TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Computer Science Institute for System Architecture, Operating Systems Group

Paper Reading:
Virtualizing I/O devices on VMWare Workstation's hosted virtual machine monitor

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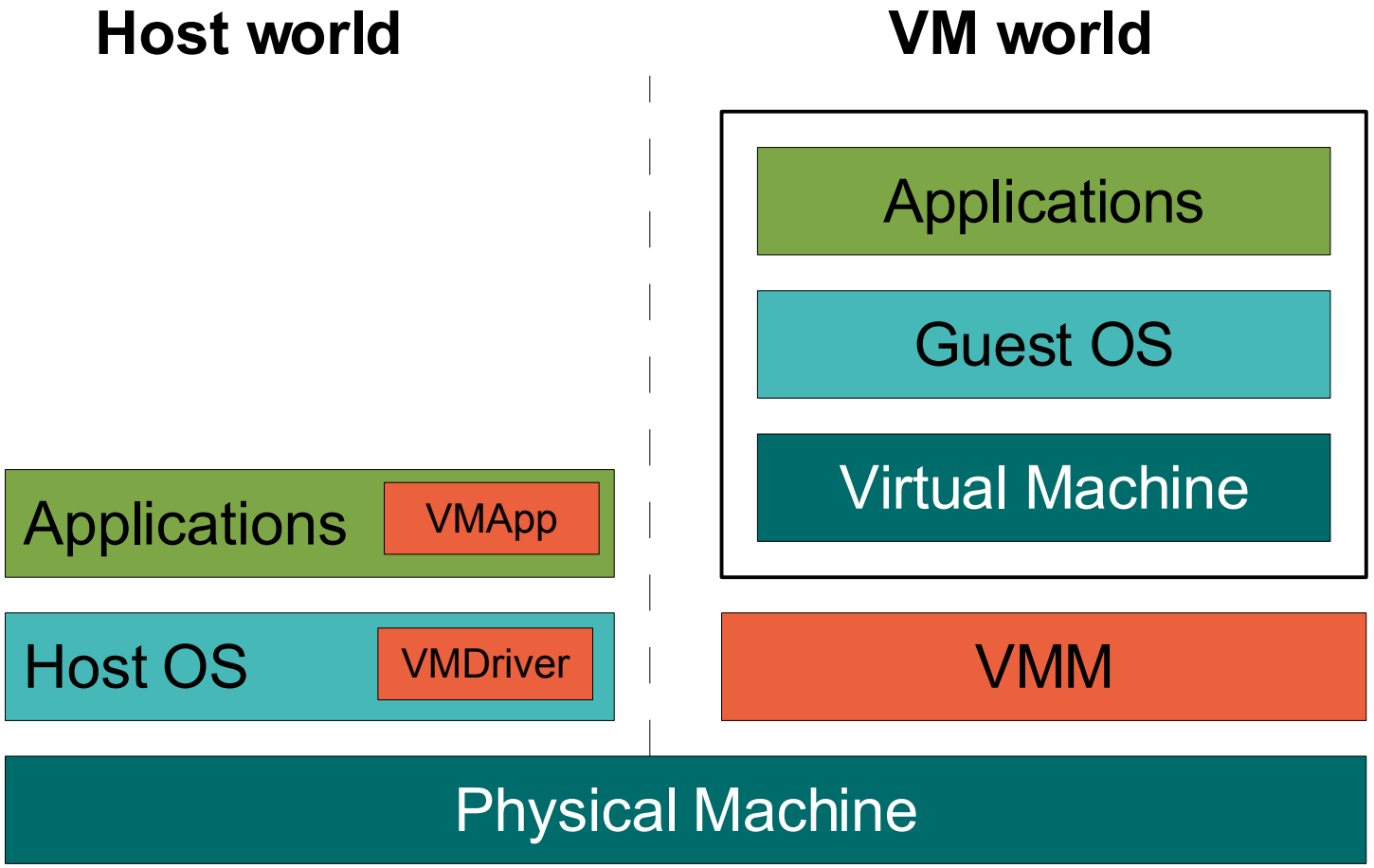
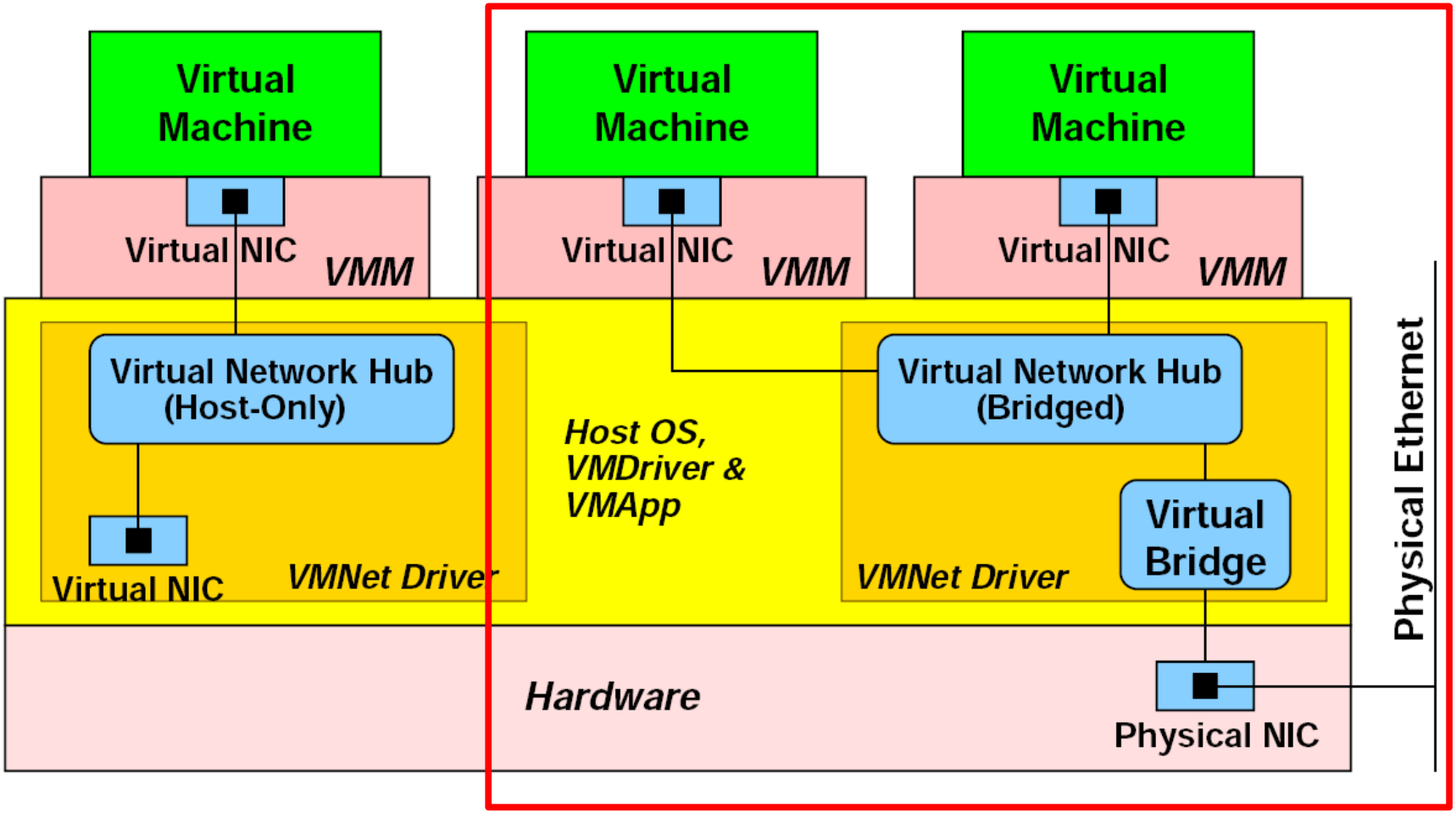
Overview

