USB/PCI

E155

Sources

- Harris and Harris 2nd Ed. Chapter 8
- http://en.wikipedia.org/wiki/Universal_Serial_Bus

PC I/O

- Memory
- Disks/storage
- Networking
- Internal Expansion
- External Devices

PC Motherboard

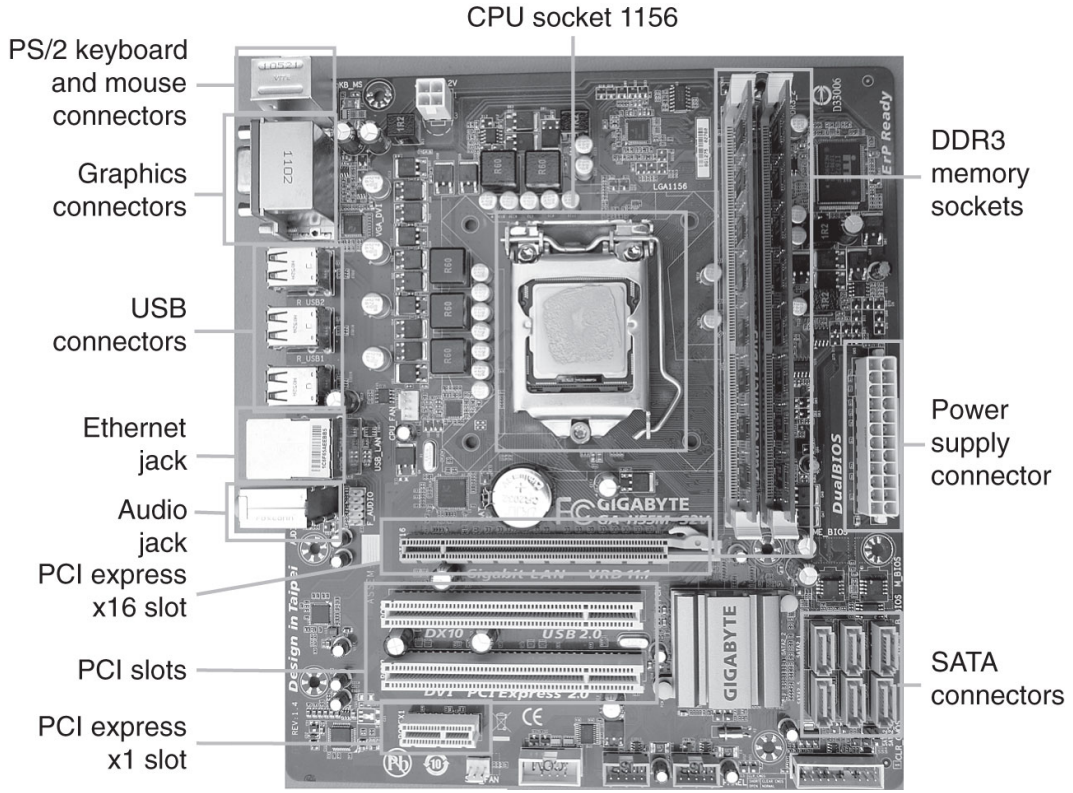


Figure 8.70 Gigabyte GA-H55M-S2V Motherboard

Peripheral Trends

- Fewer parallel ports
  - Parallel wires prevent high speeds
  - Transmission line problems
  - Reflections, different flight times
- More serial ports
  - High speed
  - Properly terminate transmission lines
  - Less noise
  - Faster than 10Gb/s over copper

PC Peripherals

- Expansion cards
  - Open case
  - Set jumpers
  - Manually install driver
- RS-232 device
  - Get the right cable
  - Configure baud rate, data, parity and stop bits

USB

- Universal Serial Bus
- Simplifies peripherals
  - Standard cables
  - Standard software configuration
- Billions of USB peripherals sold each year

