Chapter 8 – Buses and Peripherals
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Simple Bus Architecture

• A simplified motherboard of a personal computer (top view):
Simplified Illustration of a Bus

CPU  Memory  Disk

Control (C₀ – C₉)
Address (A₀ – A₃₁)
Data (D₀ – D₆₃)
Power (GND, +3.3V, +/-5V, +/-12V)
100 MHz Bus Clock

Crystal Oscillator

1 0 1 0 1 0 1 0

2 ns

Logical 1 (+3.3 V)
Logical 0 (0 V)
The Synchronous Bus

- Timing diagram for a synchronous memory read (adapted from [Tanenbaum, 1999]).

Timing diagram:
- **Leading edge** of the clock signal (Φ) occurs at time point T1.
- **Trailing edge** occurs at time point T2.
- **Address valid** period is from T2 to T3.
- **Data valid** period follows the address valid period.
- **MREQ** (Memory Request) signal is high during address sensitive period.
- **RD** (Read) signal is high during data sensitive period.
The Asynchronous Bus

- Timing diagram for asynchronous memory read (adapted from [Tanenbaum, 1999]).
Bus Arbitration

(a) Simple centralized bus arbitration; (b) centralized arbitration with priority levels; (c) fully centralized bus arbitration; (d) decentralized bus arbitration. (Source: adapted from [Tanenbaum, 1999].)
Bridge Based Bus Architecture

Bridging with dual Pentium processors.

Programmed I/O Flowchart for a Disk Transfer

1. Enter
2. Check status of disk
   - No: Disk ready?
     - Yes: Send data from memory to disk (when writing) or from disk to memory (when reading)
     - No: Done?
       - Yes: Continue
Interrupt Driven I/O
Flowchart for a Disk Transfer

Enter

Issue read or write request to disk.

Do other processing, until disk issues an interrupt.

Interrupt causes current processing to stop.

Transfer data between disk and memory.

Return from interrupt. Normal processing resumes.

No
Done?
Yes
Continue
DMA Transfer from Disk to Memory Bypasses the CPU
DMA Flowchart for a Disk Transfer

1. Enter
   - CPU sets up disk for DMA transfer
     - DMA device begins transfer independent of CPU
     - DMA device interrupts CPU when finished
     - CPU executes another process

Continue
Intel Memory and I/O Address Spaces

Address

FFFFFFFFFF

Memory Space

Address

FFFF

I/O Space

0000

00000000

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Standard Intel Pentium Read and Write Bus Cycles

CLK

ADDR

Valid

Invalid

Valid

Invalid

ADS#

CACHE#

W/R#

Read

Write

BRDY#

DATA

TO CPU

FROM CPU

READ CYCLE

IDLE

WRITE CYCLE

IDLE
Intel Pentium Burst Read Bus Cycle

- CLK
- ADDR
- ADS#
- CACHE#
- W/R#
- BRDY#
- DATA

T1 T2 T2 T2 T2 T2 Ti

VALID INVALI D

READ READ READ READ
Intel Pentium Hold-Hold Acknowledge Bus Cycle
RS-232

- The RS-232 standard commonly uses 9-pin and 25-pin connectors, but uses others as well (see the figure).
- RS-232 is used for slow-bit-rate devices such as mice, keyboards, and non-graphics terminals.
USB and Firewire

Universal Serial Bus (USB) and IEEE 1394 (Firewire) are groups of standards for interconnecting peripheral devices. USB 2.0 supports data transfer rates up to 480 Mbps, with as many as 127 devices connected to a single host controller through special hub devices in a tree-like manner.

Firewire is similar to USB but has traditionally been faster, up to 800 Mbps. A key advantage of Firewire is isochronous data transfer, in which a continuous, guaranteed data transfer is supported at a predetermined rate. This makes Firewire attractive for digital video and digital audio.

