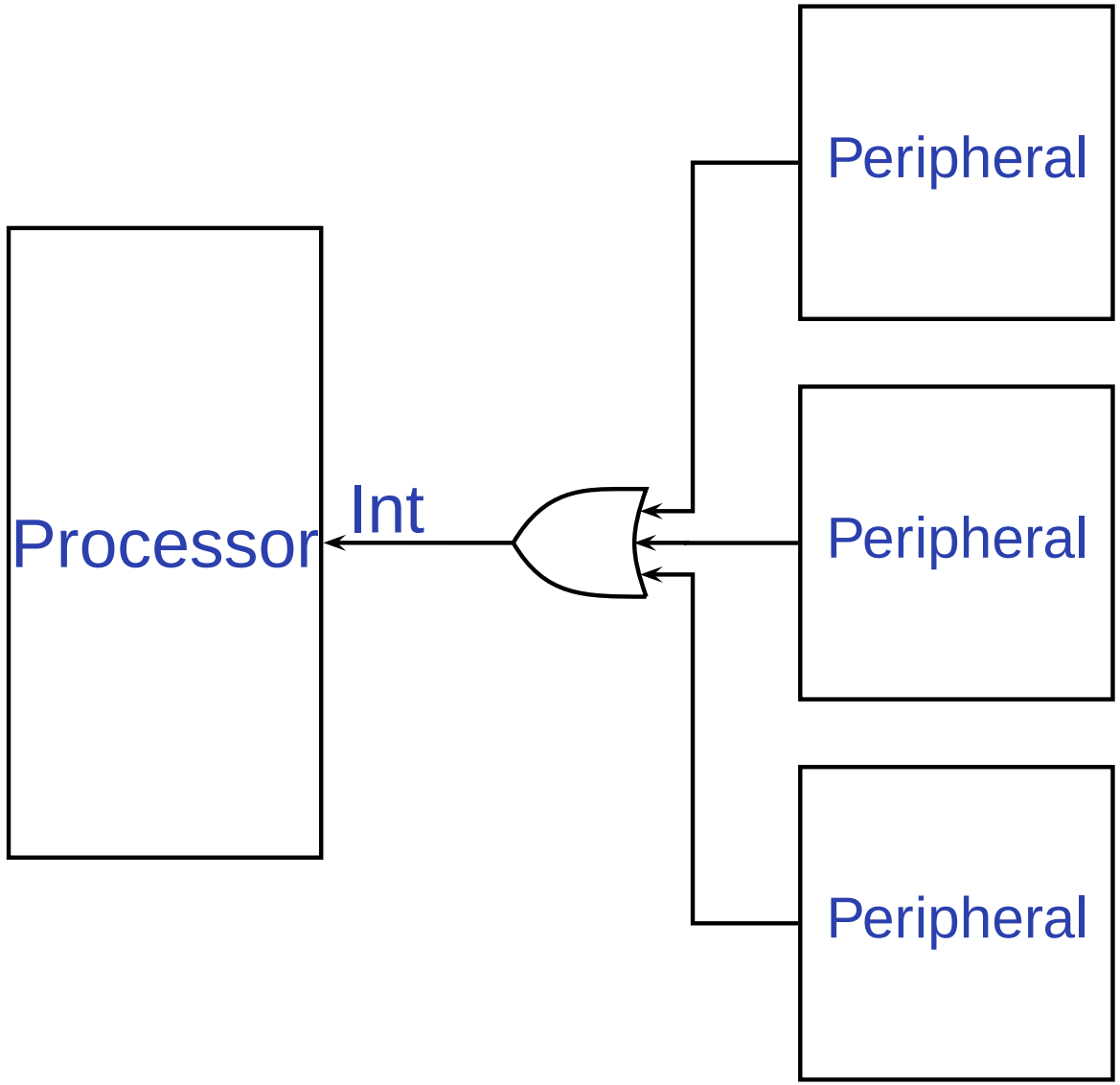
1. Peripheral asserts a processor's interrupt input
2. Processor temporarily transfers control to interrupt service routine
3. ISR gathers data from peripheral and acknowledges interrupt
4. ISR returns control to previously-executing program

