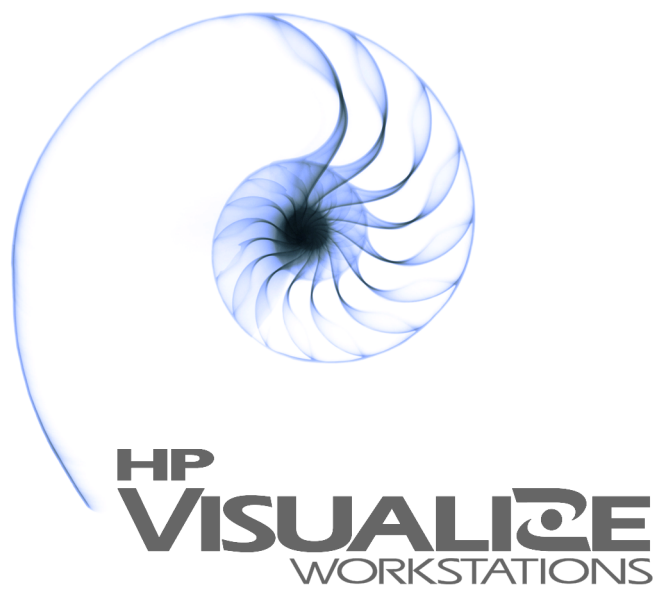

InterWorks '99



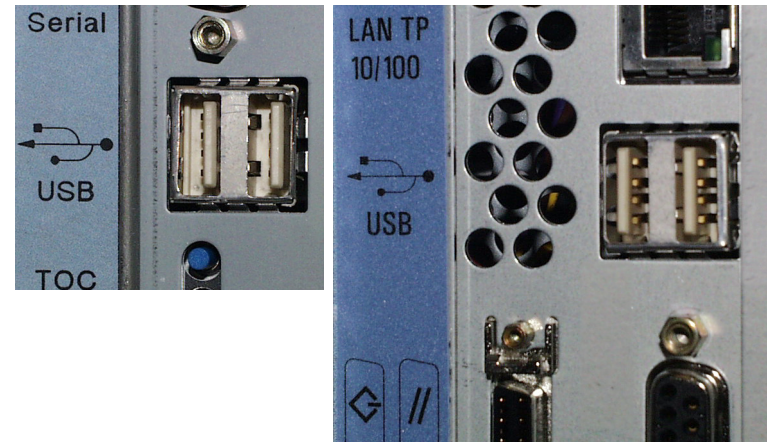
USB 
PA-RISC 
Workstation
Universal Serial Bus

March 8, 1999

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3404 East Harmony Road
Fort Collins, CO 80528-9599

USB Do You Need to Know About USB?

Several PA-RISC workstations to be introduced during 1999 require a USB keyboard and mouse. Apart from the addition of three PC-style keys to the keyboard and a scroll wheel to the mouse, most users won't notice the difference once the system is set up. And the person setting up the system is likely to notice only a different connector shape.



However, you need to absorb this presentation:

- if you plan to supply your own keyboard or mouse, or
- if you have been using other PS/2 devices, or
- if you have been considering a port of a PC or iMac USB device, or
- if you need a keyboard and mouse cable longer than 2.5m, or
- if you simply lament the passing of HP-HIL.



This presentation does not apply to Intel-based VISUALIZE workstations, as they have had USB ports for some time (as have most PCs), and like all NT Workstations, are awaiting Windows 2000 (aka NT 5) for full USB support.



What You Will Learn Here

- What is it? USB in a nutshell.
- Some history - how USB got to where it is today.
- The state of the USB standard and Unix API efforts.
- Key technical details for users and the merely curious.
- The capabilities, limitations and applications for USB.
- How USB compares to legacy and contemporary alternatives.
- How USB will roll out on PA-RISC platforms.
- How USB is supported in PA-RISC hardware, firmware and HP-UX.
- The initial USB devices.
- Considerations for buyers and users at the transition.
- Considerations for developers.

USB What is USB?

- U.S.B. stands for Universal Serial Bus (Logo:  Icon: )
- Moderate speed 12 Mbps/sec. or 1.5 Mbytes/sec.
- Multiple devices up to 126 - on a single resource set.
- Cubicle span cabling 5m per segment, 30m max. with hubs
- Flexible topology tiered star
- Flexible power devices bus- or locally-powered, w/suspend-resume APM
- Robust PnP, hot attach-detach¹
- Low-cost 4 wire
- Idiot-proof Unique modular connectors:

Style A (upstream, to hub/host):

Style B (downstream, detach at device):



Although USB ports have been shipping on PCs for over two years, widespread acceptance has been delayed by lack of devices, which, in turn, have been awaiting:

- O.S. support: Still waiting for “NT”. Win95 support is problematic.
- BIOS support: Most “USB” PCs have no USB console capability in BIOS.
- Economics: Some PS/2 devices are still cheaper than USB during 1999.

1. Hot attach-detach is planned, but not fully implemented in the first HP-UX USB support.



How USB Got Here

As with PCI, USB is sponsored by an independent consortium that was initiated by Intel. Work began on the standard in 1993.