USB 1.0

- 1996
- 4 wires
  - 5 V
  - GND
  - Differential pair for data
- Impossible to plug in wrong
- 12 Mb/s
- Up to 500 mA for the device

USB 2.0

- 2000
- Faster differential wires
- 480 Mb/s
- Fast enough for more devices
  - Webcams
  - External hard disks
  - Flash memory sticks (replaced floppy disks)

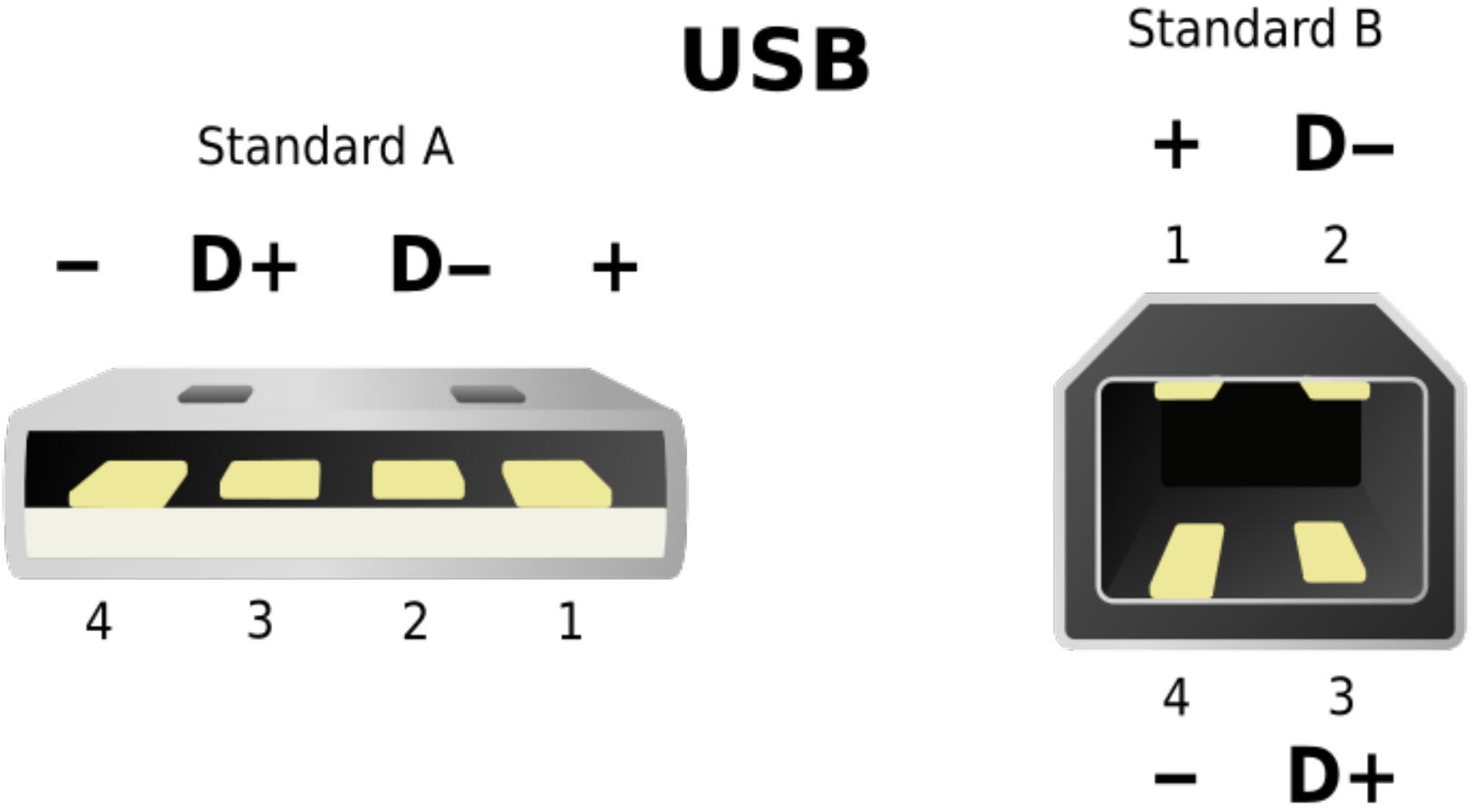
USB 3.0

- 2008
- Even faster wires
- More wires
- 5 Gb/s
- Same shape connector

USB Speeds

- LS: Low Speed (1.5 Mb/s)
- FS: Full Speed (12 Mb/s)
- HS: High Speed (480 Mb/s)
- SS: Super Speed (5 Gb/s)

USB Connector



http://en.wikipedia.org/wiki/Universal_Serial_Bus

USB 3.0

Pin	Color	Signal (B in parenthesis)
1	Red	VBUS
2	White	D-
3	Green	D+
4	Black	GND
5	Blue	StdA_SSRX- (StdB_SSTX-)
6	Yellow	StdA_SSRX+ (StdB_SSTX+)
7	Shield	GND_DRAIN
8	Purple	StdA_SSTX- (StdB_SSRX-)
9	Orange	StdA_SSTX+ (StdB_SSRX+)

USB Device Classes

- Notify the host
- Provides portability
- Devices from different manufacturers
- Host selects the appropriate driver

USB Device Classes

Class	Usage	Description	Examples
0x00	Device	Unspecified	Interface descriptors determine drivers
0x01	Interface	Audio	Speaker, Microphone, MIDI
0x02	Both	Communications	Modem, Ethernet adapter, Wi-Fi adapter
0x03	Interface	Human interface (HID)	Keyboard, mouse, joystick
0x06	Interface	Image	Webcam, scanner
0x08	Interface	Mass storage	USB flash drive, memory card reader, etc.
0x09	Device	USB hub	Full bandwidth hub
0x0D	Interface	Content Security	Fingerprint reader
0xE0	Interface	Wireless Controller	Bluetooth adapter
0xFF	Both	Vendor-Specific	Device needs vendor-specific drivers

