Computer Architectures & Operating Systems

Lecture 6: Storage & Memory

Introduction

- **This lecture looks at:**
- Why storage is necessary.
- Primary storage / Secondary storage.
- The need for different types of storage.
- The range of different types of memory chips used in computing.
- How memory chips are packaged.
- Preliminary look at how main memory works in a typical system.

Storage

- Storage of program instructions. -Stored program computer.
- Storage of data to be processed.
- Storage of processed data.
- Temporary storage in the course of processing.
- Necessary part of the Von Neumann model.

Primary Storage

- **Three areas:**

- Processor registers
- Cache
- Main memory

Primary Storage

- **Processor registers:**

- Small capacity storage areas within the processor.
- Typically 8, 16, 32 or 64 bits depending on the processor.
- Very fast.

Primary Storage

- **Cache Memory:**

- Small amount of very fast memory.
- Data from main memory is copied into the cache for faster access.
- A cache ‘hit’ removes the need for a slower retrieval from main memory.
- Onboard cache
- Multilevel cache.

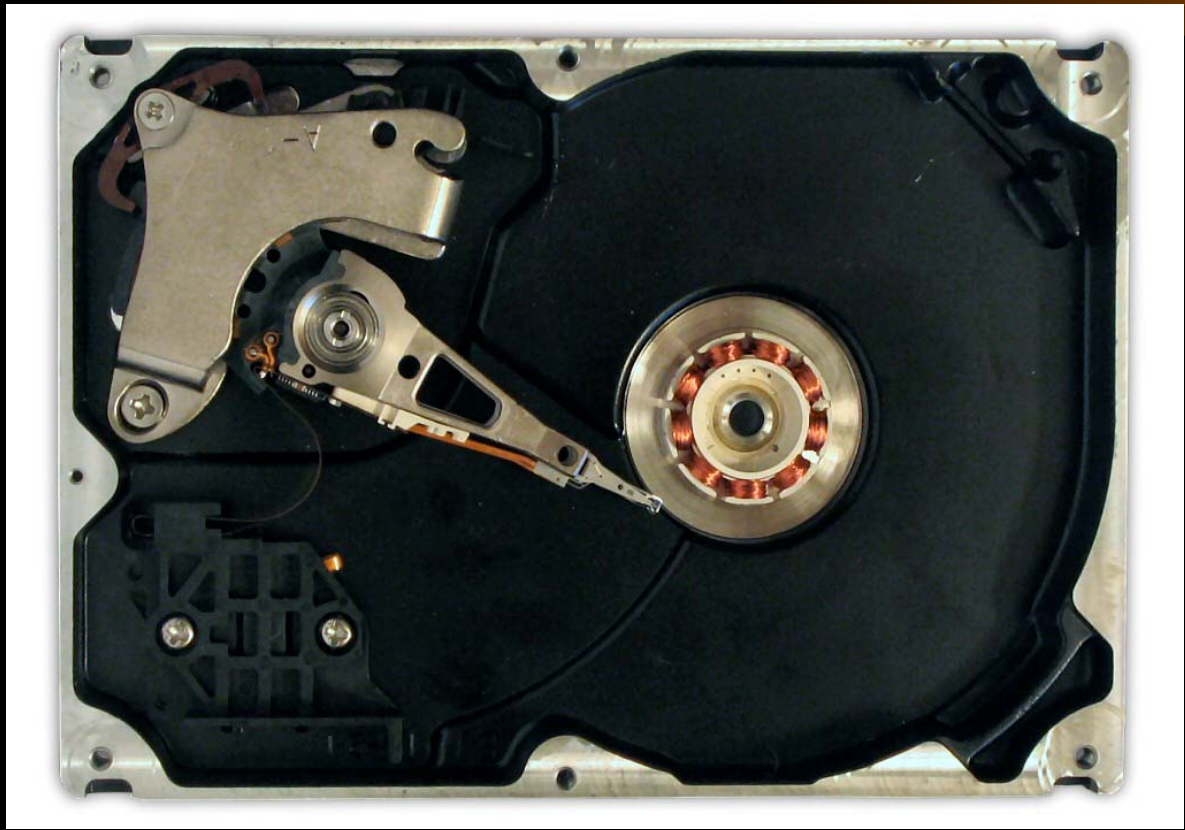
Primary Storage

- **Main Memory:**
- Random Access Memory (RAM).
- Any location can be randomly accessed. (Contrast with sequential for example.)
- Volatile. So also are cache and registers.
- While it is running, a program resides in RAM.
- Physically -chips. More typically, modules connected into the motherboard.
- Access time in the order of nanoseconds.

