6.033 Spring 2015

Lecture #7

- **Monolithic kernels vs. Microkernels**
- **Virtual Machines**

Katrina LaCurts | lacurts@mit | 6.033 2015

Enforcing Modularity via Virtualization

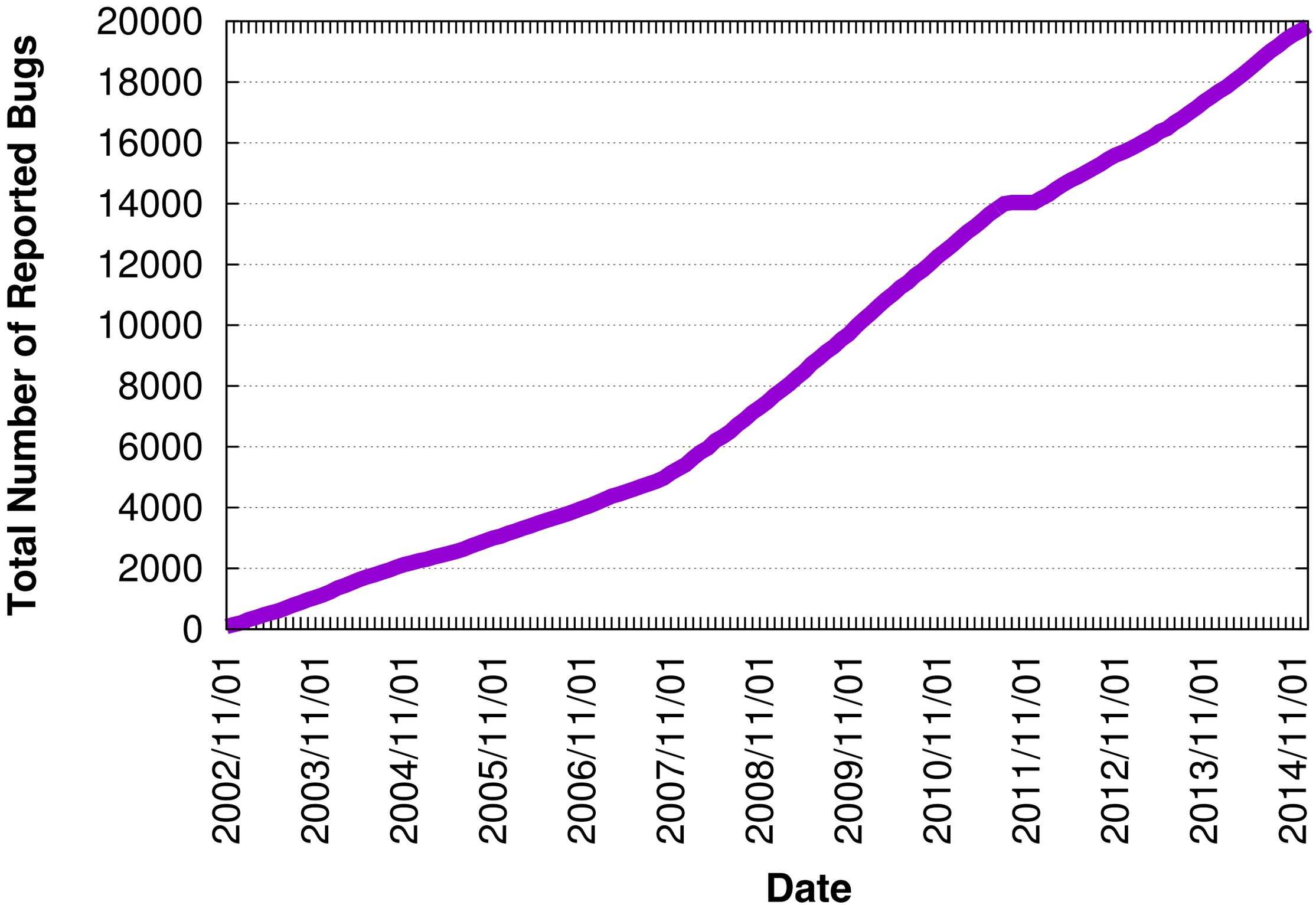
in order to enforce modularity + build an effective operating system