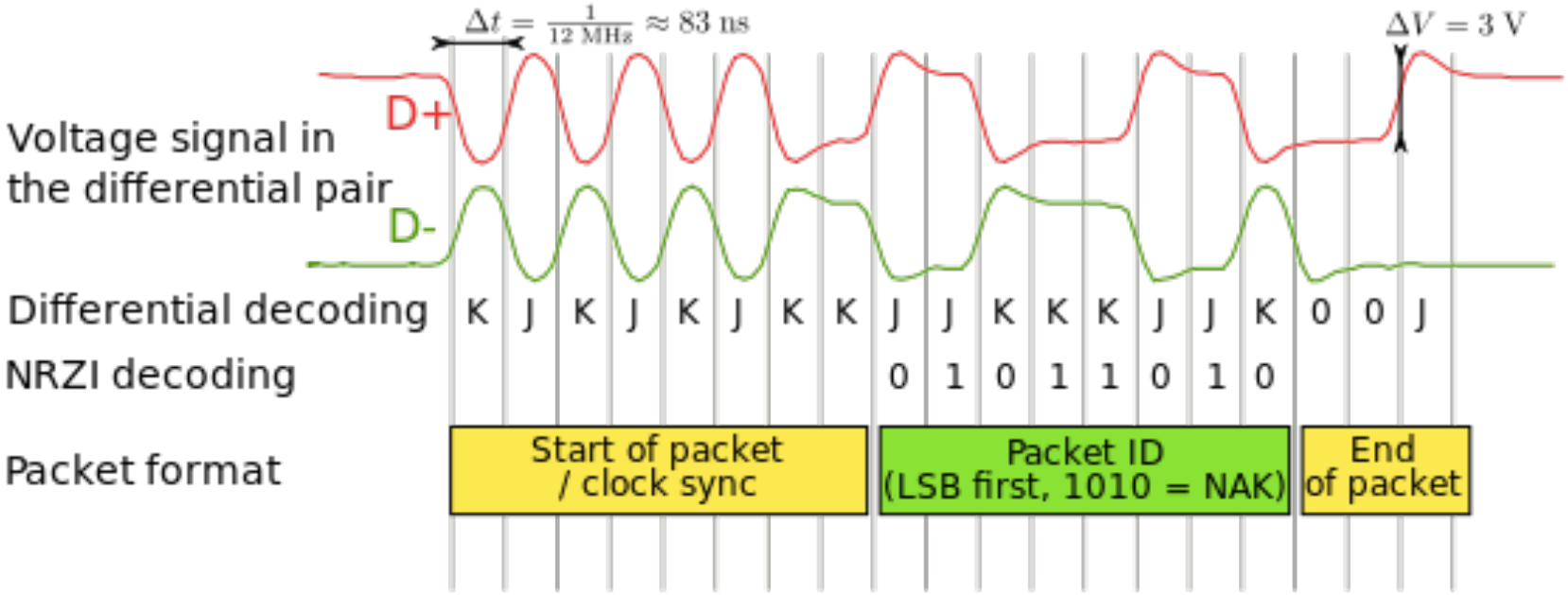
USB Packets

- Full-bandwidth and low-bandwidth
  - Low value: 0.0 to 0.3 V
  - High value: 2.8 to 3.6 V
- Hi-bandwidth
  - Low value: -10 to 10 mV
  - High value: 360 to 440 mV

USB Packets

- Two differential states: J, K
- NRZI Convention:
  - 0 indicated by switch from J to K or K to J
  - 1 indicated by staying the same
- Extra 0 after six consecutive 1s (bit stuffing)
- Start of Packet: 0000 0001 (KJKJKJKK)
- End of Packet (EOP): 2 bit times of SE0 (low) followed by J

USB Packets


$\Delta t = \frac{1}{12\ \mathrm{MHz}} \approx 83\ \mathrm{ns}$
$\Delta V = 3\ \mathrm{V}$
Voltage signal in the differential pair
D+
D-
Differential decoding
K J K J K J K K J J K K K J J K 0 0 J
NRZI decoding
0 1 0 1 1 0 1 0
Packet format
Start of packet / clock sync
Packet ID (LSB first, 1010 = NAK)
End of packet

USB Packets

- Many different types
- Look them up on your own!
- PIC32 Flash Drive: http://ww1.microchip.com/downloads/en/appnotes/01145b.pdf

PIC32

- Built in USB controller
- Supports Full Speed (FS) (12 Mbps)
- Drivers can be complicated
- Example in Lab7
- Be sure to do your research

Apple Lightning Connector

- Uses USB 2.0 for signaling
- Proprietary protocols internally

PCI (express)

- Peripheral Component Interconnect
- PCI – older (slower) standard
- PCI express (newer)
  - x16 slot: High performance
  - x1 slot: Low performance
  - x4, x8 slots: In between
- Used for expansion cards
- Serial, USB, network, sound, modem, video

