

CSSE2010/CSSE7201

Lecture 23

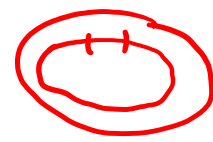
File Systems, Buses & Chipsets

School of Information Technology and Electrical Engineering
The University of Queensland

Virtual I/O - Files

- User/programmer do not want to worry about unit numbers, heads, cylinders, sectors, timeout errors, retries, etc.
- Common I/O abstraction is the file File
 - To the Operating System, a file is just a sequence of bytes
 - Any structure is up to the application program

Write
Read



File System

- Computers easier to use (and program) when files have names
- **File system**
 - Associates files (collections of sectors) with names and directories
- Some sectors used for index information (e.g. File Allocation Table)
- Other sectors store the files themselves
- Many different file systems
 - FAT, FAT32, NTFS, exFAT, EXT2, EXT3, EXT4, APFS, HFS+, UFS, ZFS, ...

Disk Formatting

• Low level format

- Reinitialises all sectors
 - Preambles, data (empty), ECCs
- No file system

• High level format

- Creates empty file system
- Only writes index/table sectors

• Deleting a file doesn't mean it's gone!

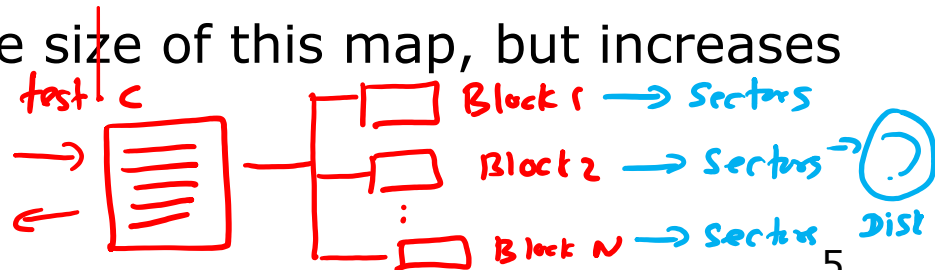
- OS may just delete the index entry, not overwrite the sectors where actual data stored