1. programs shouldn't be able to refer to (and corrupt) each others' **memory** → **virtual memory**

2. programs should be able to **communicate** → **bounded buffers** (virtualize communication links)

3. programs should be able to **share a CPU** without one program halting the progress of the others → **threads** (virtualize processors)

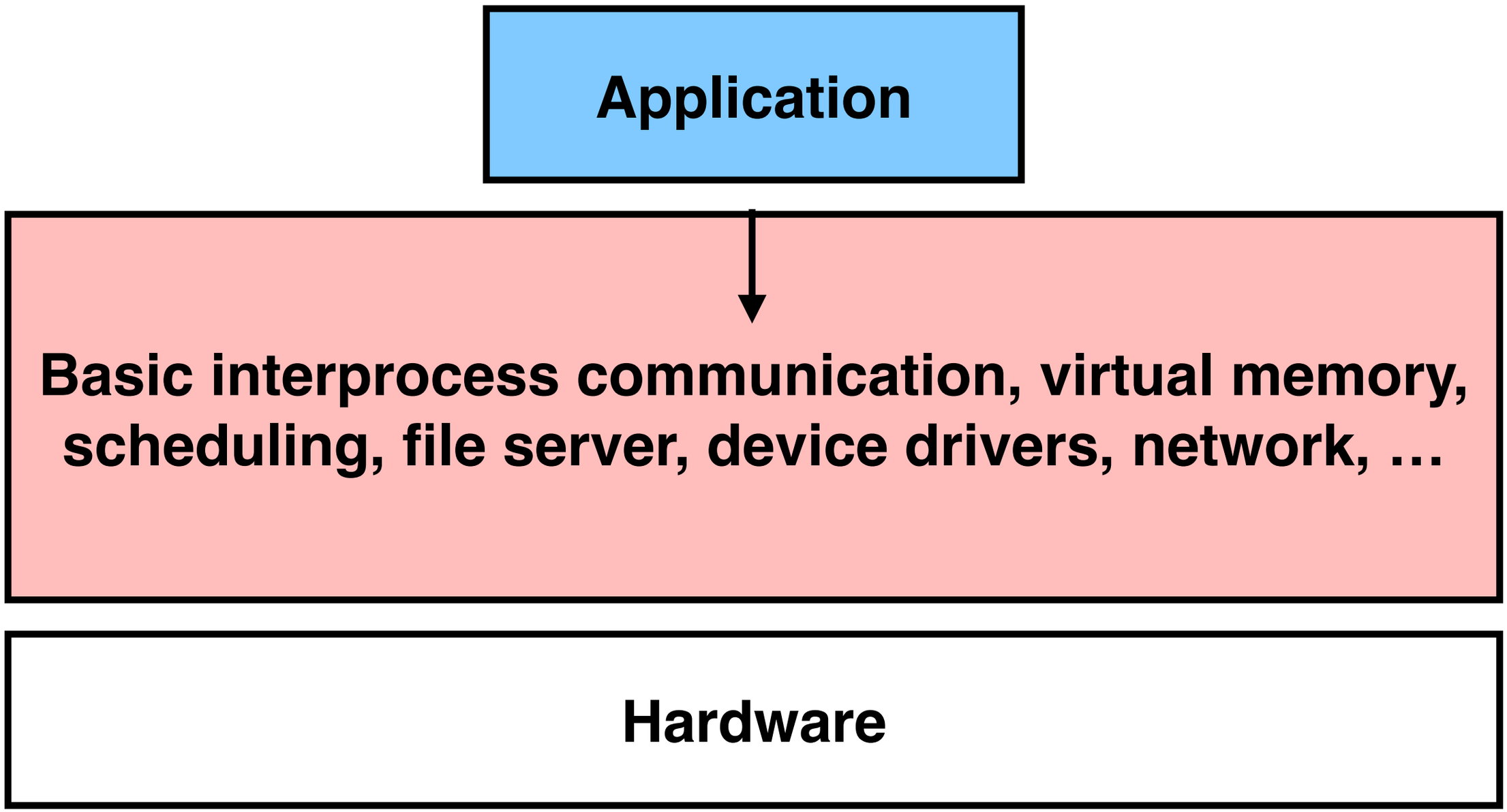
today: can we rely on the kernel to work properly?