PC Motherboard

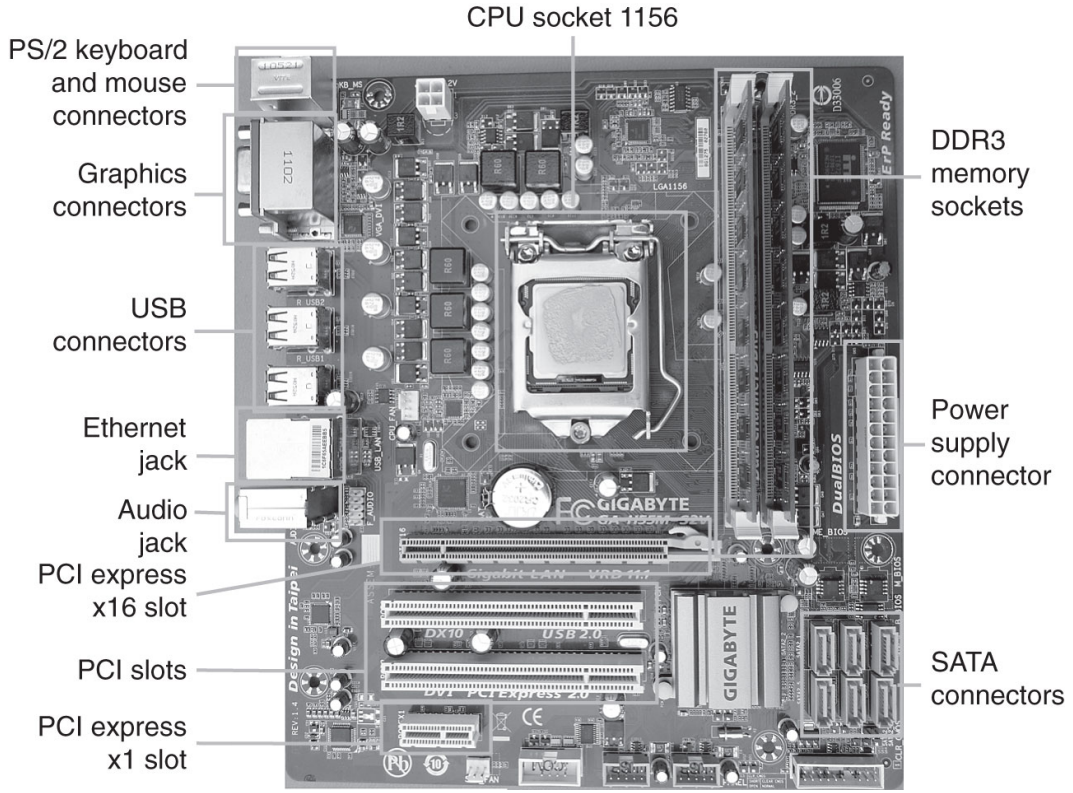