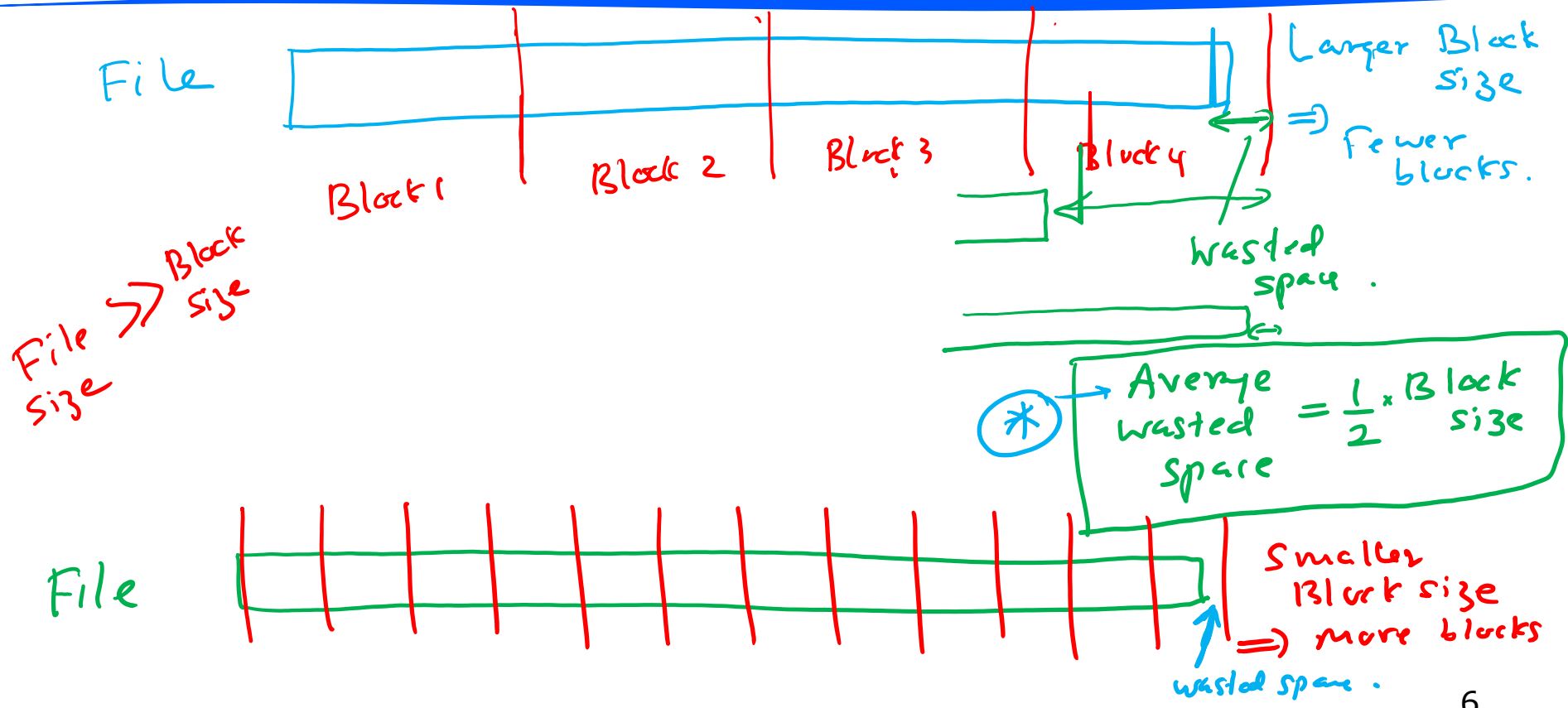
Files

- OS allows file names (e.g. FinalReport.doc) rather than cylinder and sector numbers
- File storage is allocated in **blocks** or **allocation units**
 - Block could be as small as 1 sector or could be several consecutive sectors
 - Block sizes typically 512 bytes to 32kB

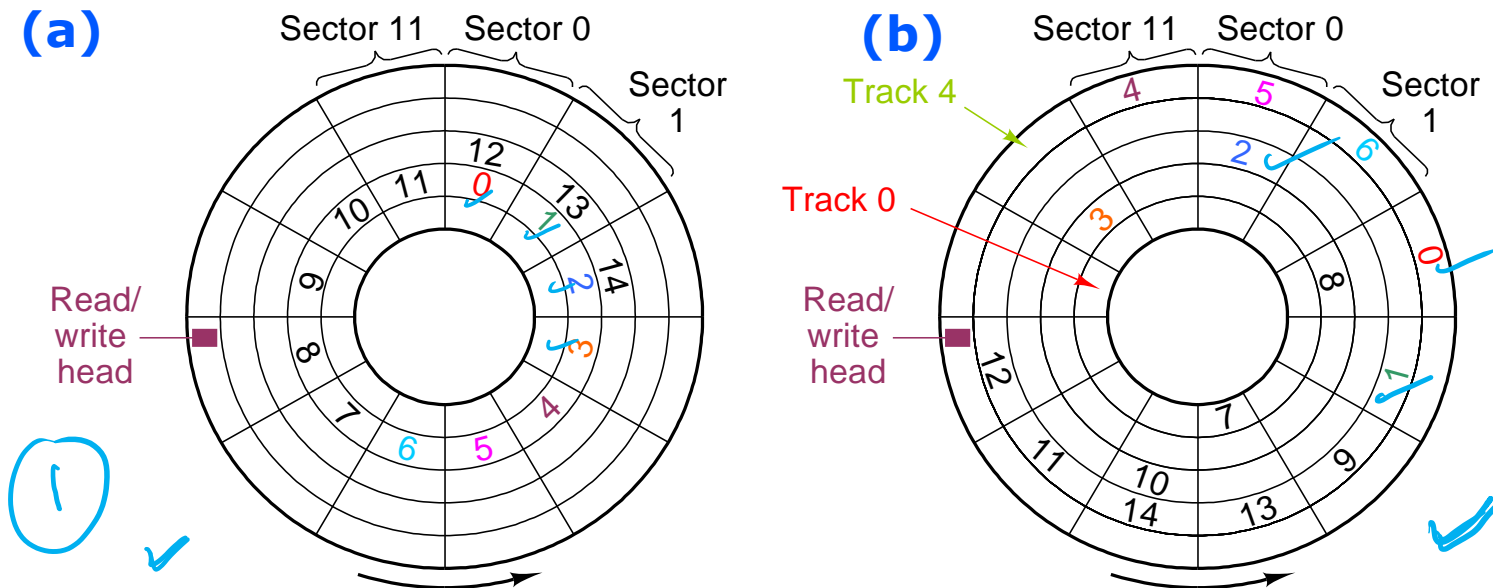
Sector → 2048 bytes
 - OS maintains map from file name to a set of blocks
 - To help users, a hierarchy of directories (folders) can be used
- Larger block sizes reduce the size of this map, but increases wasted space at EOF
 - *To be illustrated in class*