USB was a response to several issues:

1. PS/2, RS-232C serial and parallel (Centronics, ECP, EPP, IEEE-1284) have serious deficiencies, and occupy too much panel space in a shrinking world.
2. Dedicated ISA cards are vanishing. SCSI and dedicated PCI cards are overkill for many desktop applications. FDD and IDE are too resource-limited for many devices that might otherwise use them.
3. It was getting increasingly expensive for suppliers to maintain proprietary desktop connectivity solutions such as ADB (Apple Desktop Bus), Access.Bus, AT&T CHI (Concentration Highway Interface), Apple GeoPort and HP-HIL.
4. The IRQ shortage in the Intel architecture isn't going to be solved by adding more IRQs.
5. An intelligently implemented new interface could revolutionize the desktop, enabling new capabilities, lower development cost, lower prices, and dramatic improvements in supportability and ease of use.

USB^B USB Standards Report

There are two hardware Host Controller Interface architectures: UHCI (Universal), and OHCI (Open). UHCI appears on Intel motherboards. OHCI is predominant elsewhere - and is what PA-RISC workstations will use.

The underlying USB Standard is presently at release 1.1. {<http://www.usb.org>}
 Driver Classes have been defined by Working Groups for (- release level)

Common - 1.0	Hub - 1.0	Physical I/F - 1.0
Audio - 1.0	Imaging - 1.0	Power - 1.0
HID (Human I/F Device) - 1.0	InfraRed - 0.9	Printing - 1.0
Communications - 1.09	Monitor Control - 1.0	Vendor-Specific - N/A

MS Windows API Status:

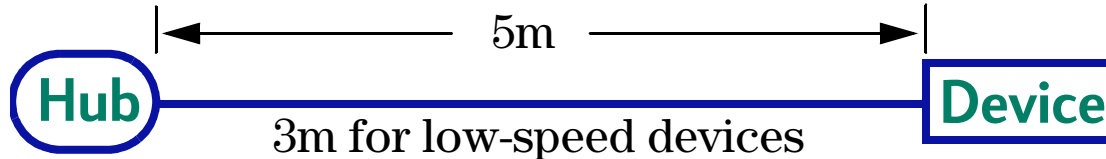
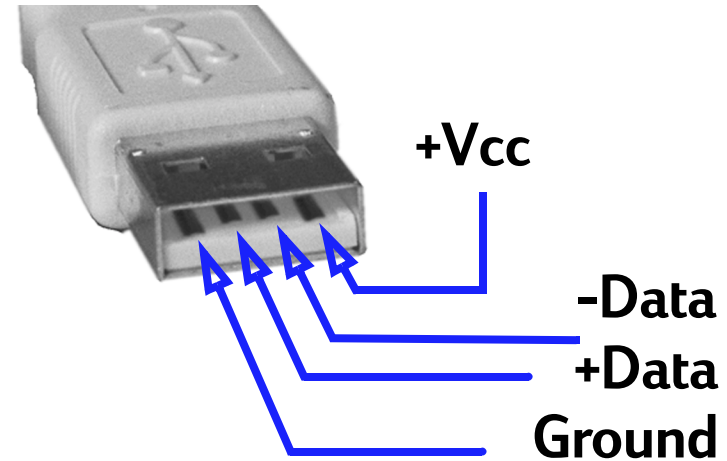
Windows provides legacy thinking code for well-behaved drivers.
 The status of open Win32 USB APIs is not clear.

Unix API Status (USB DI) is at 0.8. {URL pending}

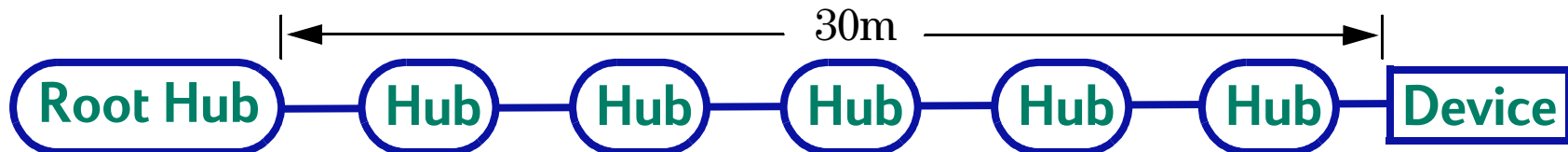
As is traditionally the case in the Unix community, standards development is well behind implementations. USB DI APIs rely on UDI Meta Language. We'll all need to re-write or think new libraries later (and implement UDI).

