A case for Virtual Channel Processors

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Motivation

- Heterogeneous multi-processors
  - Multiple processors (NP, GP, RAID, DSP, …)
  - Multi-core, SMP, SMT
- HW/SW trade-off changes (esp. for I/O)
  - No dedicated off-loading engines
- Traditional OS structure is too inflexible
  - Kernel: one protection domain, one resource domain
  - Difficult to follow HW/SW tradeoff
- Device driver bugs are already a major problem
- Can’t really change the entire OS

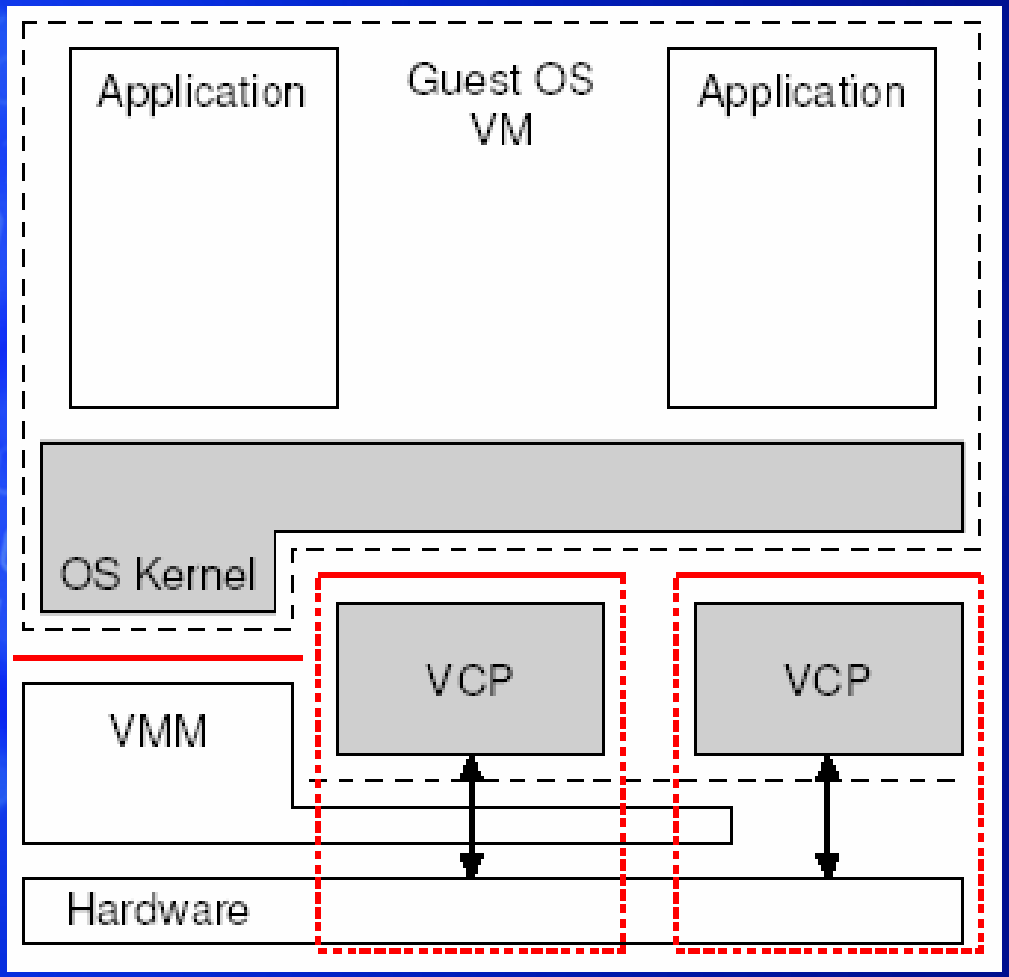
Virtual Channel Processors

- (Re-)introduce channel processors for I/O processing
  - Perform I/O on behalf of the OS
- Provide HW independent I/O abstraction
  - Clean and simple interfaces
  - Restructure OS to use channel processors
- Provide performance and fault isolation
  - Execute in different resource & protection domains
- Channel processors are *virtual*
  - May execute on the main CPU(s)
- Enable different, evolving implementations (HW/SW)
  support multiple, heterogeneous cores, novel I/O devices