Block Size and Wasted Space



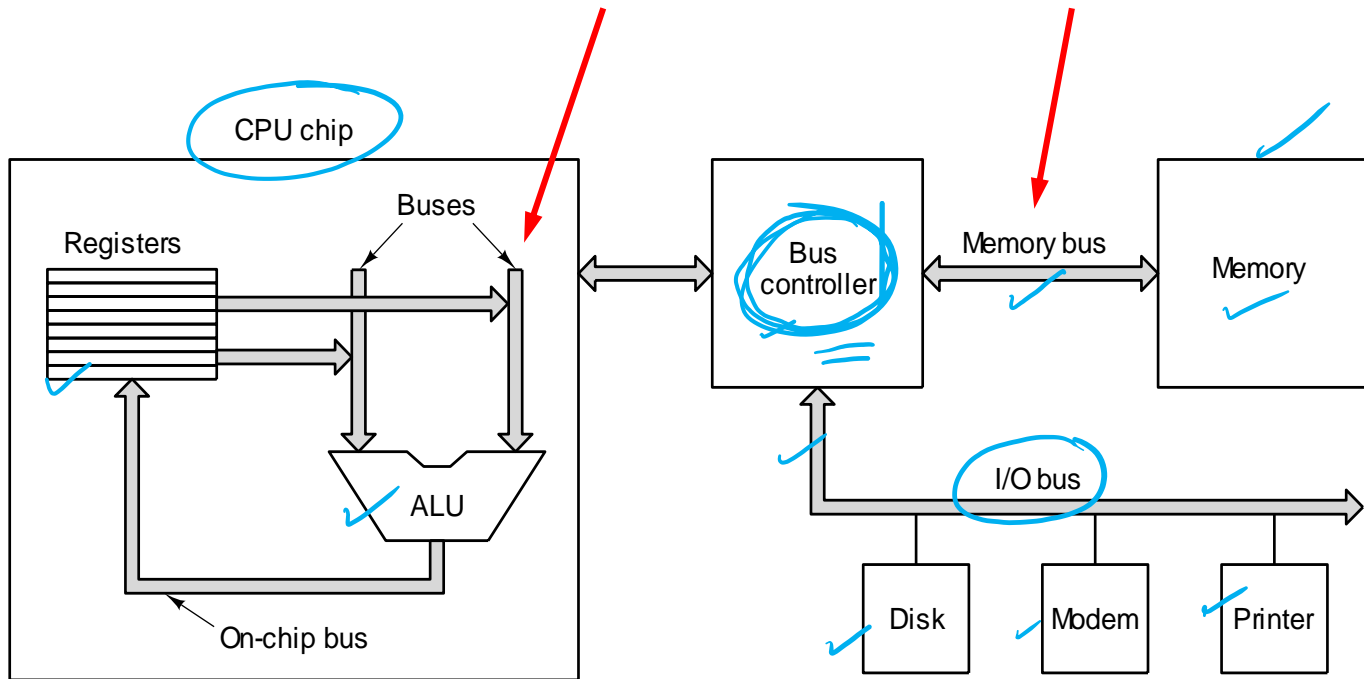
Disk Allocation



- Two possible allocations of 15 sectors (assume 1 block = 1 sector)
- (a) is ideal but unlikely as disks become fragmented (e.g. (b))
- Fragmentation → slow access (seek time and rotational latency)

Buses are Everywhere...