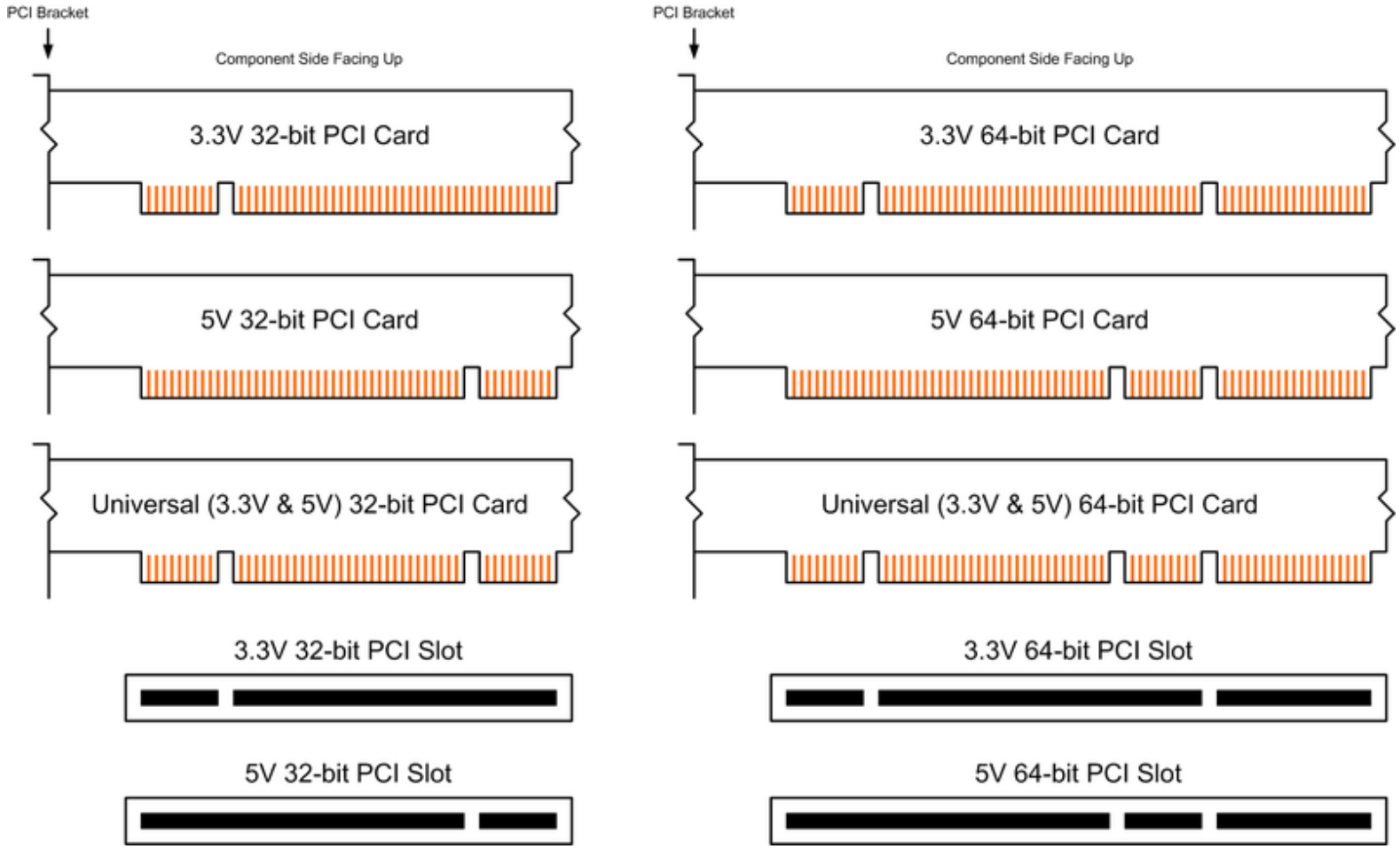