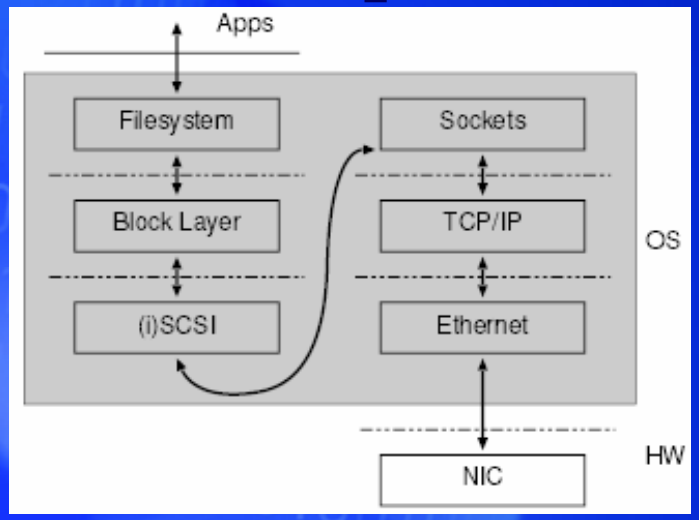
More on VCPs

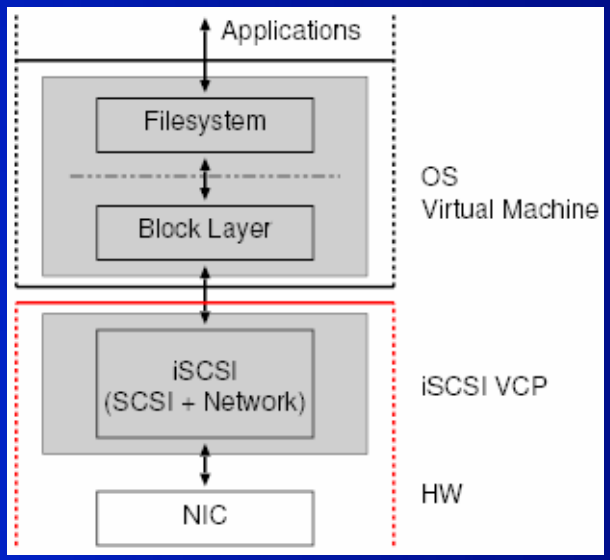
- Leverage Virtual Machine technology
  - Execute VCPs or part of VCPs in a VM
  - “clean slate”, software becomes simpler
  - Software can be optimised for the task at hand
  - Run device drivers within a VCP
  - OS independent device drivers
- Provide an idealised I/O interface to OS and Apps
  - Asynchronous, zero copy message queues

The big picture



Example: iSCSI





- Non-public APIs
- Interactions between sub-systems
  - e.g., buffer-cache vs socket buffer
- HW offloading?
- Complex implementation

- Simple API
- Optimised network implementation
- HW offloading contained within VCP
- Better resource control

Implementation Plans

- Use the Xen Virtual Machine Monitor
  - Virtualisation with low overhead (cf SOSP'03)
  - Runs Linux (and others) as a guest operating system
- Use network processing/iSCSI as test app
  - Other examples: RAID, soft-modems
- Investigate use of SMT and SMP features
- Incorporate novel HW (cf TwinCities)

Challenges

- Interfaces between VCPs and OS & APPs
  - Mainly for the control path
- Changes to the OS kernel required
- Performance impact
- Scheduling
- Fault recovery

Related Work

- Original Channel Processors (IBM CP-67, VM/370)
  - Dedicated hardware, channel programs
- TCP Servers/Split-OS, ETA, Piglet/AsyMOS
  - Dedicate processors to I/O processing
  - VCPs provide a more flexible abstraction
- Micro Kernels
  - Execute device drivers etc in different processes
  - VCPs are less generic, focus on bulk data transfer
- I/O interfaces: FBufs, IO-Lite, RBufs, …

Conclusions

- Virtual Channel Processors (VCPs)
  - Encapsulate I/O processing
  - Provide performance and fault isolation
  - Provide flexibility for changing HW/SW tradeoffs
- Implementation plans
  - Based on the Xen VMM
  - iSCSI as sample application

Questions?