- Buses are both internal and external to the CPU

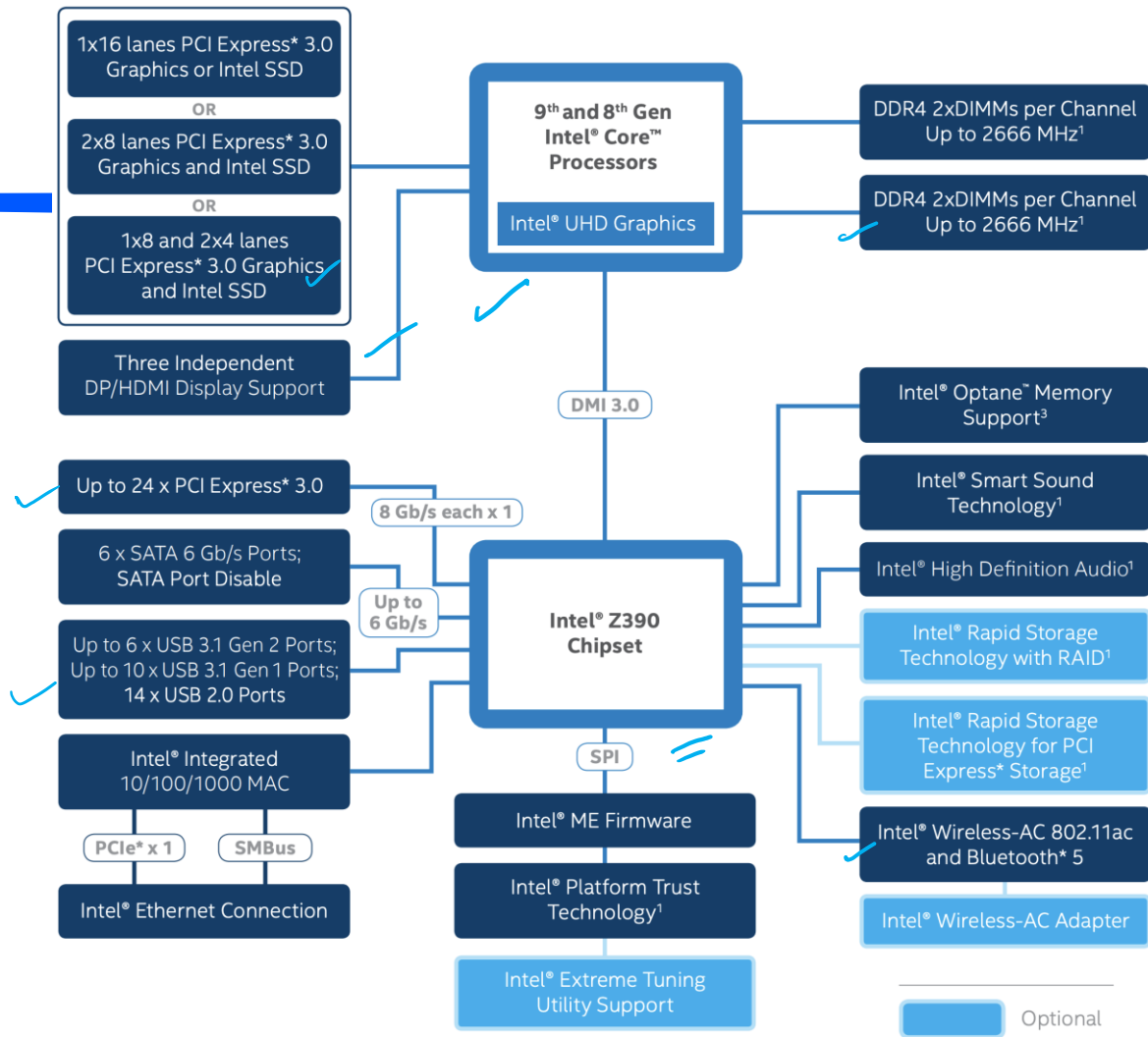


Bus Controller

- In the PC world, Bus Controller is called a **chipset**
- Particular chipsets support particular bus standards
- Memory:
 - DDR4-RAM, DDR3, DDR2, ...
- I/O:
 - PCI Express, USB, SATA, PCI, ...