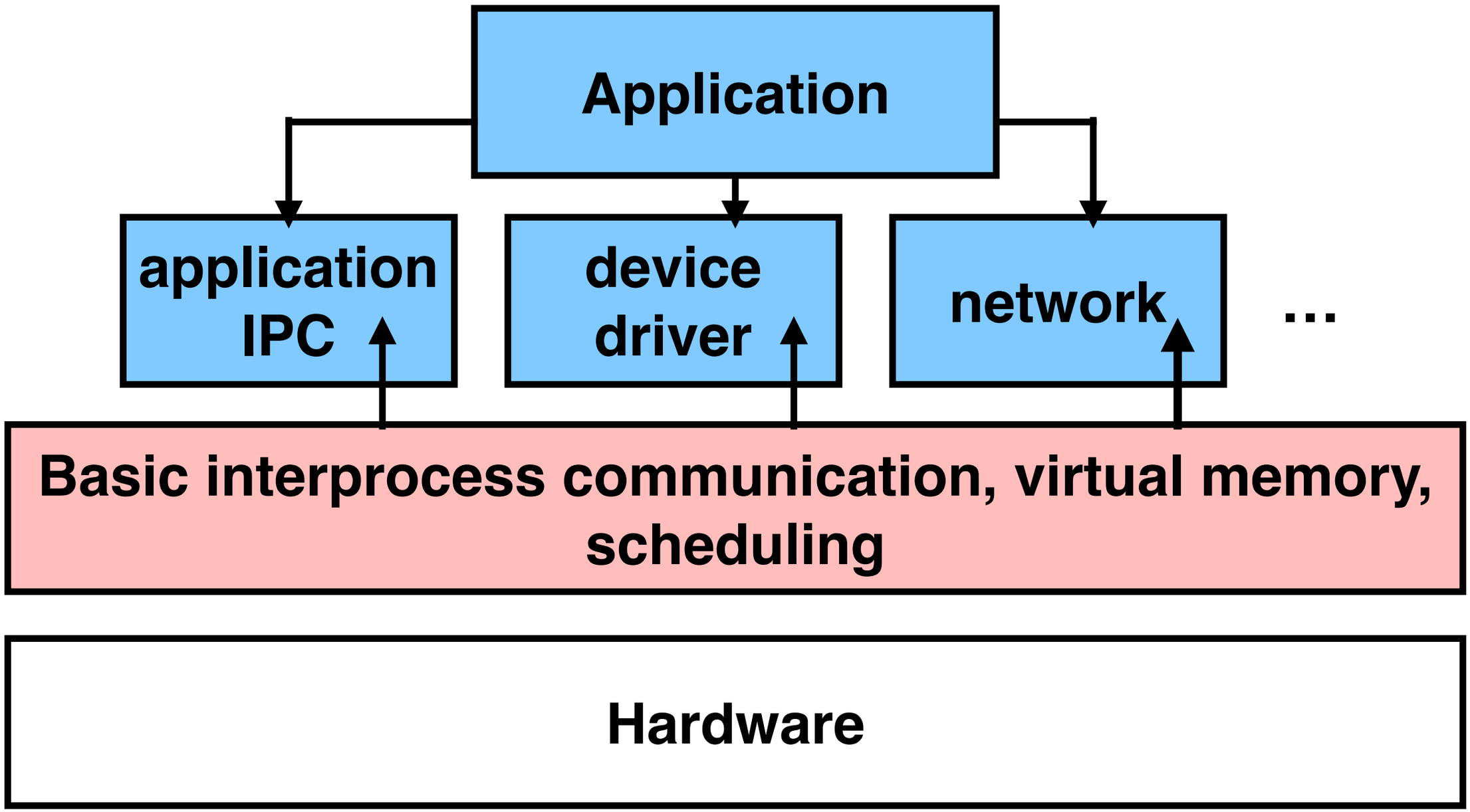
source: bugzilla.kernel.org, count of all bugs currently marked NEW, ASSIGNED, REOPENED, RESOLVED, VERIFIED, or CLOSED, by creation date