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Performance

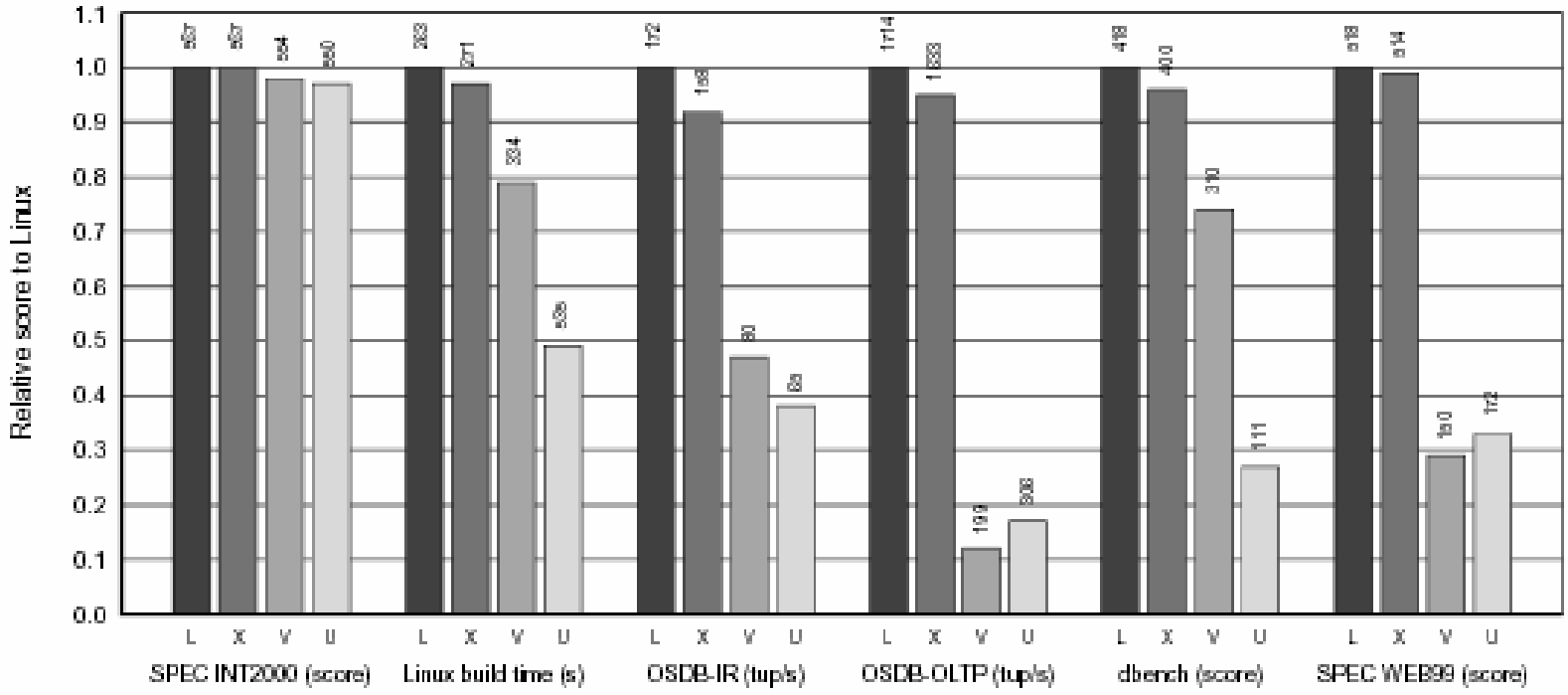

Figure 3: Relative performance of native Linux (L), XenoLinux (X), VMware workstation 3.2 (V) and User-Mode Linux (U).