USB A Closer Look

- Devices may be compound (have multiple functions) or contain hubs.
- Devices are high-speed (12 Mbps) or low-speed (1.5 Mbps) only. Hubs are high only.
- Differential Data Signalling (3.3V NRZI)
- +Vcc is 500mA @ 5 Vdc
- Devices may supply own power.
- Vcc and Ground make contact before Data lines.
- Maximum length of any single Hub-Device segment:

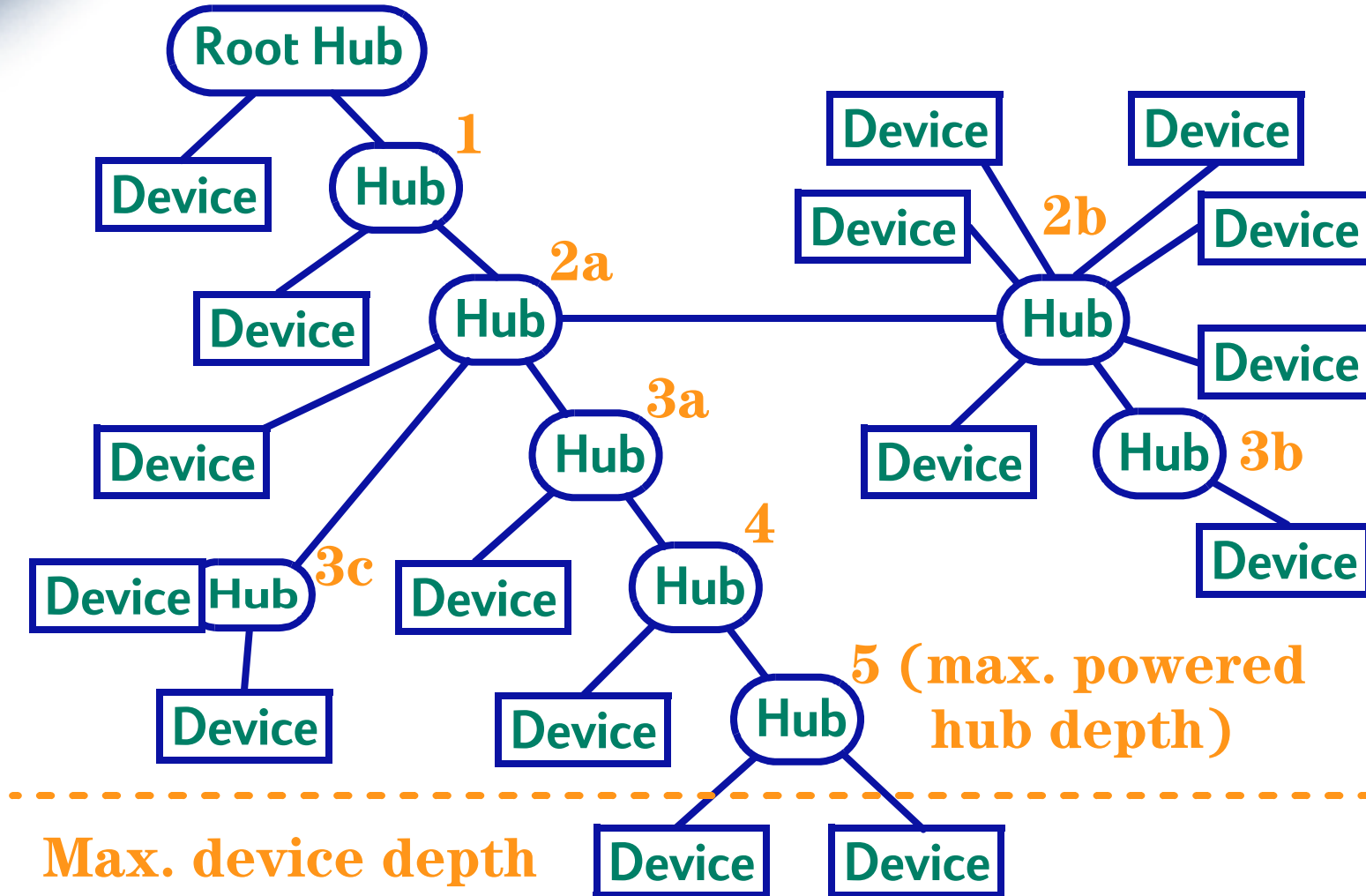


- Maximum length to any (high speed) device (5 external hub tiers):



- Connectors are friction/detent capture only, and may not be suitable for moderate or high shock/vibration environments (without user-designed capture).

USB USB Topology - "Tiered Star"



- Only devices (not other hubs) may be connected to an un-powered hub.

USB at the Limits

Disallowed:

- Host-to-host direct cabling. Host-to-host solutions exist, but presently require LAN adaptors, modems or null modems in the cabling path, none of which are transparent extensions of the USB. It is not yet clear if any true bridges or remote-repeaters for USB will appear (the equivalent of LAN bridges, the HP 46082A/B HIL extensions or the HP 37204A HP-IB extender).

Strongly Discouraged:

- Style A (receptacle) to Style A (plug) passive extension cables. Notwithstanding, they do exist, and can lead to specification violations and unreliable operation. Exception: active cables (5m single-port bus-powered hubs also exist - and they're legal, as long as they aren't used to interconnect hubs).

Performance:

- Of the theoretical "1.5 MByte/sec." available, in practice, typical sustained throughput is more like 600 KBytes/sec., about 33% lower than asynchronous SCSI (which doesn't provide its theoretical 1.5 MB/s either). The fastest USB device reported to date is a Belkin host-to-host LAN emulator, at 700 KBytes/sec.