Katrina LaCurts | lacurts@mit | 6.033 2015

monolithic kernels: no enforced modularity within the kernel itself



microkernels: enforce modularity by putting subsystems in user programs

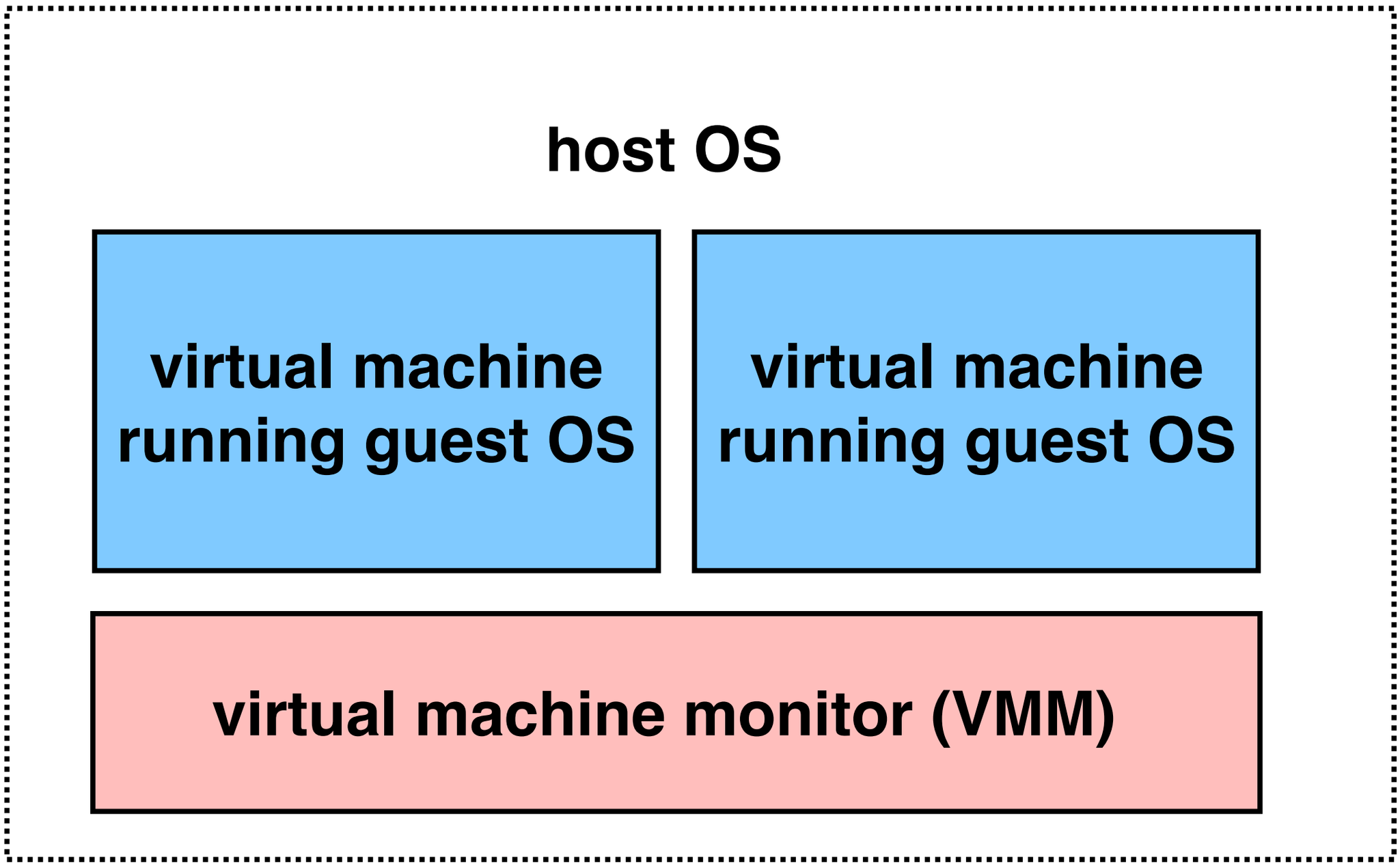


problem: how do we deal with bugs in the Linux kernel without redesigning Linux from scratch?