Network Performance

	TCP MTU 1500		TCP MTU 500	
	TX	RX	TX	RX
Linux	897	897	602	544
Xen	897 (-0%)	897 (-0%)	516 (-14%)	467 (-14%)
VMW	291 (-68%)	615 (-31%)	101 (-83%)	137 (-75%)
UML	165 (-82%)	203 (-77%)	61.1 (-90%)	91.4 (-83%)

Table 6: `ttcp` Bandwidth in Mb/s

Network Performance

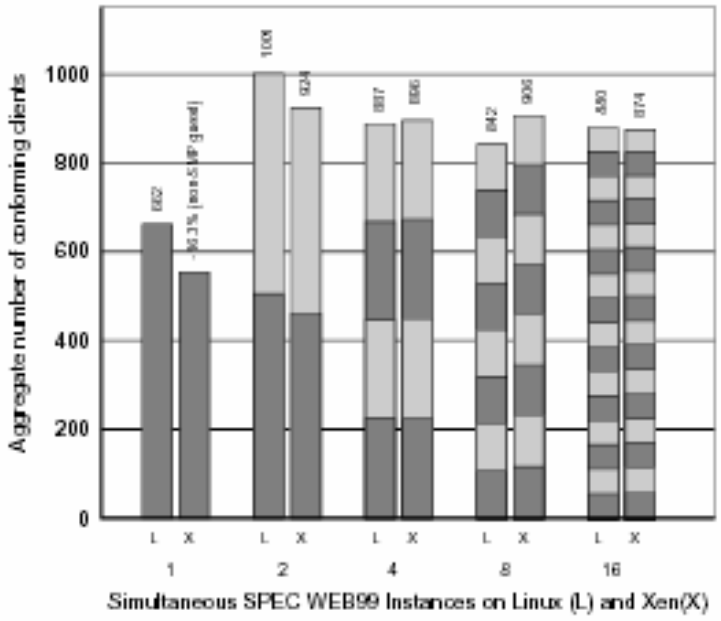

Figure 4: SPEC WEB99 for 1, 2, 4, 8 and 16 concurrent Apache servers: higher values are better.

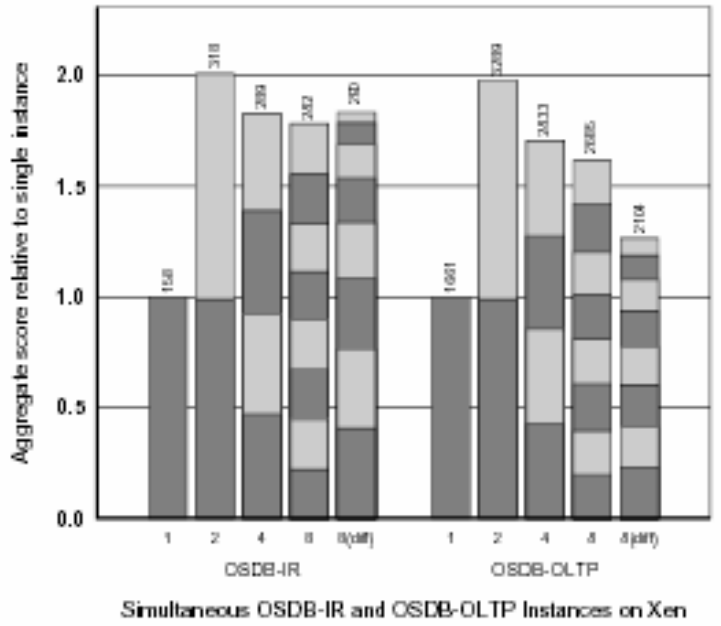

Figure 5: Performance of multiple instances of PostgreSQL running OSDB in separate Xen domains. 8(diff) bars show performance variation with different scheduler weights.

Para-Virtualization

- Retain ABI
- Run guest OS at lower privilege (ring 1 on IA32)
- Port guest OS to make calls to hypervisor rather than priv instrs
  - e.g. cli/sti, page table updates
- Use virtual device drivers (timer, network, disk)
  - exports "ideal" device interface
  - greatly reduces overhead
- Exposing real resources can be beneficial
  - time: virtual (scheduling) and real (SRT apps, TCP timers etc)
  - machine memory (page colouring)
  - physical disk number (for sw raid)

Porting OSes

Section \ OS	Linux	XP
Arch indep	78	1299
Virtual network	484	
Virtual block driver	1070	
Xen specific (non-driver)	1363	3321
Total	2995	4620
Code base	220k	1200k

Linux and NetBSD almost all changes to arch-dependent code

- XP MM HAL interface isn't ideal, requires “arch-indep” changes
- Effort small relative to writing a new OS