Figure 8.70 Gigabyte GA-H55M-S2V Motherboard

PCI

- 1994
- 32-bit parallel bus33 MHz clock
- 133 MB/s
- 5 V signaling
- 64-bit option (confusingly called PCI-X)

PCI Picture


PCI Bracket
Component Side Facing Up
3.3V 32-bit PCI Card
5V 32-bit PCI Card
Universal (3.3V & 5V) 32-bit PCI Card
3.3V 32-bit PCI Slot
5V 32-bit PCI Slot
PCI Bracket
Component Side Facing Up
3.3V 64-bit PCI Card
5V 64-bit PCI Card
Universal (3.3V & 5V) 64-bit PCI Card
3.3V 64-bit PCI Slot
5V 64-bit PCI Slot

PCIe

- PCI Express
- One or more high-speed serial lanes
- PCIe 3.0 each lane is 8 Gb/s
  - Up to x16 lanes
  - 16 GB/s
- PCIe 4.0 each lane is 16 Gb/s
  - Up to x16
  - 32 GB/s (16 GB/s in each direction)

What is a lane?

- Two differential signal pairs
  - Send, receive
  - 4 wires (signal traces)
- Functions as a byte stream (8-bits)
- PCIe slots from 1-32 lanes
- 16 is the largest in common use