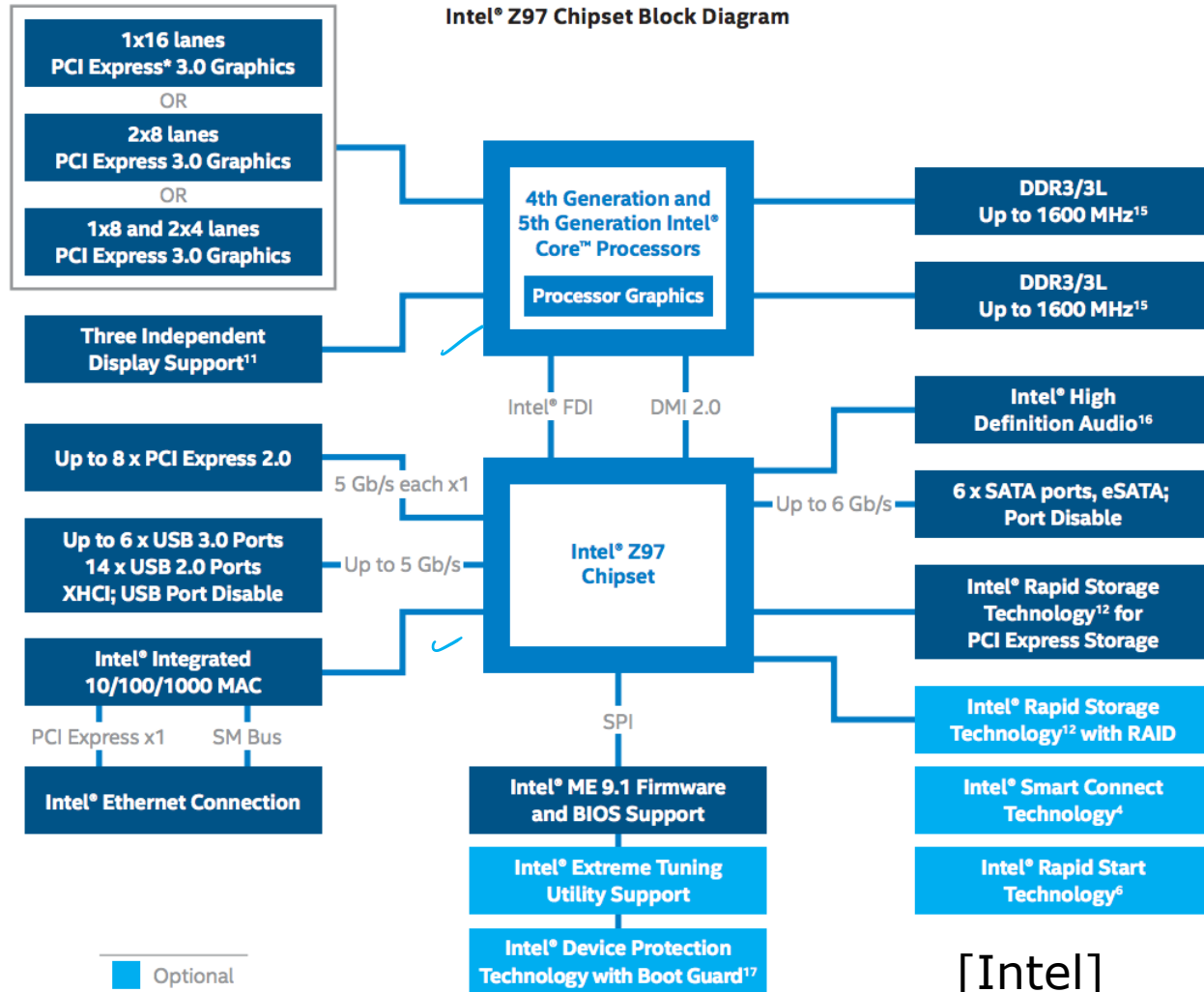
Intel Z390 Chipset

(Late 2018)