The Uses of USB

Ideal Uses

- Most human input devices: bar code, buttons, digitizers, gaming, gloves, joysticks, keyboards, knobs, light-pens, mice, 6-axis, tablets, trackballs, touch-pads
- Modem & telephony: POTS, FAX, ISDN, T1, ADSL, low-end cable modem
- Printers, up through 40 ppm or so
- Simple audio: MIDI, speakers, mono&stereo I/O, 5.1 compressed surround output (moving the audio codec outside the box has benefits but overhead hazards)
- Low-demand imaging: digital still cameras, low-rate and/or low-resolution motion video (e.g. conferencing), monitor calibrators, custom displays, monitor control
- External floppy drives (FDD, LS-120, HiFD, ZIP)
- Legacy adaptors (USB-IR, USB-serial, USB-parallel, USB-PS/2)
- Security authentication: biometric input, dongles, intrusion detection
- Power management: UPS, cryo-cooler control

Hot-attach/detach permits simple (albeit break-before-make) console switching, and the 5m segment length can handle most server rack situations.

The Non-Uses of USB

Marginal Uses

- Scanners (USB max'd out for color above FAX resolution [200 dpi])
- LAN and high-end cable modems (USB is max'd-out for 10Mbit LAN)
- CD-ROM, CDR, DVD (USB max'd-out at a mere "4x" CD-ROM)
- MO, tape (USB already too slow for DAT, DLT and other streaming formats)
- Instrumentation (USB no faster than HP-IB), PCMCIA (PC Card) adaptors
- Character-mode terminals, home appliance control (cable length)

Despite this, the industry is leaping to USB from Parallel, SCSI and dedicated ISA or PCI cards, purely based on the lower cost and ease of support. If IEEE-1394 (Apple "FireWire") becomes established on the PC, they'll jump again.

Contra indicated Uses

- Hard disks, external or internal
- Broadcast-quality video, HD video of any kind
- Studio-quality multi-track audio

IEEE-1394 had been capturing some of these applications and we were unlikely to see USB used (rationally) for any of them. Unfortunately, since the iMac lacks external ports faster than USB, irrational USB devices are already appearing.

USB^B Comparing USB to Legacy

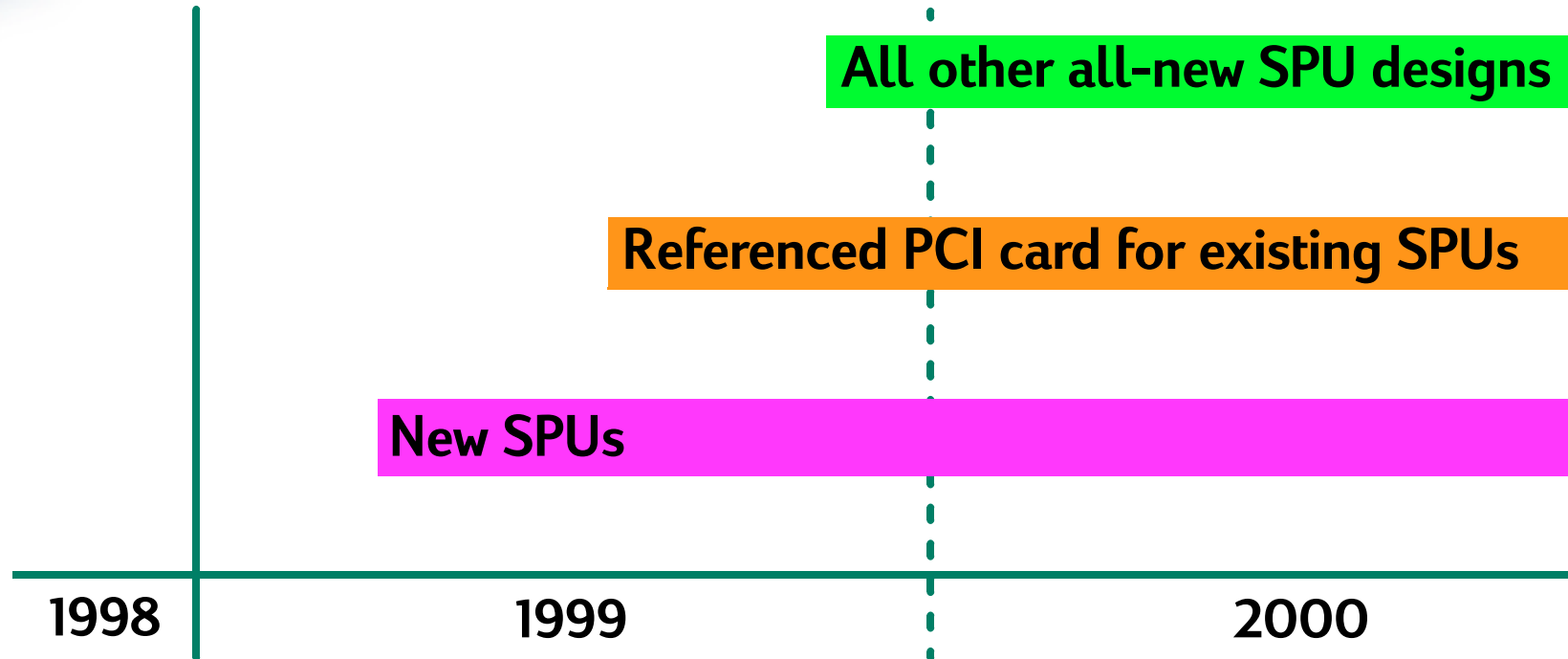
Attribute	USB	PS/2	HP-HIL	Serial	Parallel
Ports per host	Open (2 typ.)	2	1	Open (2 typ.)	1...3 (1 Typ.)
Pin count	4	6 (4 used)	4	3...25 (9 typ.)	34
Cable segment length	5m	~4m	3m	50 ft., however	3m
Max. transparent distance	30m	~4m	~45m	Unlimited w/repeaters	Unlimited w/repeaters
Topology	Tiered Star	Point-to-Point	Daisy-Chain	Point-to-Point	Point-to-Point
Device-to-Device I/O?	No	N/A	No	No	No
Hot attach/detach	Yes	No	No	No	No
Device power	Bus or Local	Host or Local	Host only	Local or Parasitic	Local or Parasitic
Power available	100-500mA / port	1 A / port	1 A / system	Pull-up Trickle	Pull-up Trickle
Power management	Yes	No	No	No	No
Devices/port controller	127	2 + eavesdrops	7	1 + eavesdrops	1 + eavesdrops
Device enumeration	All	Keyboard and Mouse only	Yes	Rarely	Sometimes
Peak transfer rate	12 Mbps	~12.5 Kbps	60 Kbps	~115 Kbps	~3 MB/s (typ. < 1 MB)
Error control	CRC	None	None	Per device	None
Flow control	Packet re-try	Clocked I/O	Clocked I/O	Unreliable	Handshake

