13. I/O Systems

13.1 Overview

I/O devices are widely varying in speed.

Define speed?

Time between actions or throughput?

Keyboard — 60–120 words per minute? $0.12 \times 10^3$

Modems — 64Kbits/second? $0.064 \times 10^6$

DSL and Cable? $\uparrow$?

Ethernet — 4, 10, and 100 Mbytes/second? $10 \times 10^6$

Disk — 0.5Gbits/second $500 \times 10^6$
13.2 I/O Hardware

Growing list of attached devices: storage, transmission, and CHI.

**Port** Serial and parallel. For many years RS-232 was the terminal connection. Now USB is used for keyboard, mouse, . . .

Port typically is a connection point and four registers data-in, data-out, status, and control.

**Bus.** Devices using common wires and a rigidly defined protocol.

**Daisy chain.** One device connects to another [maybe more in the sequence] which then connects to a port? using only one connection point.

**Controllers** operate a port, bus, or device. Today they usually have a CPU (of some form) and local memory which also may serve as a cache.

Depending upon the device, the controller can be quite simple to complex. Graphics controller, laser printer controller, sensor controllers, disk controller.
Memory-mapped I/O and copy-on-write

Buffers moved to virtual memory space.
Efficient means of making sure that changed pages is already a characteristic of the VM.

copy-on-write allows for shared pages and separate copies are made only when modified.
13.2.1 Polling

Review the handshaking six-steps on page 499.

13.2.2 Interrupt. Can be more efficient than polling if many of the devices being polled are not participating. The interrupt notifies system when it is ready.

Efficiency dictates:

- need to be able to defer handling interrupts
- need to efficiently dispatch to the correct handler
- need multilevel interrupts

13.2.3 DMA offers gains in efficiency if handling large amounts of data, like to/from disk.
13.4 Kernel I/O Subsystem

i. I/O Scheduling — obvious need

ii. Buffering — different speeds – double buffering, different sizes, copy semantics

iii. Caching

iv. Spooling

v. Error Handling

vi. I/O Protection

vii. Kernel Data Structures
13.5 Transforming I/O Requests to Hardware Operations

13.6 STREAMS

13.7 Performance

13.8 Summary
File Attributes

1. Name
2. Identifier
3. Type
4. Location
5. Size
6. Protection
7. Time, Date, and User Identification
File Operations

1. Creating a file
2. Writing a file
3. Reading a file
4. Repositioning within a file
5. Deleting a file
6. Truncating a file

Information associated with an open file.

1. File pointer
2. File-open count
3. Disk location of the file
4. Access rights