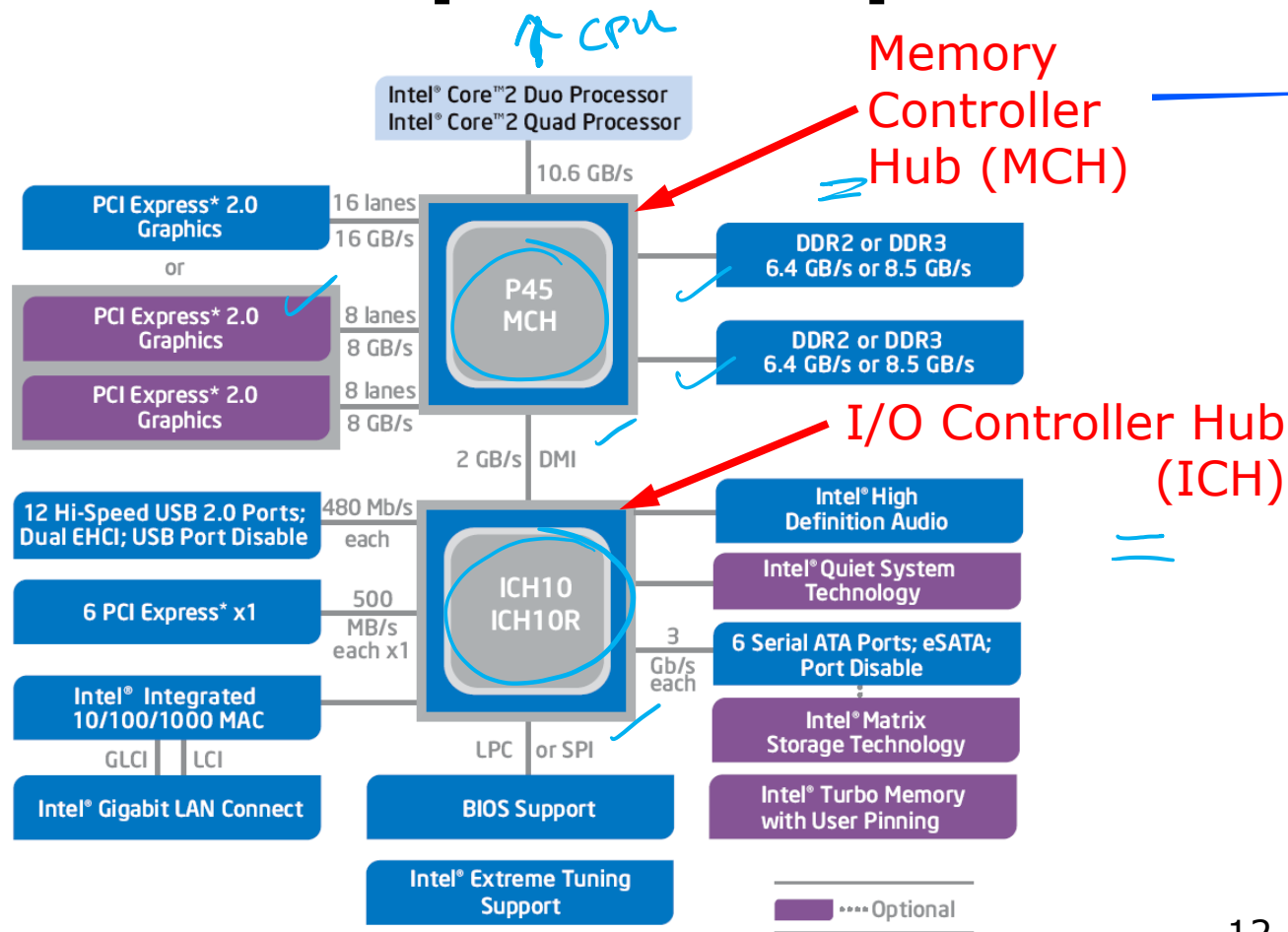
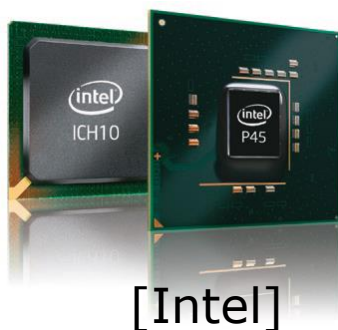
[Intel]

Intel® Z97 Chipset Block Diagram



Intel P45 Express Chipset

Last chipset
to use
MCH/ICH
(2008)

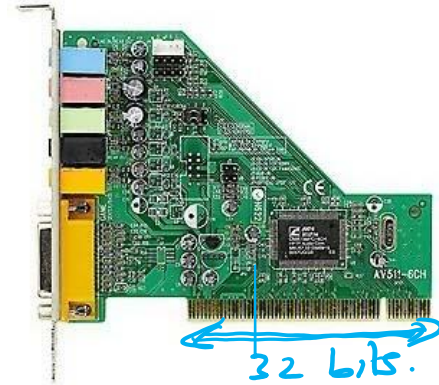


Peripheral Buses (or I/O buses)

- **Peripheral** = External input/output device
- Peripheral bus = input/output bus
- Examples:
 - ✓ ■ PCI Express
 - ✓ ■ PCI
 - ✓ ■ USB
 - Firewire
 - ✓ ■ SATA
 - SCSI
- And some “dead” ones:
 - ISA, EISA, Omnibus, Unibus, Multibus, MCA, Nubus, AGP,
...