Secondary Storage

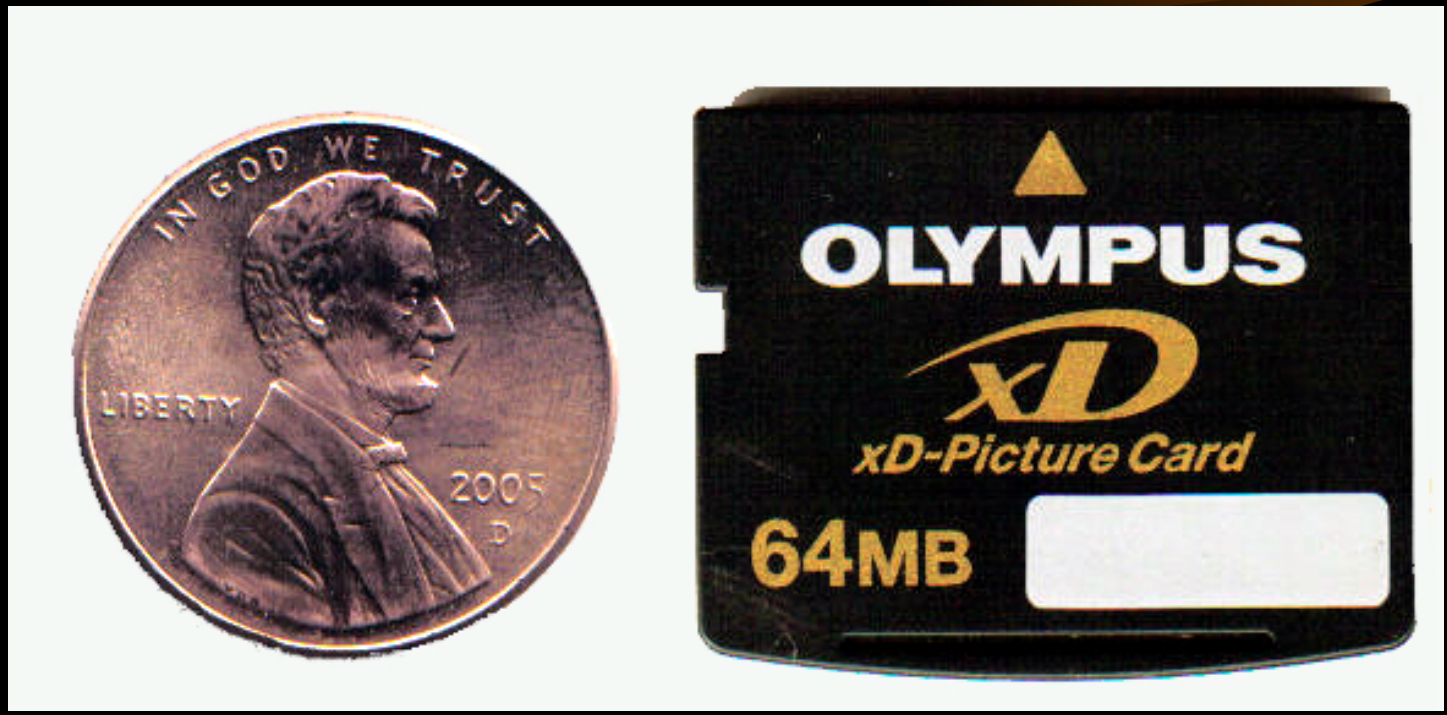
- **Disk Drives and other Devices:**
- Typically, storage on disk drives but includes storage on a range of other devices.
- Tape drives.
- Optical devices including CD-R, DVD-R
- USB memory devices.
- Cards, including SmartMedia, Secure Digital (SD), Extreme Digital (XD)
- Access time in the order of milliseconds.
- Non volatile.

Hard Disk Drive (HDD)



Secure Digital Card

Extreme Digital Card



Storage Requirements

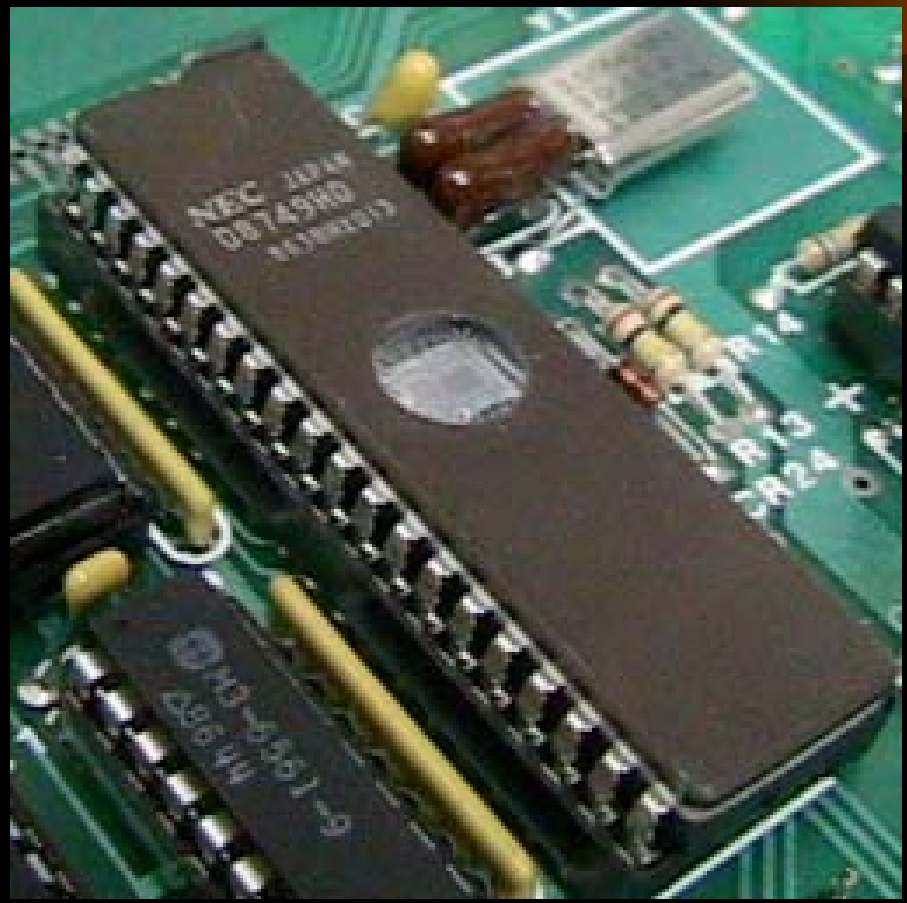
- **Computers contain a range of storage areas to meet a number of different storage requirements:**