- VMWare workstation overview
- Virtualizing I/O
- I/O performance
- Optimizations
- Further Ideas

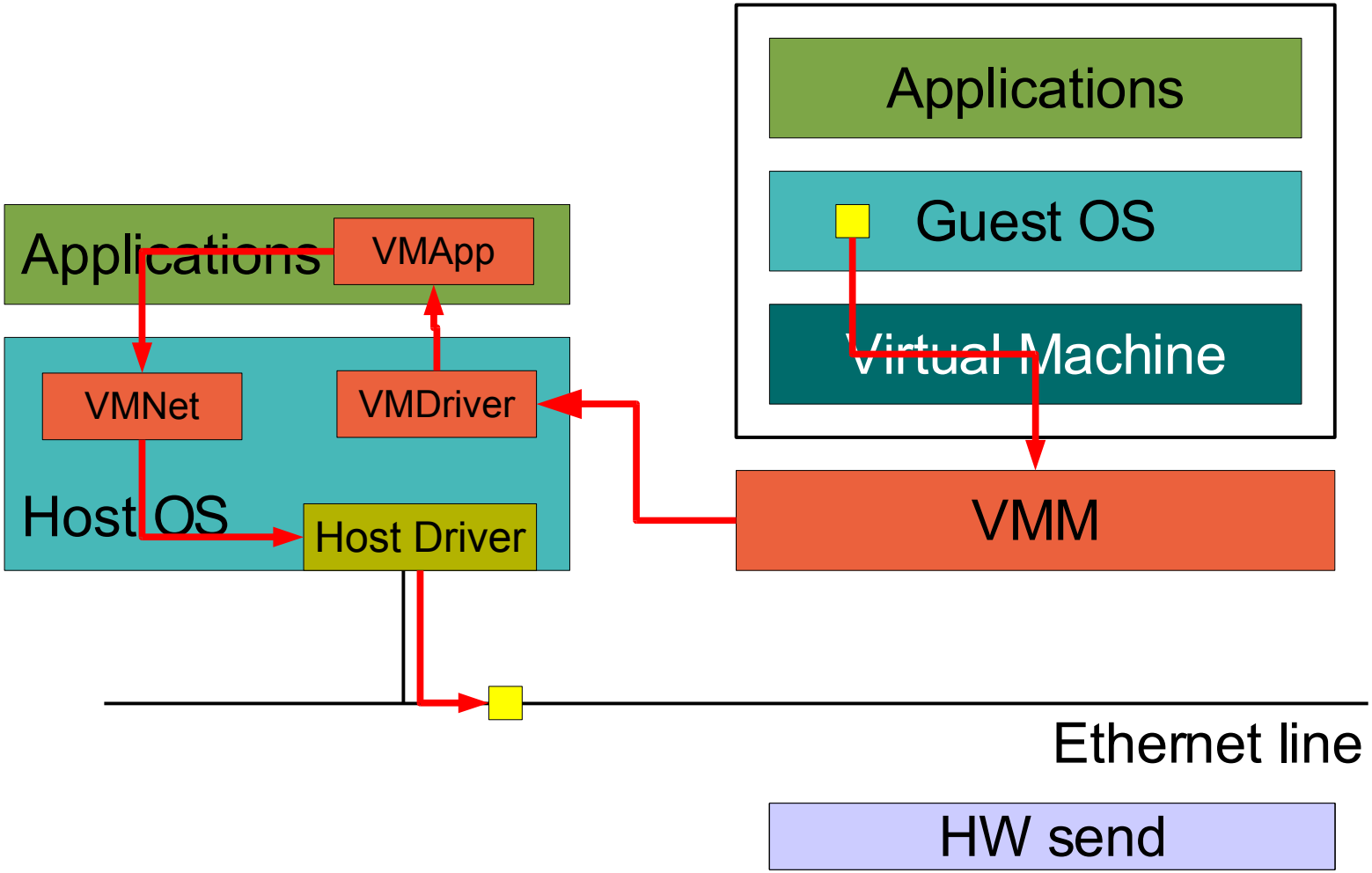
VMWare overview



I/O: Network interfaces

