

Virtualized Networks based on System Virtualization

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- Network Virtualization
- System Virtualization Background
- Virtualizing Core Networks based on System Virtualization
 - Virtual Router, Virtual Link, Virtual Network
- Conclusions



- Well known approaches
 - PlanetLab, GENI
 - Programmable / active networks
 - VLANs, VPNs
 - Peer-to-peer overlays
 - Virtualization of routers
- System virtualization based approach
 - Specific and systematic approach to virtualize routers and networks
 - What happens if system virtualization is applied to core networks (routers and links)?



System Virtualization

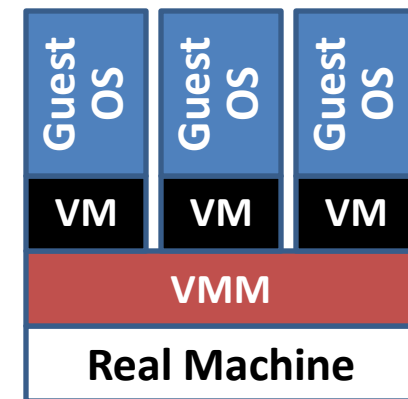
Background

- System virtualization is mainly used to virtualize servers and desktops
- Virtualization in data centers (e.g. XEN, VMWare ESX Server)
 - Consolidation of services on servers (saving hardware, utilizing resources)
 - Running web and mail server on the same machine - sandboxed
- Virtualization on desktops (e.g. VMWare Workstation)
 - Testing of new software/drivers
 - Using several Operating Systems simultaneously

System Virtualization

Background

- A **virtual machine monitor (VMM)** provides virtual machines on top of a real machine
 - Resources are distributed to virtual machines
- A **virtual machine (VM)** is a full recreation of a real machine
 - Virtual CPUs, virtual memory, virtual network interface cards, ...
 - An Operating System (OS) can be installed in it
 - Several OSs can run in parallel on top of a real machine



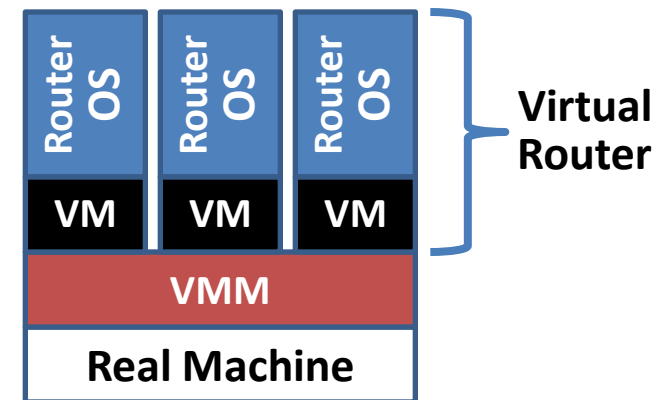
System Virtualization

Background

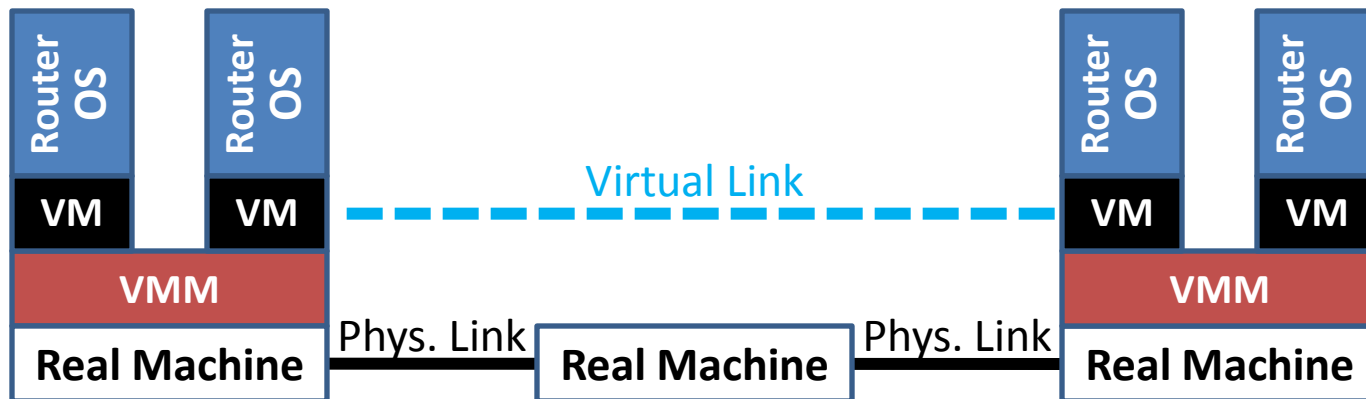
- Basic management primitives of VMM
 - Create VM, destroy VM
 - Start VM, stop VM
 - Copy VM, move VM (even “live migration” of services)
 - Save VM, restore VM
- System virtualization can be used to virtualize core networks
 - Predetermined network arises
 - Virtual routers, virtual links, virtual networks
 - Network elements gain new features through virtualization