- Very small storage areas for immediate processing.
- Smaller areas of fast temporary storage.
- Main working store for programs and data.
- Long-term, non-volatile storage of files and data.
- Storage of programs needed for boot-up before disks or main memory are operational.
- Storage of configuration settings used during boot-up.

Memory Chips: ROM

- ROM (Read Only Memory)
- PROM (Programmable Read Only Memory) - OTP
- EPROM (Erasable Programmable Read Only Memory)
  - With quartz window. Very expensive.
- EEPROM (Electronically Erasable Programmable ROM)
  - EEPROM can be programmed and erased electrically.
- RAM (Random Access Memory)

EPROM



RAM

- DRAM
- SRAM
- SDRAM

DRAM

- DRAM -Dynamic Random Access Memory
- DRAM chips used for main memory.
- Elements consist of transistor and capacitor.
- Dense. Large capacity, small chips.
- Relatively inexpensive.
- Dynamic. Refresh necessary to maintain data. Refresh typically requires several processor cycles.
- Slow, when compared compared with processor speed.
- Slow, compared with SRAM.

SRAM

- SRAM -Static Random Access Memory.
- Static. No refresh required. Does not consume processor resources for this activity.
- Fast. Access time ~2ns.
- Cluster of 6 transistors used for each storage element. (1 bit)
- Expensive.
- Cache memory.

SDRAM

- SDRAM -Synchronous DRAM.
- Runs in synchronisation with the memory bus.
- Removes the latency involved with asynchronous DRAM
- Works with faster system bus cycling and a memory read completes in fewer cycles.
- The cost is not significantly higher.
- Must be supported by the motherboard chipset.

RAMBUS

- Rambus DRAM
- Chip to chip memory bus first developed for gaming systems (Nintendo)
- Somewhat more expensive than SDRAM
- Narrow channel devices. 16 bits wide compared with up to 64 bits for SDRAM devices.
- Although narrow channel, much faster speed.
- Overall throughput about twice that of SDRAM.
- RIMM modules.
- Continuity modules are required for empty sockets.

RAMBUS


Rambus
Rambus, Inc. | RMBS
Last Sale:
$ 16.57
Net Change:
0.19 1.13%
Share Volume:
2,057,249
Make chart selection changes
Order Official Time and Sales Reports
(Available only for NASDAQ stocks)
8 Year
10/24/06
$150.00
120.00
90.00
70.00
50.00
40.00
30.00
20.00
10.00
3.00
99 Jul 00 Jul 01 Jul 02 Jul 03 Jul 04 Jul 05 Jul 06 Jul

DDR SDRAM

- Double Data Rate SDRAM
- The same overall clock and timing signals are used.
- Instead of doubling the clock rate, data is transferred on both the leading and falling edges of the clock cycle.
- Proposed as a low-cost license free alternative to RDRAMS.
- Intel official position was that it supported RAMBUS for its systems.
- DDR appeared at first in non-Intel processor systems.

Physical RAM

- Early computer motherboards has socketed Dual Inline Package (DIP) chips.
- Memory modules -Chips mounted on circuit boards with edge connectors.
- The modules have notches to ensure that they can not be connected the wrong way around in the motherboard memory slots.
- SIMM -Single Inline Memory Module
- DIMM -Dual Inline Memory Module
- RIMM -Rambus Inline Memory Module

SIMMs

SIMMs: Top 30 pin and bottom 72 pin SIMMs.

DIMMs

DIMMs: Top 168 pin SDRAM module. Bottom 184 pin DDR SDRAM module.

NVRAM

- Non Volatile RAM
- RTC NVRAM chip.
- Stores system configuration and includes a Real Time Clock.
- Preserves the date and time even when the system is powered down.
- Date and time are read by software on power-up.
- Typically, a Lithium type battery powers the chip.
- Power requirement is small, so a capacitor is used to store power in some systems, eg. HP.

Memory Management

- Multiprogramming, Multitasking systems.
- Task of the operating system (OS)
- Memory Management Requirements:
  - Relocation
  - Protection
  - Sharing
  - Logical Organisation

- Physical Organisation