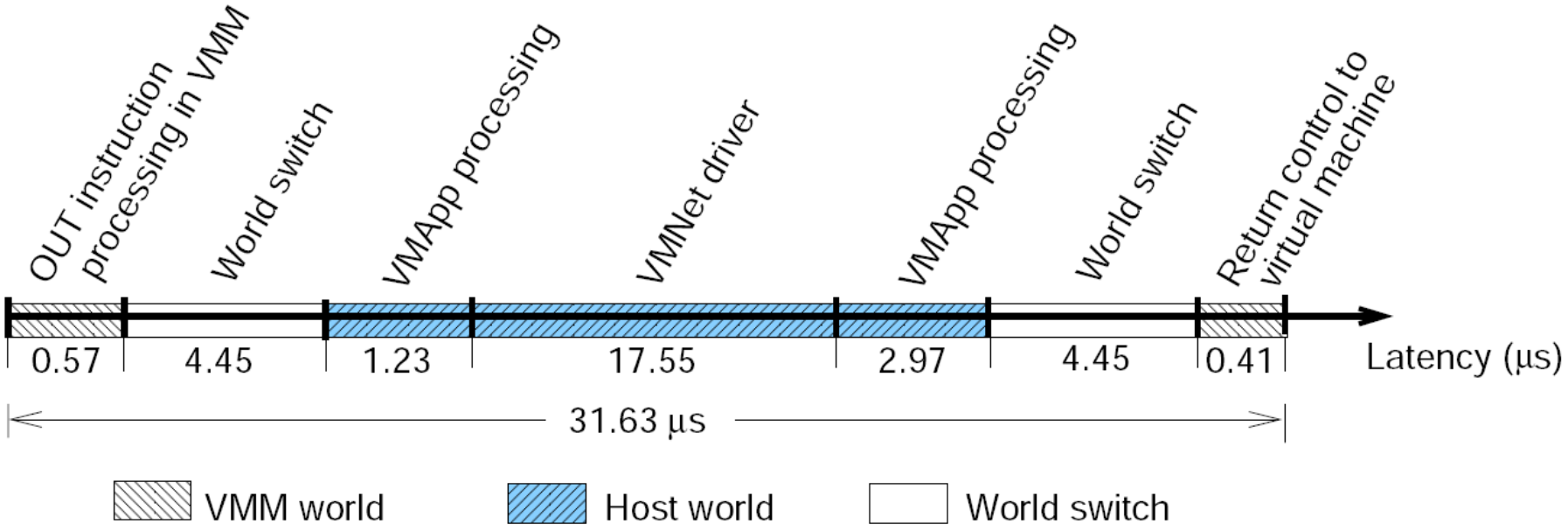


I/O: Network send



I/O: Performance

- Receiving packet even more complicated
- Overhead occurs for every packet!