USB^B USB Alternatives

Attribute	USB	IEEE-1394	async SCSI	sync SCSI
Ports per host	Open (2 typ.)	Typ. 1...4	Open (1 typ.)	Open (1 typ.)
Pin count	4	6	50	50 or 68
Cable segment length	5m	4.5m	6m (single-ended)	varies
Max. transparent distance	30m	72m	Unlimited w/repeaters	Unlimited w/repeaters
Topology	Tiered-Star	Tiered-Star	Parallel Bus	Parallel Bus
Device-to-Device I/O?	No	Yes	Theoretically	Theoretically
Hot attach/detach	Yes	Yes	No	No
Device power	Bus or Local	Bus or Local	Local only	Local only
Power available	100 to 500 mA per port	1.5 A / port	N/A	N/A
Power management	Yes	Yes	Only recently	Recently
Devices/port controller	127	63 ^a	7	7 or 15
Device enumeration	All	All	Mostly	Usually
Peak transfer rate	1.5 MB/s	50+ MB/s	1.5 MB/s	80 MB/s
Error control	CRC	CRC	Parity	Parity
Flow control	Packet re-send	Packet re-send	Handshake	Handshake

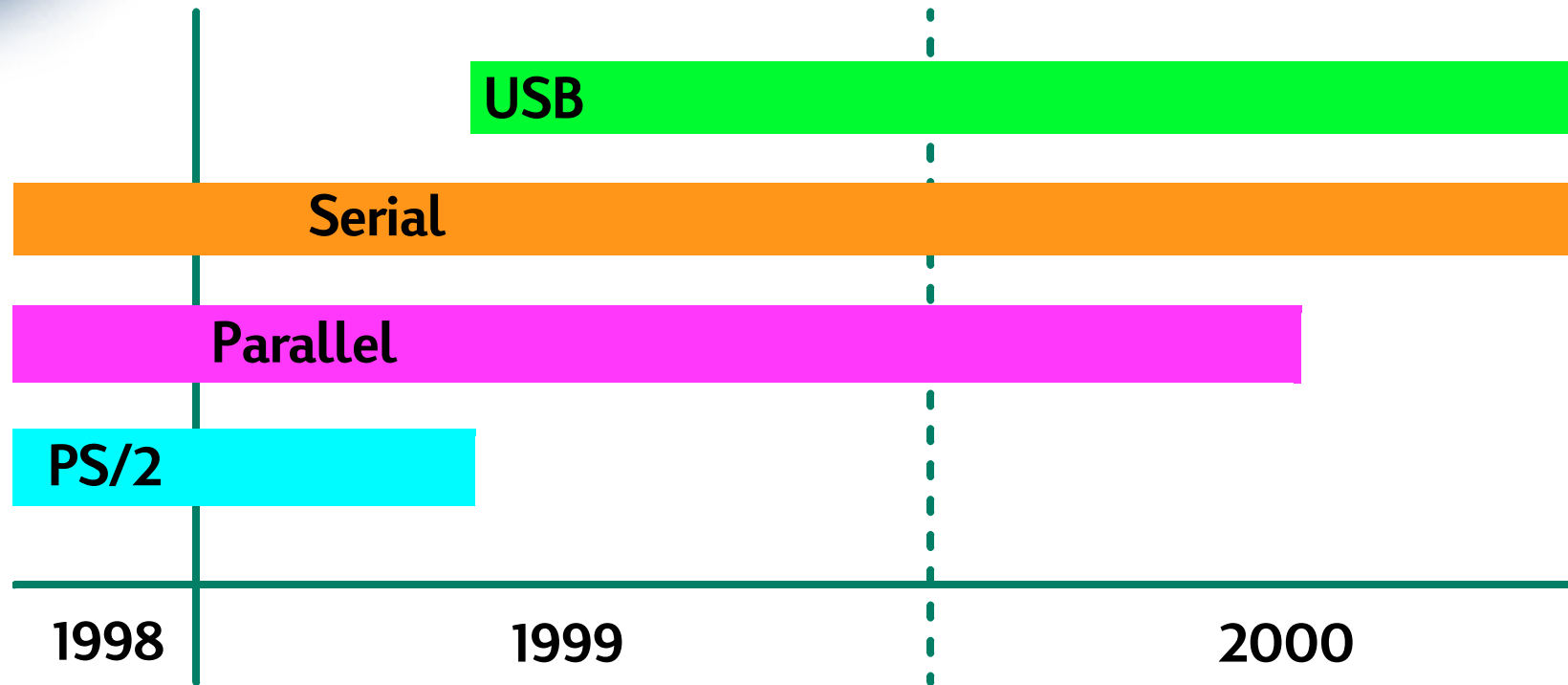
a. Bus-to-bus bridges permit transparent access to over 60,000 nodes.

