

Peripheral Bus Extension for Device Sharing over IP Network

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Outline

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Background

- Pervasive Computing
 - various peripheral devices of computers
 - diverse computers and their OSs
- Scenario
 - *"When I bring back my mobile PC to my desk, I use existing devices seamlessly with my mobile PC ..."*
- Device Sharing for Pervasive Computing
 - on-demand and seamless
 - for any device from any OS
 - anytime

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Motivation

- Conventional Device Sharing
 - controls specific remote devices with few elaborated operations
 - NFS, RFS, VNC, etc.
 - but ...
 - only abstracted operations on RPC
 - interface gap between remote and direct devices
 - difficult interoperability
 - only for specific devices
 - not suitable for pervasive computing world

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Objective

- provide suitable device sharing architecture for pervasive computing
- focus
 - how to integrate remote device access with today's OS architecture

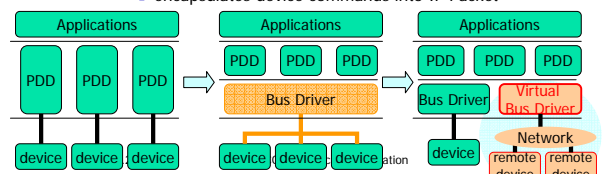
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Peripheral Bus Extension(1)

- Extend Peripheral Bus to IP Network
 - Sophisticated Peripheral Bus
 - Serialized I/O, Plug-and-Play, multiple transport mode
 - Reconstruction of OSS
 - layered device drivers, dynamic device management
 - Virtual Bus Driver
 - encapsulates device commands into IP Packet



Peripheral Bus Extension(2)

- advantage
 - Full Functionality
 - the smallest granularity of RPC (bus commands over IP)
 - Network Transparency
 - preserve the same interface as directly-attached devices
 - transparent to applications and most parts of OSs
 - Interoperability
 - interoperable between different OSs
 - bus commands are independent of OSs
 - Generality
 - applied to any device
 - IP encapsulation mechanism is common to all bus commands

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Design Criteria

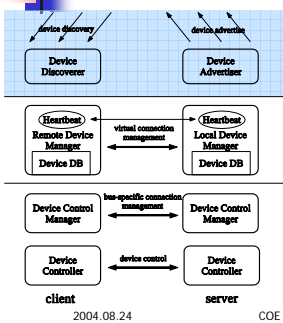
- get maximum benefit from modern peripheral interfaces and their support in OSs
- consistent with OS's device management
- with little modification of OSs
- simple architecture
- portable between OSs
- can support multiple virtual buses
 - USB, IEEE1394 ...

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Design(1)



Name Space Management Layer

- Device Discovery
- Device Advertisement
- Multicast DNS
- DNS Service Discovery

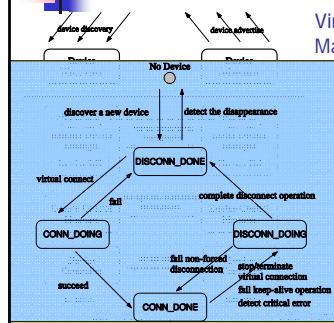
Blue-Ray DVD Recorder_rdev._tcp.local
 USB Camera XYZ._rdev._tcp.local
 Ergonomic Keyboard_rdev._tcp.local

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Design(2)



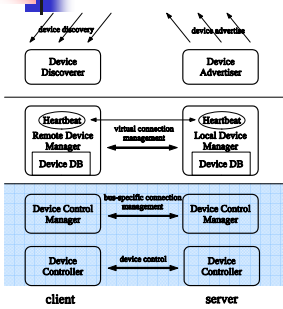
Virtual Connection Management Layer

- Virtual Connect / Disconnect
- Error Detection / Handling

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Design(3)



Bus Extension Layer

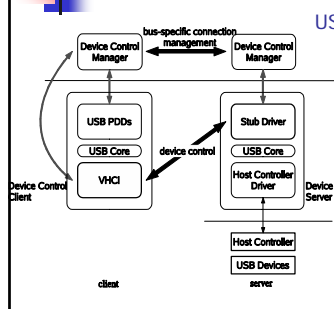
- dependant of OS and bus
- bus-specific connection management
- remote device control
- Virtual Bus
 - USB/IP prototype

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USB/IP



USB over IP

- a prototype of virtual bus
- encapsulate USB Request to IP Packets
- VHCI Driver
 - Virtual Host Controller Interface
- USB bus Driver
- Stub Driver
 - USB PerDevice Driver

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Usage Example

- Worked for all USB devices tested
HDD, DVD, keyboard, mouse, camera, printer, etc..

```
3: Fujitsu USBkeyboard
: IP:PORT : 10.0.0.2:3000
: local_state : CONN_DONE
: remote_state : INUSE
: remote_user : 10.0.0.3
: remote_module: USBIP
2: Logitech M4848
: IP:PORT : 10.0.0.2:3000
: local_state : DISCONN_DONE
: remote_state : AVAIL
: remote_user : NOBODY
: remote_module: USBIP
```

devconfig output
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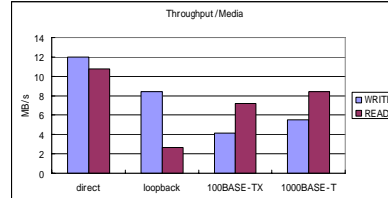


usbview output
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Performance

- Sequential I/O to virtually-attached USB HDD
- Network
 - 1000BASE-T / 100Base-TX without any network switch
 - directly-attached HDD



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Discussion

- Network transparency
 - the same usage via device files or drivers
- Error handling
 - virtually disconnect failed remote devices
 - expect USB driver stack to recover
- Concurrent access to one device ?
 - complementary with conventional sharing

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Related Work

- iSCSI
 - SCSI requests over TCP/IP
 - only for storage devices
 - can be integrated to our system
- Netstation
 - a distributed system composed of processor nodes and network-attached peripherals
 - no compatibility with today's computers

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Future Work

- USB/IP
 - Performance issue
 - Isochronous transfer devices
 - refine command queuing
 - UDP/IP encapsulation
- Peripheral Bus Extension
 - AAA, QoS for remote devices

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Conclusion

- Peripheral Bus Extension
 - Device Sharing with
 - Network Transparency
 - Full Functionality
 - Interoperability
 - Generality
- USB/IP
 - one of the peripheral bus extensions
 - VHCI (Virtual Host Controller Interface)
 - Virtual Bus Driver
 - all remote USB devices work !

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