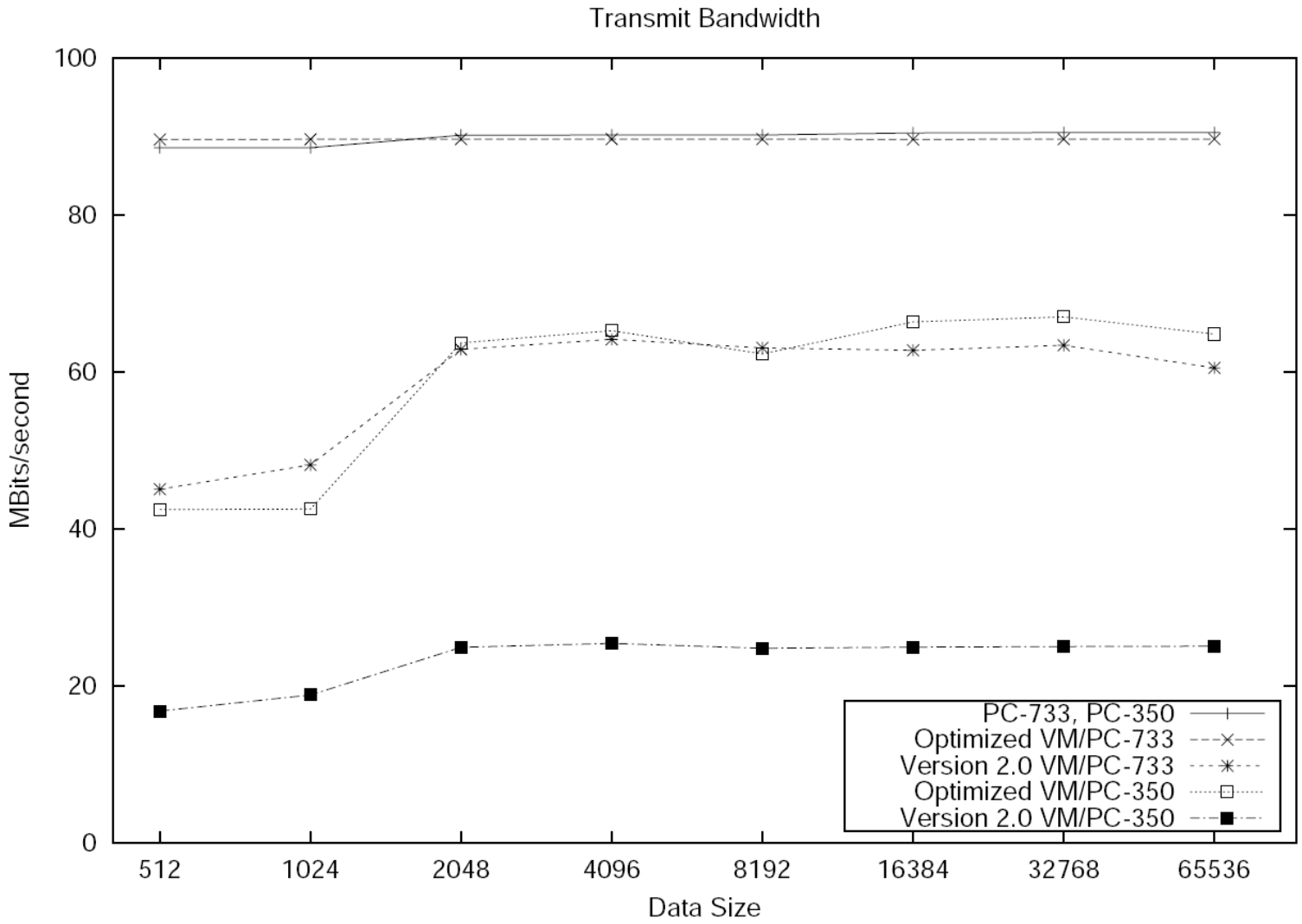
I/O: Performance (2)

- Packet send involves 11 (!) separate IN/OUT instructions that are propagated to the real NIC
  - 26.8 % of all overhead
- One interrupt on every send or receive
  - VMM not able to handle IRQs itself
  - IRQ handlers typically execute further IN/OUT instructions
- VMApp uses `select()` to wait for events on network devices (incoming / outgoing)

Performance optimizations

- Handle I/O port accesses in VMM
  - only 1/3 needs to be propagated to host
  - most effective optimization, because many world switches are avoided
- Send combining
  - queue packets in VMM, send several at once to save some more world switches
- Use shared mem between VMApp and VMNet driver to save expensive `select()` calls

Performance optimizations (2)



Further optimizations

- Reduce CPU virtualization overhead
  - modify virtualized PIC for better performance
- Modify guest OS
  - avoid PT switches from/to idle task
  - removes some of the 8.5% overhead spent for PT virtualization
- Optimized guest device driver
  - idealized interface with fewer IN/OUT instructions per send/receive
  - requires specialized driver for each guest (however many guests support loadable modules...)

Further optimizations (2)

- Modify Host OS
  - adapt Linux' `sk_buff` handling
- Bypass Host OS
  - only host handles IRQs
  - leads to lots of world switches
  - can we drive the device directly from the VMM?
    - need additional management to multiplex device between VMMs and host
    - need own drivers for VMM
  - called "hypervisor direct I/O" in VMWare ESX Server

Discussion

- "Further optimizations" are basically para-virtualization. Will future virtualization techniques benefit from best of both worlds?
- Can we encourage OS developers to make their OSes more virtualization-friendly? Tradeoff between increased complexity and increased performance?
- Is improved hardware the only real solution? (TCP Offload Engines, Remote DMA, Intel I/OAT, Passthrough I/O using I/O MMUs and Partitionable I/O devices)