USB USB Port Roll-Out on PA-RISC SPUs



- USB is the standard human interface port for all-new processors in the future.
- Performance upgrades of existing processors may integrate USB.
- Existing processors with PCI may use a USB PCI card (and require an upgrade to at least the USB release of HP-UX 10.20 or 11.x).

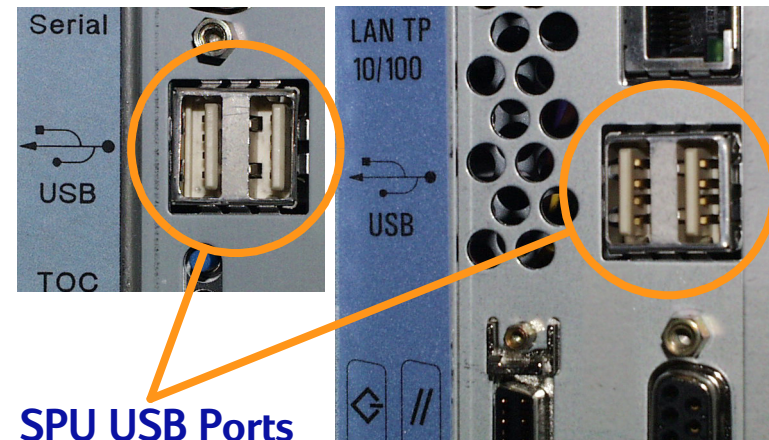
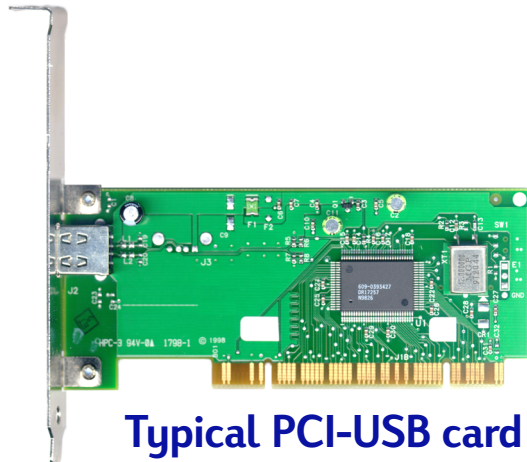
USB  Port Evolution on all-new PA-RISC SPUs



- PS/2 is not present on SPUs with built-in USB, and is not expected to re-appear on any future all-new processor design prior to IA-64.
- Parallel may be replaced by a USB-parallel adaptor in the next generation.
- RS-232C remains available. Next generation may have only one port (a PC trend already in progress).

USB USB Support: PA-RISC Hardware

- Root hub is based on a National PC87560 Super I/O chip.
- This is an OHCI controller.
- There are two ports, both located on the rear panel. There is no provision for enabling the USB pins on any EVC connectors present in the SPU.
- No USB hub is required for the keyboard and mouse in the USB User Interface Kit. Future monitors may include or support a built-in hub.
- Full 500 mA Vcc+ per port is available.
- One or more USB PCI cards (similar to that pictured below) may be used in addition to the internal USB ports. {A supported card list was unavailable at publication.}





