

# 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

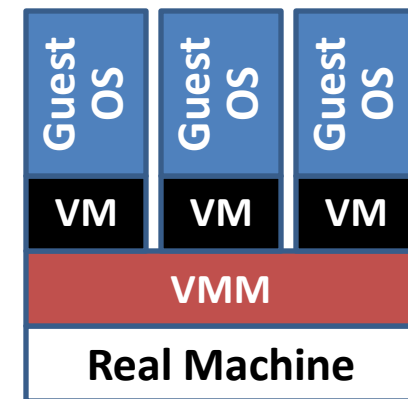
## Background

- 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



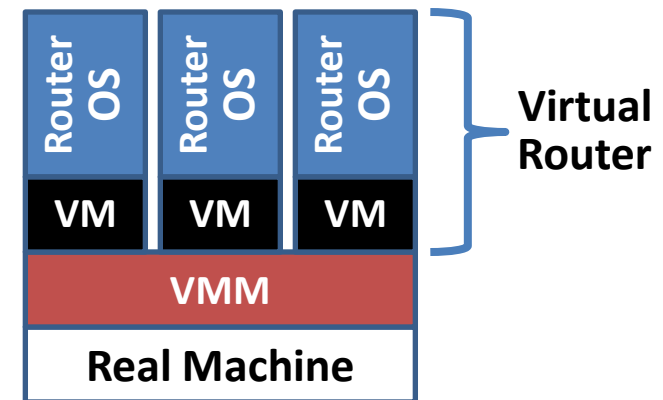
# System Virtualization

## Background

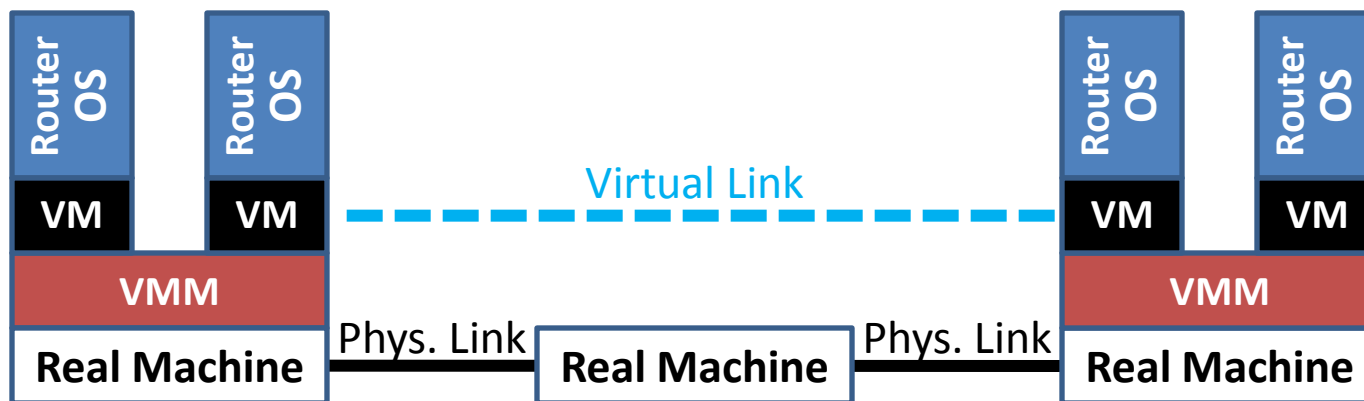
- Basic management primitives of VMM
  - Create VM, destroy VM
  - Start VM, stop VM
  - Copy VM, move VM (even “live migration” of services)
  - Save VM, restore VM
- System virtualization can be used to virtualize core networks
  - Predetermined network arises
    - Virtual routers, virtual links,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



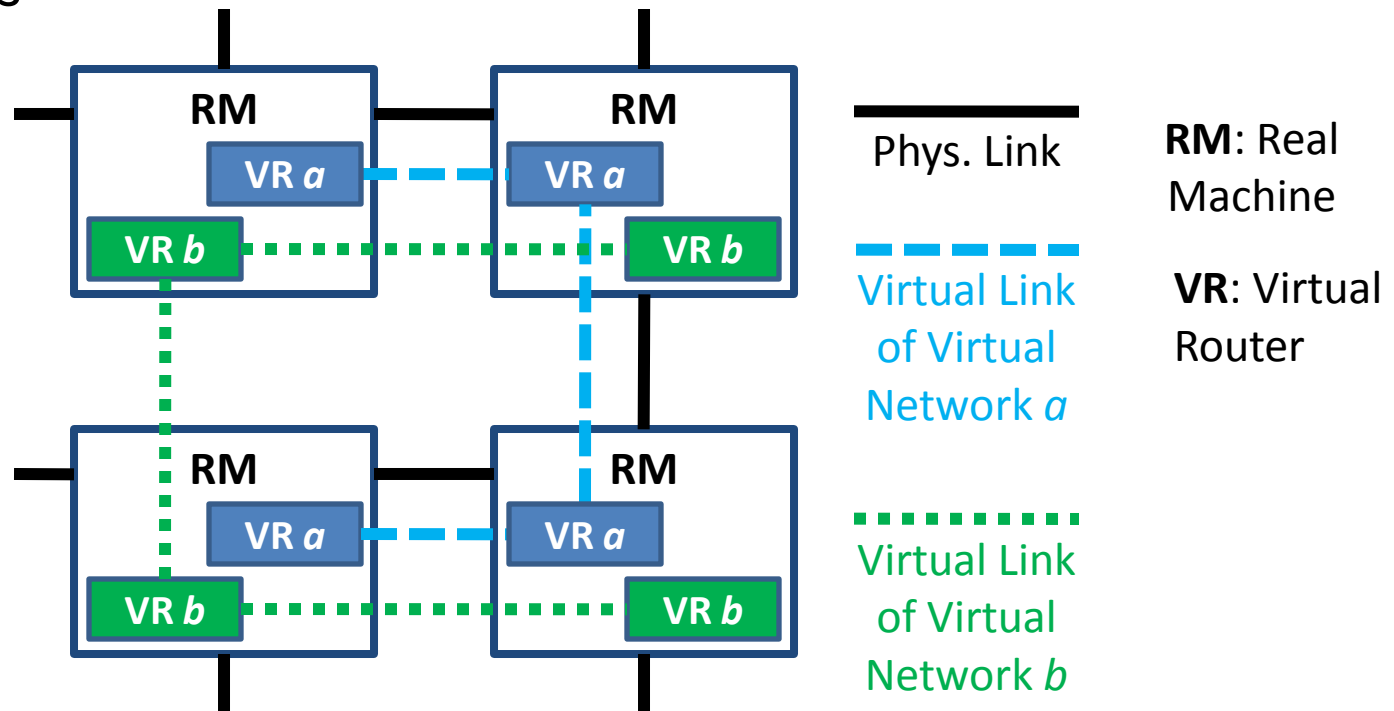
- **Virtual link** in the context of system virtualization
  - Logical interconnection of two virtual routers
  - Appearing to them as a direct physical link
  - Properties can change dynamically (e.g. bandwidth)
  - Can traverse more than one physical link



- **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