(left) USB hub; (middle) USB cable; (right) Firewire cable.
A Magnetic Disk with Three Platters

- Top surface not used
- Surface 3
- Surface 2
- Surface 1
- Surface 0
- Bottom surface not used
- Spindle
- Comb
- Head
- Air cushion
- Surface
- Read/write head (1 per surface)
- Direction of arm (comb) motion

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Manchester Encoding

- (a) Straight amplitude (NRZ) encoding of ASCII ‘F’;
- (b) Manchester encoding of ASCII ‘F’.

(a) Straight amplitude (NRZ) encoding of ASCII ‘F’:

```
1 0 0 0 1 1 0
```

= ‘F’

(b) Manchester encoding of ASCII ‘F’:

```
1 0 0 0 1 1 0
```

= ‘F’
Organization of a Disk Platter with a 1:2 Interleave Factor

Inter-sector gap
Interleave factor 1:2
Inter-track gap
### Master Control Block

#### Files

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#### Free blocks

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#### Bad blocks

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### Preamble

- No. surfaces on disk = 4
- No. tracks/surface = 9618
- No. sectors/track = 768
- No. bytes/sector = 512
- Interleave factor = 1:3
Magnetic Tape

- A portion of a magnetic tape.

Punched holes at either end of the tape trigger a reversal of direction.
Digital Audio Tape (DAT)

- Digital audio tape (DAT) formatting supports high densities, on the order of 72 GB for a small 73 mm x 54 mm profile. The read / write head is placed at an angle to the tape as shown in the figure, allowing data to be criss-crossed over the same area, using opposite polarities which maintains separation of the bits.
Spiral Format for Compact Disk

• Unlike a magnetic disk in which all of the sectors on concentric tracks are lined up like a sliced pie (where the disk rotation uses constant angular velocity), a CD is arranged in a spiral format (using constant linear velocity). The speed of rotation is adjusted so that the disk moves more slowly when the head is at the edge than when it is at the center.
Redundant Arrays of Inexpensive Disks (RAID)

• RAID level 0 – striped disk array without fault tolerance.

• RAID level 1 – mirroring and duplexing.
RAID (Continued)

- RAID level 2 – bit-level striping with Hamming Code ECC.

- RAID level 3 – parallel transfer with parity.
RAID (Continued)

- RAID level 4 – independent data disks with shared parity disk.

- RAID level 5 – independent data disks with distributed parity blocks.
RAID (Continued)

- RAID level 6 – independent data disks with two independent distributed parity schemes.

- RAID level 7 – asynchronous cached striping with dedicated parity.
RAID (Continued)

- RAID level 10 – very high reliability combined with high performance.

- RAID level 53 – high I/O rates and data transfer performance.
ECMA-23 Keyboard Layout

- Keyboard layout for the ECMA-23 Standard (2nd ed.). Shift keys are frequently placed in the B row.

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The Dvorak Keyboard Layout

The Dvorak Keyboard Layout is a modified QWERTY keyboard layout designed to increase typing speed and reduce the potential for strain injuries. It achieves this by moving frequently used keys to more ergonomically efficient positions

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Tablet with Puck

Cable to host computer

Puck

Coil

Buttons
Mouse and Trackball

A mechanical mouse (left), a three-button trackball (center), and an optical mouse (right).
Touch Sensitive Pen-based Display

- Pen-based personal digital assistants (PDAs) use a passive matrix in which the pen can be anything that induces pressure on the screen.

- Two transparent conducting layers are placed on the screen, separated by spacer dots. When the user applies pressure to the top layer, as with a stylus or simply a finger, the top and bottom layers make contact. The induced voltage at the edges varies according to the position of the stylus.
Joystick

- A joystick with a selection button and a rotatable rod:
Laser Printer

- Schematic of a laser printer (adapted from [Tanenbaum, 1999]).
Cathode Ray Tube

- A CRT with a single electron gun:
Display Controller

- Display controller for a 1024×768 color monitor (adapted from [Hamacher et al., 1990]).
Active Matrix Color Liquid Crystal Display

Liquid crystals are twisted at every pixel by a transistor, rotating the light from 0° - 90°.

Red, green, blue filters pass light according to the filter color.

Fluorescent panel

Polarizing filter passes horizontally polarized light.

Polarizing filter passes vertically polarized light.

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Matrix Parhelia-512 GPU