Katrina LaCurts | lacurts@mit | 6.033 2015

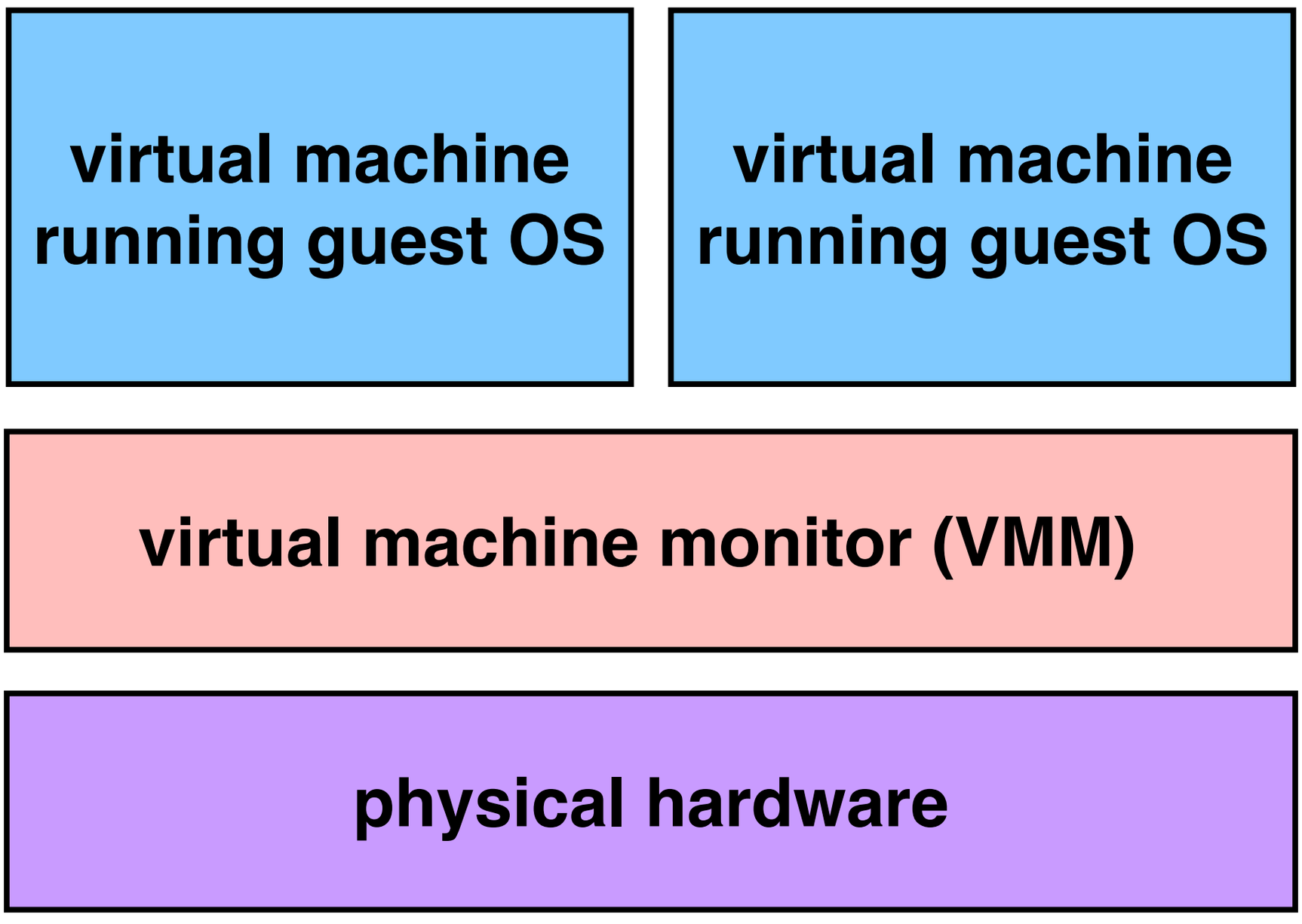
Virtual Machines

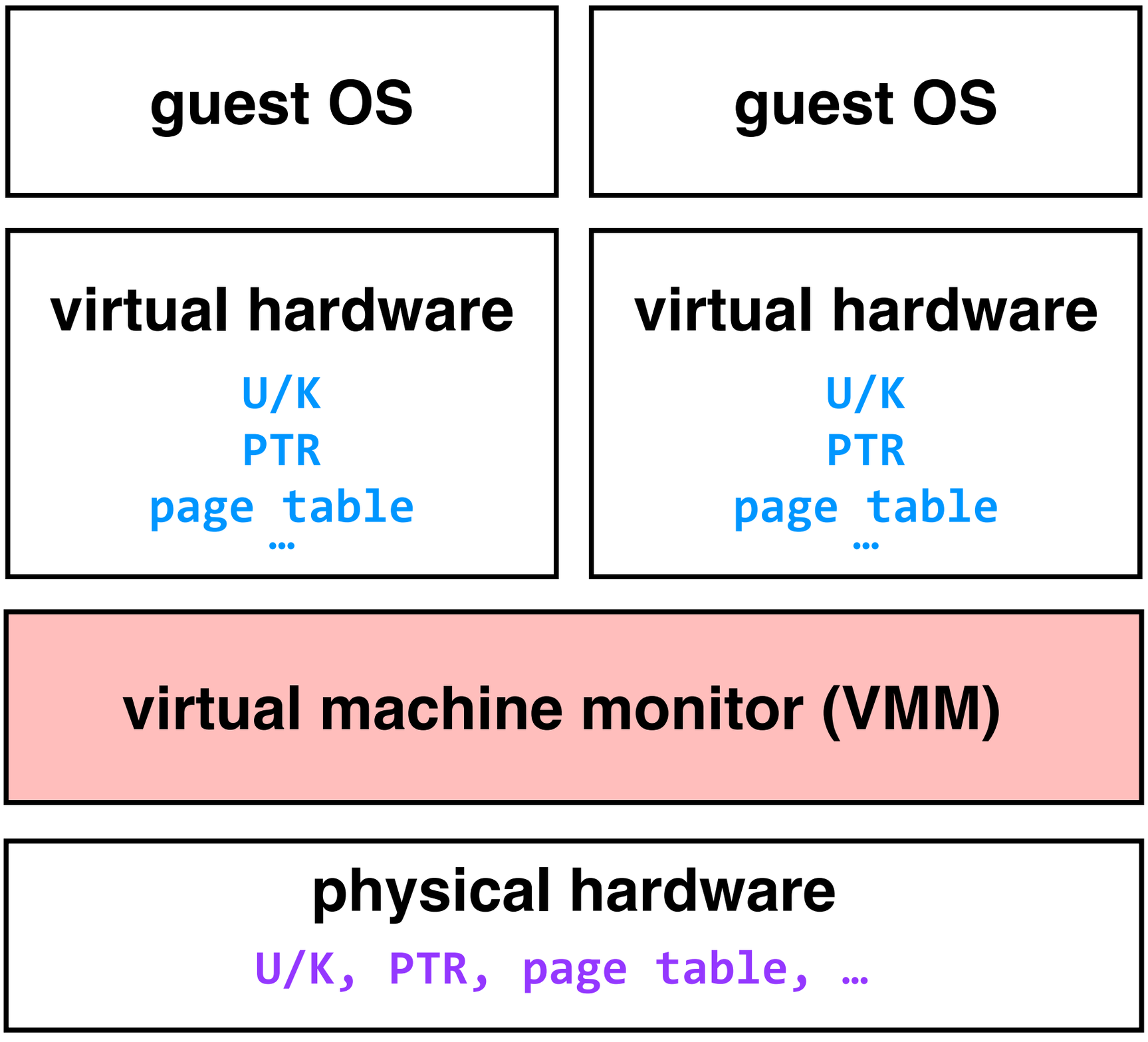
one approach: VMM runs as user program inside host OS



Virtual Machines

another approach: VMM runs in kernel-mode on hardware





VMM's goal: virtualize hardware

guest OS

guest OS

virtual hardware

U/K

PTR

page table

…

virtual hardware

U/K

PTR

page table

…

virtual machine monitor (VMM)