PCI Bus

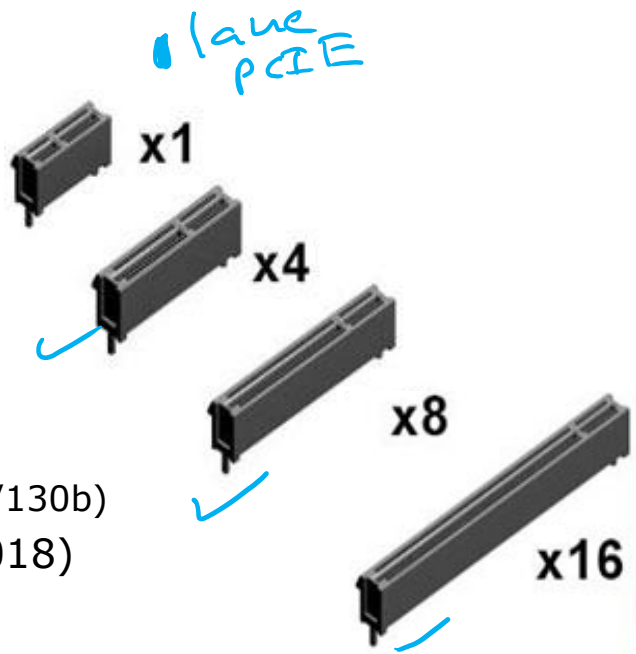
- **P**eripheral **C**omponent **I**nterconnect bus
- Patented by Intel, but in public domain
 - PCI 1
 - 32 bits wide, 33MHz → 132MB/sec max transfer rate
 - PCI 2.2
 - up to 64 bits, 66MHz → 528MB/sec max transfer rate
 - 32 bit cards have 120 pins; 64 bit cards have an extra 64-pin connector
- It is a parallel bus
- 5V and 3.3V options



PCI Express (PCIe) Bus

- High-speed, serial bus standard
- x1 version = 2 Gbits/second
- x16 version = 32 Gbits/second = 4 GBytes/second
Max transfer rate.

- PCI Express 2.0 (2007)
 - doubles the data rates above
- PCI Express 3.0 (2010)
 - 8 GT/second (GigaTransfers – using 128b/130b)
- PCI Express 4.0 (standard ratified Jan 2018)
 - double PCIe 3.0
- PCI Express 5.0 (expected 2019)
 - double again



Standard released 29 May 2019
PCI Express 6.0 expected 2021

Universal Serial Bus (USB)

- Originally only 4 wires (power, ground, data x 2)
- Devices can be powered from cable
- ✓ • Up to 127 devices
- ✓ • Hot-pluggable (i.e. can plug in/out whilst power is on)
- USB1.0 (1996, updated to v1.1, 1998)
 - 1.5Mbits/sec (**low-speed**)
 - 12Mbits/sec max (1.5MB/sec, **full-speed**)
- USB2.0 (2000)
 - 480Mbits/sec max (**hi-speed**)
- ✓ • USB3.0 (2008, 9 wires, different connector)
 - 5Gbits/sec (**super-speed**) (full duplex)
- USB3.1 – 10Gbps (2013)
- USB3.2 – 10Gbps and 20Gbps over USB-C connector (2017)

**Rates are
data signaling
rates**

$\boxed{\text{E}}$ $\times 2$

Realistic Transfer Rates

- Most buses can't achieve maximum transfer rates in real-life situations

Floating point

- Communication occurs in both directions
- Buses are often shared between multiple devices

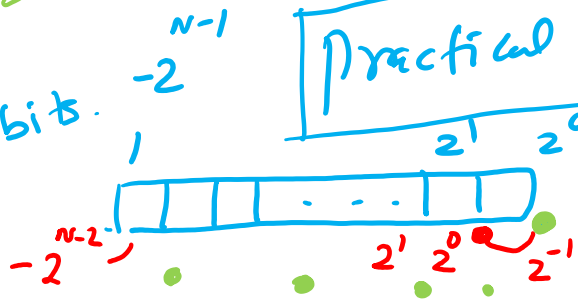
$\frac{1.2 \times 10^5}{1.2 \times 10^5}$

10^{-6}
 10^6

$\begin{matrix} 101010 \\ 111111 \end{matrix} \} + \checkmark$

Practical transfer rate = 50%, max transfer rate.

N bits



Fixed point

00001001
4 0.5

Range

Accuracy

0.5 ✓
4.5 ✓