Picture Time

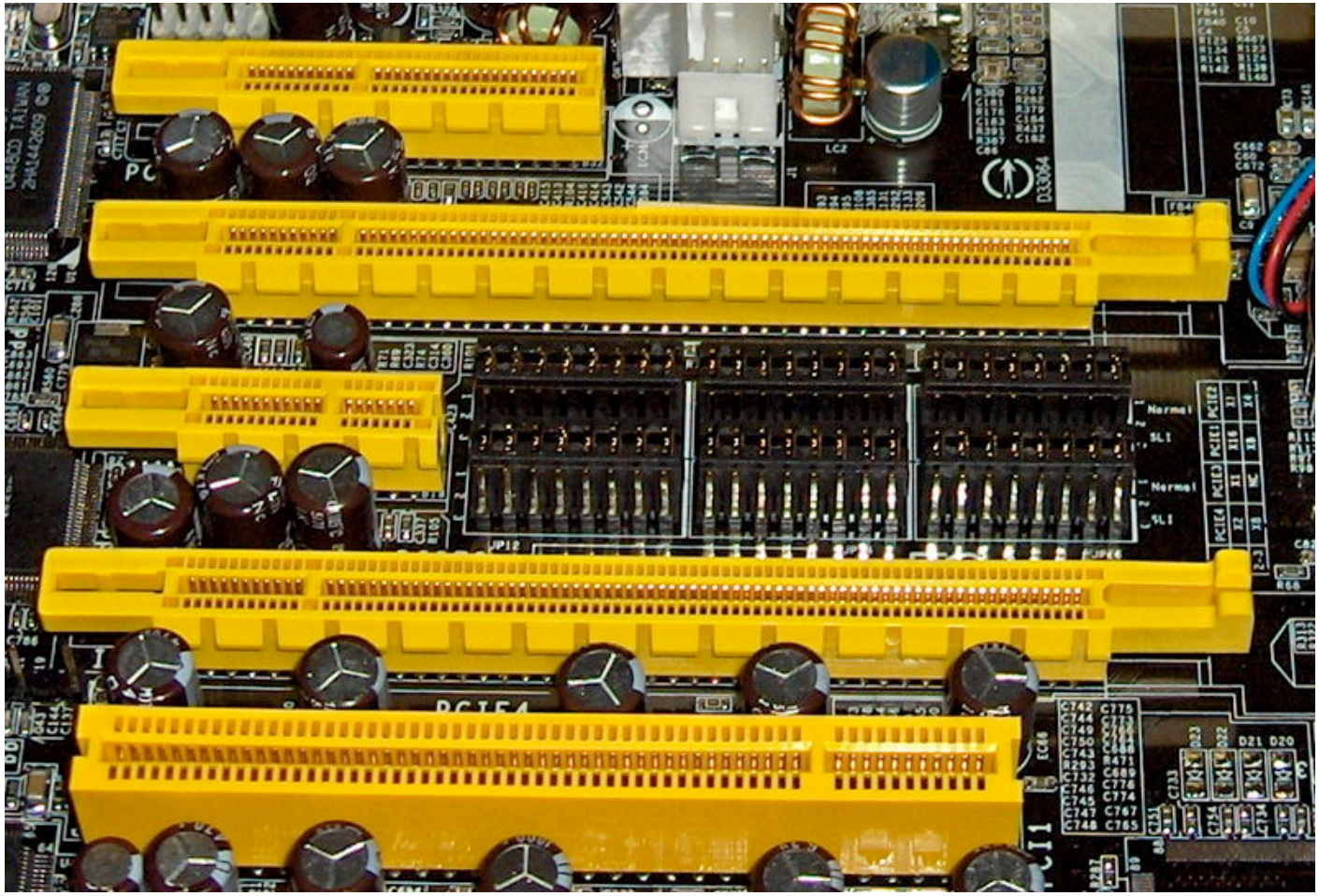
x4

x16

x1

x16

PCI



PCI vs. USB

- Many previously PCI devices moving to USB
- Motherboards build in lots of USB
- PCIe used for graphics cards
- Other high-performance accelerators
  - Intel Xeon Phi
  - Caustic RT Accelerator
  - µMudd32 ?

More information on PCI

- http://www.cs.uml.edu/~bill/cs592/PCI_slides.pdf
- http://www.cs.unc.edu/Research/stc/FAQs/pci-overview.pdf

Quick SD Card Note

- http://hades.mech.northwestern.edu/index.php/PIC32MX:_Interfacing_to_a_Secure_Digital_(SD)_Flash_Card