SPU USB Ports
Style A receptacles



USB Support: PA-RISC Firmware

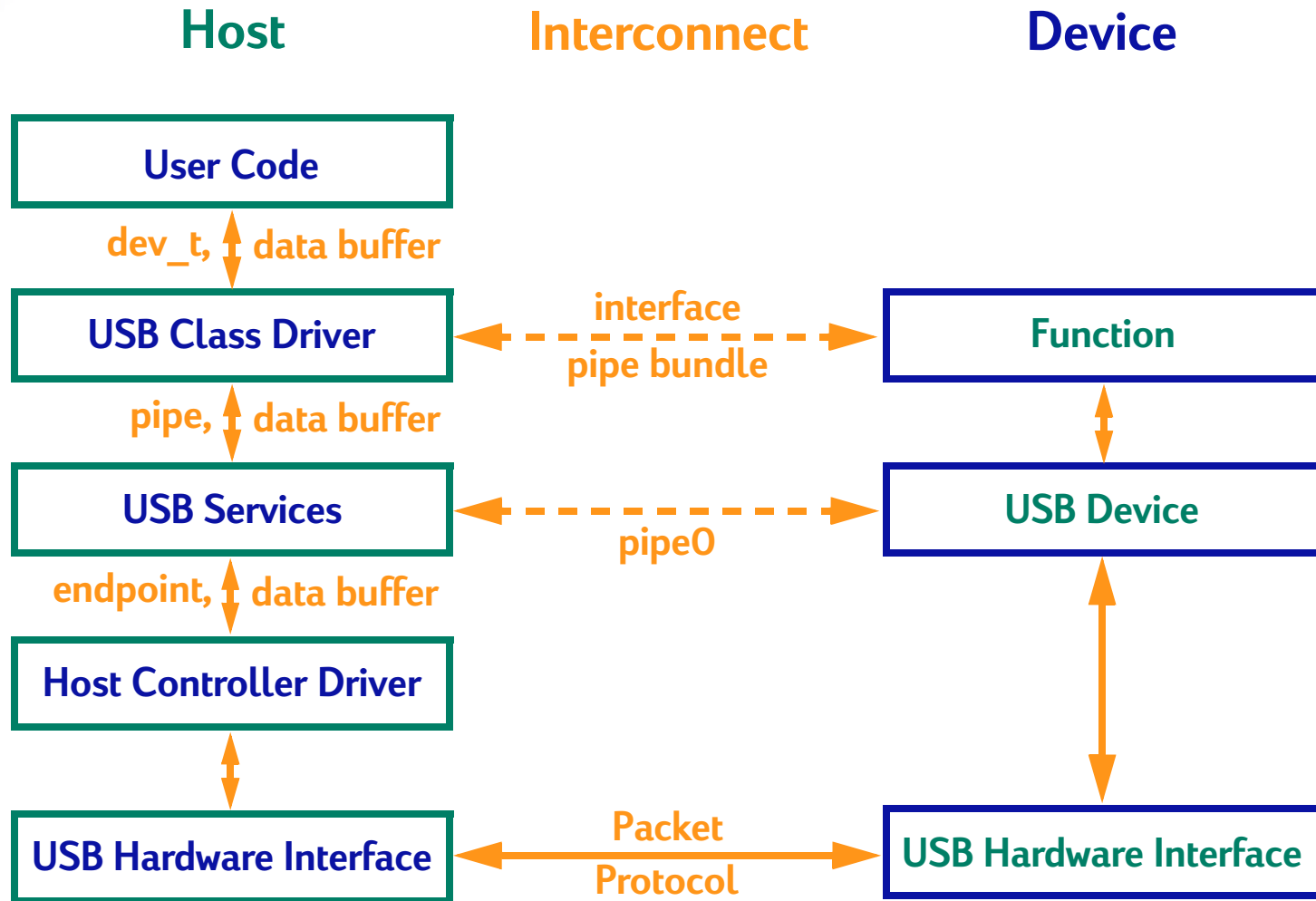
- PDC/IODC has been updated only for SPUs with built-in USB.
- Firmware searches for a keyboard on the USB controller path specified (by default, the built-in controller, but PCI-USB cards are addressable).
- At initial release, the console keyboard must be one of the first seven devices found. If it is connected directly to the host, or there is only one 4-port or 7-port hub in use, it will be.
- Firmware accepts input from the first keyboard found, in a breadth-first search for the keyboard topologically closest to the processor.
- Only “HID Boot” devices are eligible for boot console. Any device, such as a USB numeric pad, that identifies as “HID boot”, but is not a full keyboard, needs to be located beyond the console keyboard in the topology.
- Hot detach-reattach is not supported. The SPU must be rebooted if the keyboard is disconnected during boot.
- If no keyboard is found, firmware seeks console on the first serial port.

USB Support: HP-UX ITE¹

- Requires 10.20 ACE-4, or
- Requires 11.x (exact release nomenclature unknown at publication)
- Supports all WSY-supplied localized layouts.
- Does not support Euro (€), since the ITE emulates HP *term0*, which defines only the HP-Roman8 character set, which has no available code position for Euro. Euro is supported in Xserver.
- Does not support the “logo”  or “menu”  keys (may later). These keys are supported in Xserver.
- Responds to first keyboard found (same search algorithm as firmware).
- Permits detach / re-attach (console switch) if only one keyboard is present. If two or more are present, console will move to the next available keyboard when the first disappears.