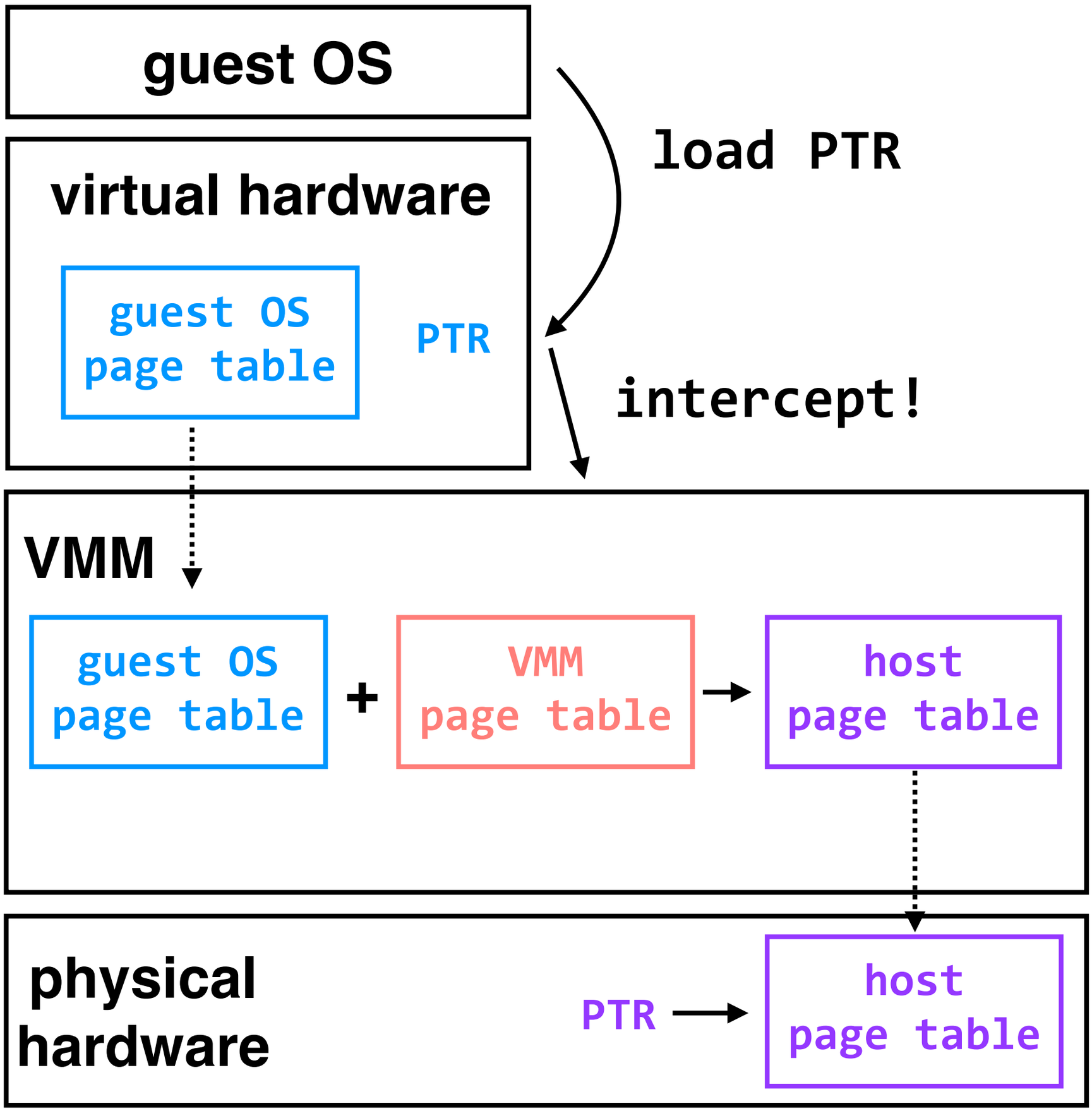
physical hardware

U/K, PTR, page table, …

guest virtual address

guest physical address

host physical address



guest OS
page table

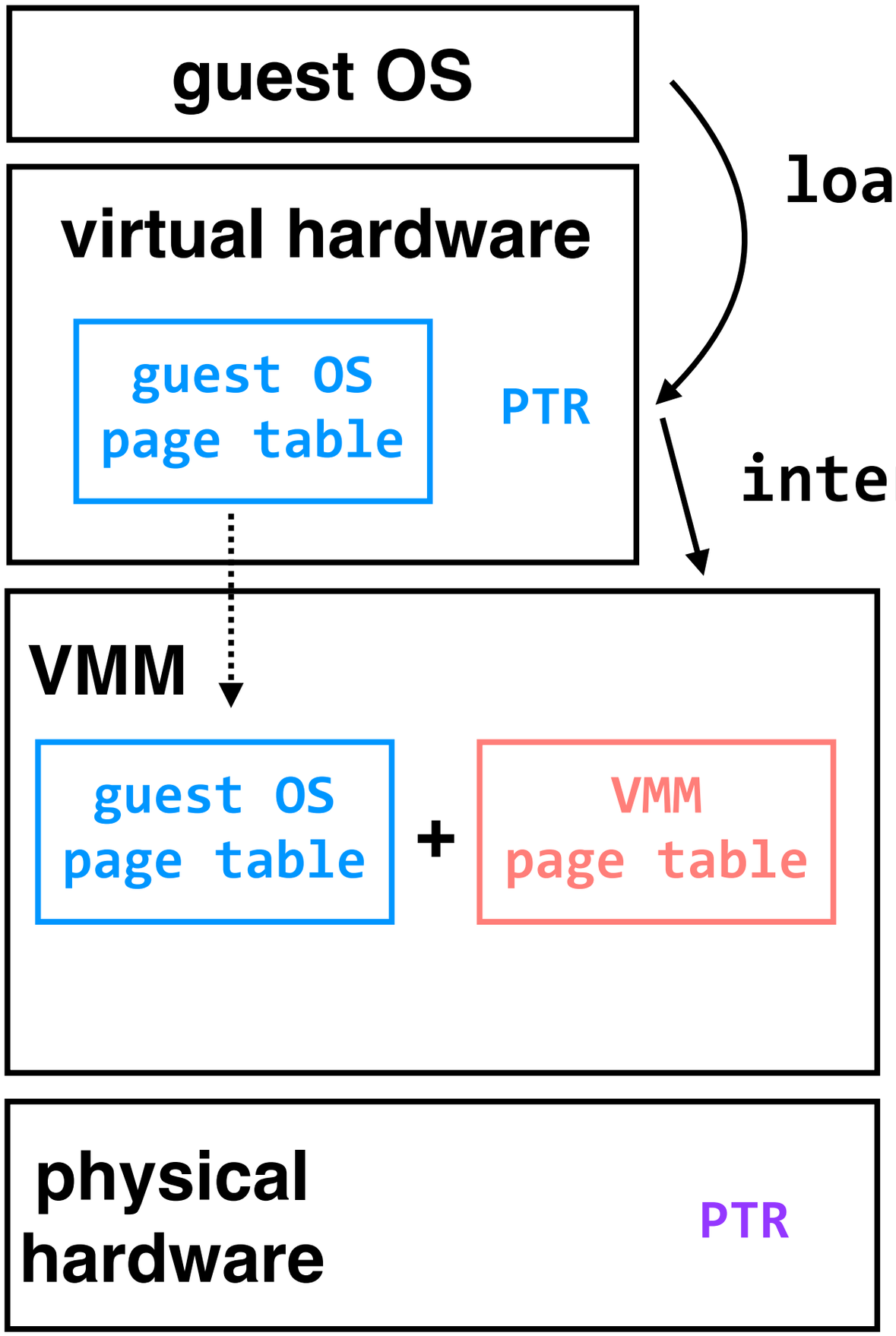
guest virtual ->
guest physical

VMM
page table

guest physical ->
host physical

host
page table

guest virtual ->
host physical



guest OS
page table

guest virtual ->
guest physical

VMM
page table

guest physical ->
host physical

in modern hardware, the physical hardware is aware of both page tables, and performs the translation from guest virtual to host physical itself

- **Kernel Structure**

  Monolithic kernels provide no enforced modularity within the kernel. **Microkernels** do, but redesigning monolithic kernels as microkernels is challenging.

- **Virtual Machines**

  Virtual machines allow us to run multiple **isolated** OSes on a single physical machine, similar to how we used an OS to run multiple programs on a single CPU. VMs must handle the challenges of virtualizing the hardware (examples: virtualizing memory, the U/K bit, and disk).