Many Different Interrupts



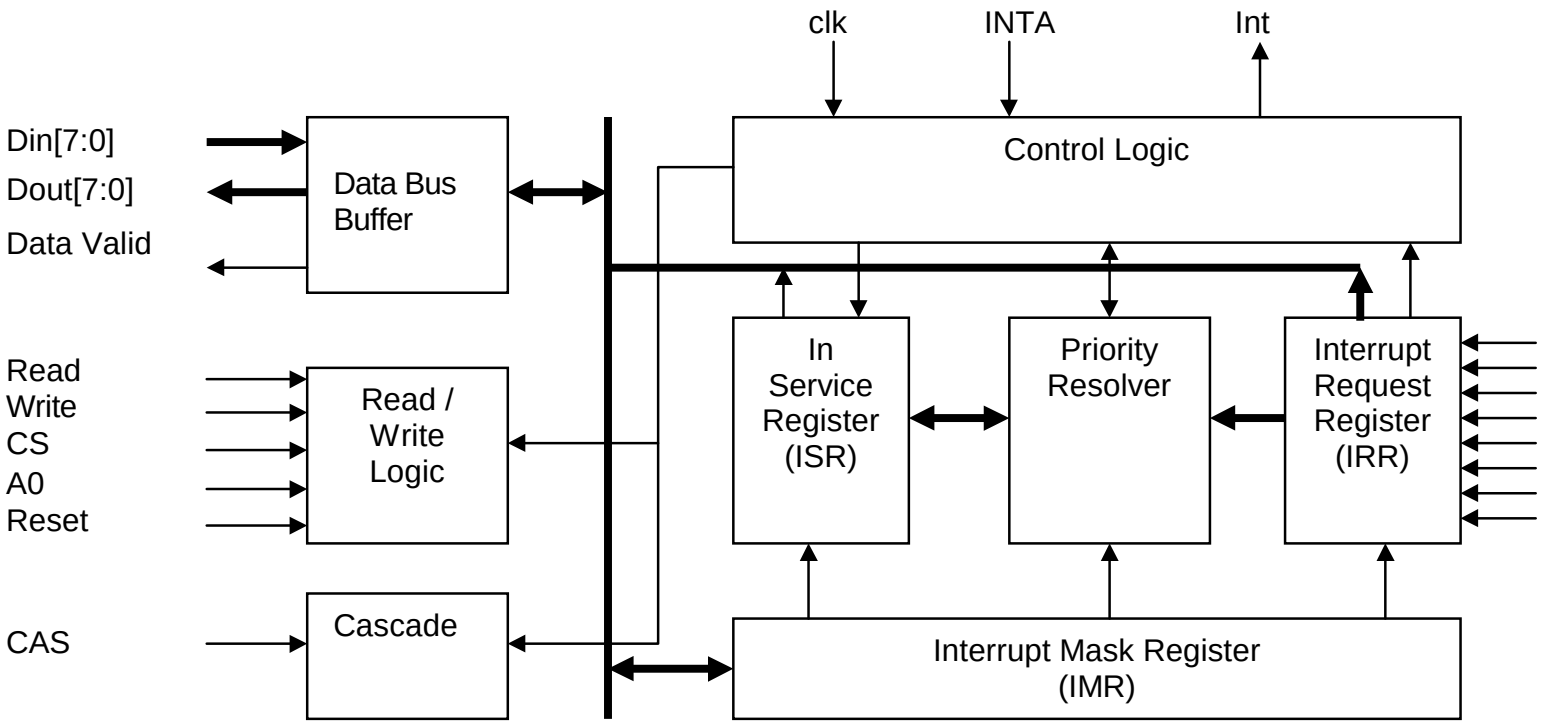
What's a processor to do?

Interrupt Polling



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