1. ITE: Internal Terminal Emulator - the pre-windows HP *term0* console mode.

USB  USB Support: HP-UX Kernel (Apps & Admin)



USB Support: HP-UX Kernel (cont.)

- Only OCHI controllers are supported, and all tested to date work (although some will appear in *ioscan* as “unsupported”). HP-UX support for UHCI, although not currently scheduled, will be necessary at or before IA-64.
- USB drivers are implemented as WSIO drivers. Big-little endian conversion is handled transparently. Code is multi-thread and multi-processor safe.
- Although libraries have been added for USB support, the drivers are implemented such that standard commands required essentially no modification.
- Standard user-space I/O calls: *open()*, *close()*, *ioctl()*, *read()*, *select()*, but not *write()* (yet, because Hub and HID Class require no “write”). These calls only access Class drivers. User-space I/O to the raw bus is not supported.
- USB-specific Class developer calls: pipe management (13), data transfer (8), device management (13), device enumeration (2)
- Include files: `kernel - hid.h`, `usb.h`, `usbio.h`, `user-space - hidio.h`
- Minor number format is based on logical device enumeration (and not topological location).



USB Support: HP-UX Kernel (cont.)

USB Class Drivers supplied at initial release:

- Hub: Root and external
- HID: Human Interface Device

Note that thinking makes USB “boot” devices appear to be PS/2.



Class Drivers under investigation (but not yet committed):

- Communication: For serial adaptors primarily. WAN attach might be addressed, but LAN is a non-objective, given that USB is slower than 10BaseT.
- Printer: However, it may be trivial, mainly because Unix has no GDI. Further, at the I/O port level, HP-UX presumes only a raw data stream (*lprpp(1M)* handles EOL mapping, and the app or spooler is responsible for the PDL). The USB-parallel adaptors tested so far simply work, once the device file is created.

Class Drivers under consideration:

- Audio: For external speakers primarily.
- Imaging
- Mass Storage
- Monitor Control (in HID Class)

USB Support: Xserver

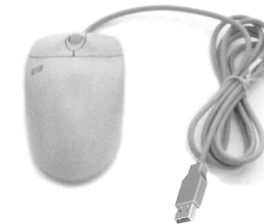
- Whether a device is USB, PS/2, or serial is generally (and deliberately) invisible.
- Consequently, the Euro (€), “logo”  and “menu”  keys are supportable on all interfaces. Euro support is a retrofit to the current PS/2 keyboards (in work now as User Interface Kit A4030G).
- Hot attach/detach does not ship in the first release.
- HP-UX will implement X-USB APIs as standards emerge.
- See next page for feature support on the USB keyboard and mouse.

USB The Initial USB Device List

- Localized A4983-604xx USB Keyboards
Coincident PC-104/105 layout transition
Coincident JIS-109 layout transition
The logo key is Meta-left and Meta-right. Menu is X “menu”.
Coincident Euro support (on Euro keyboards - the EC “forgot” the US and Asia)
13 localized layouts (Japan and Korea were modified to meet local demand).
2.5 meter cable.



- USB 3-Button Scroll Mouse
Scroll-wheel has separate motion & button
Forward is X-button4, reverse button5.
2.5 meter cable.



- HP D6804A USB Hub (already on CPL)
4-port, powered
Docks with emerging HP monitors
Not officially supported, but if you must have a hub, use this one.



USB USB Buyer/End-User Considerations

- Depending on development schedules, and what major applications you run, the next USB device you need to connect may be one or more software security dongles. Several already exist, and they are very appealing to ISVs, as they provide even more capability, at lower cost, than was available in the days of the HP 46084A HP-HIL ID Module.
- The new SPUs have two USB ports. Both ports are used by the required input devices. If you add any USB devices, you will need a hub. None are officially supported yet, but so far, every hub we've tested has worked.
- Some random USB devices simply work. HP-UX does not strictly reject unknown/unsupported devices. However, do not assume that any random "plug&play" USB device from a PC reseller will work - many will not - for example, HP USB scanners don't (no Class driver, no application port).
- At time of publication, WSY had not located a USB console switch (or even a simple USB mechanical switch) to test.





USB Developer Considerations

- The HP-UX DDK has not yet been updated for USB. If you know how to write a WSIO driver, you are qualified to write a USB Class driver. A “CDDK” (Class Driver Developer’s Kit) is under investigation.
- Many non-HID devices so far introduced for Windows PCs are using the Vendor-Specific Class (not an encouraging development, compared to iMac, where devices by and large are using standard Classes). Getting documentation on V-S command sets is often difficult or impossible.
- Caution: the current National Super I/O chip used for the built-in USB does not support isochronous USB protocol. If your device can’t be operated correctly using USB bulk or USB interrupt I/O, you’ll need to rely on a PCI-USB card to support isochronous.
- Not all audio devices require isochronous, but many of them feature multiple devices, often of the HID Class (knobs, buttons, etc.).