USB
(Universal Serial Bus)

Presentation to UCHUG - 2/06/08
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What is USB?

• Universal Serial Bus
• A computer peripheral interface
• Ubiquitous across all computer platforms
• Several variations - continues to evolve
• Hot-swapable
• Provides three advantages
  – Port expansion
  – Performance
  – Standard connection method
In the Old Days . . .

• Mice and keyboards only connected to dedicated connectors or serial port
• Networking (as such) was only through serial com port
• Printers had their own connector
• Not much else!
Typical Performance

<table>
<thead>
<tr>
<th>Connection / Port</th>
<th>Maximum Speed</th>
<th>Connector Pins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Parallel Port</td>
<td>0.115 MBytes/s</td>
<td>25</td>
</tr>
<tr>
<td>Enhanced Parallel Port</td>
<td>3.0 Mbytes/s</td>
<td>25</td>
</tr>
<tr>
<td>Extended Capabilities Port</td>
<td>3.0 Mbytes/s</td>
<td>25</td>
</tr>
<tr>
<td>Standard RS-232 COM Port</td>
<td>0.03 Mbytes/s</td>
<td>9</td>
</tr>
<tr>
<td>PS-2 Port</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>USB 2.0</td>
<td>60 Mbytes/s</td>
<td>4</td>
</tr>
</tbody>
</table>

USB provides much higher data transfer speeds, with fewer wires!
Birth of USB

- Defined by Intel and other industry leaders in early 1990s
- Ease of use was primary goal
- Four-wire interface
- Point-to-point, host-target architecture
- Bus expansion
- Replace legacy connectors
USB Connectors
USB Cables

- Four wires (+5V, Return, data twisted pair)
- Up to 5 m (16.4 ft)
- Longer connections use hubs or active extensions
  - Active extension incorporates a bus-powered hub
USB Details

• Host initiates all transfers
  – Target can be “dumb”

• Three device types
  – Host controllers
  – Hubs
  – Functions (Peripherals)

• Accommodates 7 tiers
  – 5 hub levels, 127 devices

Physical interconnect is a tiered-star topography
Host Controller

• Only one host in any USB system
  – Typically implemented in PC chipset (root hub)
  – Host responsibilities
    • Detect attachments and removals
    • Manage control and data flow between host and devices
    • Monitor status and activity
    • Provide power to attached devices
  – Class drivers included in most operating systems
Hubs

• Combined splitter and repeater
• Must detect connections and disconnections downstream and report to host
• Must manage downstream power
  – Bus-powered hubs (Power from upstream)
    • Must draw no more than 500 mA from upstream
    • Must supply 100 mA to each downstream port
  – Self-powered hubs (External power source)
    • May draw up to 100 mA from upstream
    • Must supply 500 mA to each downstream port
Peripherals

• Logical or physical device that performs a function
  – Examples: Keyboards, mice, printers, Flash memory devices, external drives, audio players, digital cameras

• Four types of data transfers
  – Control (all devices must support)
  – Interrupt (keyboards, mice, joysticks)
  – Bulk (printers, scanners, storage devices)
  – Isochronous (web-cams, speakers)
Peripheral Power

- **Bus-powered**
  - Low-power: May draw up to 100 mA
  - High-power: May draw up to 500 mA
- **Self-powered**
  - May draw up to 100 mA from upstream
  - Can have a low-power suspend state
- How a device reports itself determines how much current it can draw
- Battery charging of devices
USB Evolution

- **USB 1.0** - January 1996
  - LS (low-speed): 1.5 Mbps
  - FS (full-speed): 12 Mbps
- **USB 1.1** - July 1998 - major clarifications
- **USB 2.0** - April 2000
  - Full backwards compatibility with USB 1.1
  - Adds high-speed: 480 Mbps
USB Evolution

• USB OTG - July 2003 - portable devices
  – Adds limited host capabilities to peripherals
  – Intended to share data without a computer
  • Sharing data between PDAs
  • Printing directly from camera to printer
  – Supplies only 8 mA; has limited target list
  – Same three speeds as USB 2.0

• Wireless USB (WUSB) - May 2005
  – Up to 480 Mbps at 3 m, 110 Mbps at 10 m
  – Encrypted data
USB Uses

- **Human Interface Devices**
  - Keyboards, mice, joysticks, game controllers
  - Low-speed, interrupt data transfer
    - Mice are polled every 8 ms, respond with 32 bits

- **Mass Storage Devices**
  - External hard drives, DVD/CD-RW, floppy, zip, Flash card readers, USB Flash drives

Time required for 1 GB data transfers
USB Uses

- Digital Cameras, Portable Media Players
  - Similar to mass storage, so speed is important
  - Will also use high speed, bulk data transfers
- Printers
  - Also uses high-speed
- PC Cameras or Webcams
  - High-speed, isochronous transfers

Table 1. WebCam Bandwidth Requirements

<table>
<thead>
<tr>
<th></th>
<th>Cam 1</th>
<th>Cam 2</th>
<th>Cam 3</th>
<th>Cam 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horiz. Pixels</td>
<td>640</td>
<td>800</td>
<td>1024</td>
<td>1280</td>
</tr>
<tr>
<td>Vert. pixels</td>
<td>480</td>
<td>600</td>
<td>768</td>
<td>1024</td>
</tr>
<tr>
<td>Frames / sec</td>
<td>30</td>
<td>27</td>
<td>24</td>
<td>15</td>
</tr>
<tr>
<td>Bits / pixel</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Raw BW (Mbps)</td>
<td>221</td>
<td>311</td>
<td>453</td>
<td>472</td>
</tr>
</tbody>
</table>
Novel USB Devices

Fondue Pot
Warming Gloves
Cooking Pot
Warming Slippers
Microscope
Foam Missile Launcher
Novel USB Devices

Thumb Drive

Vacuum Duck

Chameleon

Pencil Sharpener
Novel USB Hubs

Engine Hub

Tape Dispenser Hub

Self Destruct Hub

Gold Brick Hub
The Future of USB

- **USB 3.0**
  - Intel leading effort for specification for 4 Gb/s transfers
  - 300 MB/s of useable data transferred
  - Also called SuperSpeed USB
  - Aims to kill IEEE 1394 (Firewire)
  - Uses two twisted pairs
    - Data
    - Acknowledgement
  - Due to release spec in 2008
Acknowledgements

• Dan Harmon, “Which Version of USB is Right for Your Application (Parts 1-2)”, www.planetanalog.com

• Rick Merritt, “USB 3.0 Effort Aims to Smoke FireWire”, EE Times, 9/24/07

• Wikipedia - USB