- **Virtual router** in the context of system virtualization
 - OS with routing functionality
 - Encapsulated in a VM
 - Managed by a VMM
- Virtual routers
 - Are not necessarily aware of other virtual routers
 - Can provide different routing protocols/features on the same (real) machine
 - Have basic management functions



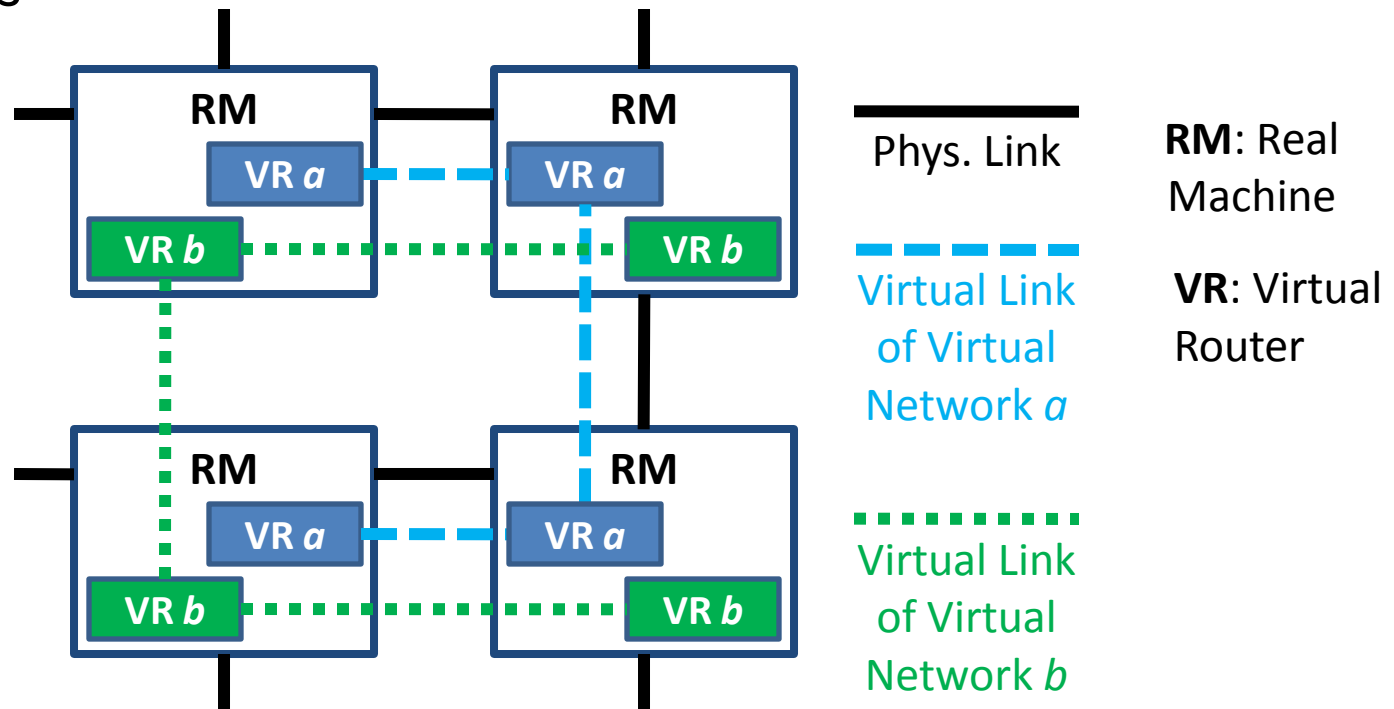
- **Virtual link** in the context of system virtualization
 - Logical interconnection of two virtual routers
 - Appearing to them as a direct physical link
 - Properties can change dynamically (e.g. bandwidth)
 - Can traverse more than one physical link



- **Virtual network** in the context of system virtualization
 - Virtual routers that are connected by virtual links
- They form an undirected connected graph
 - **Overlay** (or virtual topology) of the virtual network
- Several independent virtual networks with different overlays can exist in parallel
 - With different network protocols/features
 - Isolated from each other



- Example of two parallel virtual networks with different overlays



- System virtualization can be applied to core networks
- A predetermined network model emerges that consists of
 - Virtual routers, virtual links, virtual networks
 - Overlays are created on top of the physical network
- System virtualization based networks can be realized with current technologies (e.g. XEN)
 - Proof of concept has been implemented
 - Performance issues



Appendix



System Virtualization Background

Two popular implementations

- Full virtualization
 - VMM (“Hypervisor”) located directly on top of real machine, e.g. XEN, VMWare ESX Server
- Hosted virtualization
 - VMM located on top of OS, e.g. VMWare Workstation

