Network Virtualization
Software Defined Network

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Let’s focus on the NIC

**Computer System Organization**

- **CPU**
  - MMU
- **Memory**
  - Controller
- **Local Bus**
- **High-Speed I/O Bus**
  - NIC
  - Controller
  - Bridge
  - Frame Buffer
- **Low-Speed I/O Bus**
  - LAN
  - CD-ROM
  - USB
Network Virt

• What layer? Ethernet or TCP/IP

• What is the network identity?

• Do the physical attached devices matter?
VNETs

Vnets in a Hosted Architecture
VMware’s Hosted vnet API

```c
char packet[1500];

fd = open("/dev/vmnet1", O_RDWR);

ioctl(fd, ...);

read(fd, packet, 1500);

write(fd, packet, 1500);

close(fd);
```
DHCP Service

DHCP Service

VM 1

Guest NIC Driver

NIC Emulation

VM 2

Para-virtualized NIC Driver

Para-virt Interface

vnet

TCP/IP Stack

vnet DHCP Server

HW NIC Driver

LAN

VMM / Hypervisor / Host OS
Host-only Networking

- **Host-only Networking**
- **VM 1**
  - Guest NIC Driver
- **VM 2**
  - Para-virtualized NIC Driver
- **TCP/IP Stack**
- **vnet**
- **vnet NIC Driver**
- **HW NIC Driver**
- **vnet DHCP Server**
- **NIC Emulation**
- **Para-virt Interface**
- **VMM / Hypervisor / Host OS**
- **LAN**
Bridged Networking

VM 1
Guest NIC Driver

VM 2
Para-virtualized NIC Driver

Nic Emulation
Para-virt Interface

vnet

TCP/IP Stack
Bridge

HW NIC Driver

LAN

VMM / Hypervisor / Host OS
Secure Networking: 2 NICs

- Intranet App
- Internet VM
  - Browser

- TCP/IP Stack
- Bridge
- vnet

- HW NIC 1 Driver
- HW NIC 2 Driver

- LAN
- www

VMM / Hypervisor / Host OS
NAT Networking with vents
VLAN Trunking

VLAN Switch

VLAN 1

VLAN 2

VLAN 3

VLAN 1

VLAN 2

VLAN 3

VLAN Trunk

<1, P>

<3, Q>

VLAN Trunk

VLAN Switch

VLAN 1

VLAN 2

VLAN 3

VLAN 2
VLANs with vents

VM 1 on VLAN 1

VM 2 on VLAN 2

VMM / Hypervisor / Host OS

Bridge

vnet1

vnet2

HW NIC Driver

VLAN 1

VLAN 2
VLAN Trunking with vents
From NIC to Switches

- Network Theory
Things Get Complicated

- Firewalls
- Traffic Shaping
- Priorities
- Accounting
- Deep packet inspection
Data and Control Plane

- Data Plane: Routing FLITs (pieces of packets)
- Wormhole Routing (aka Cut-Through)
- Virtual Channels / Virtual Circuits
Software Defined Networks
VM allocation to PMs in the cloud

- Cloud data centers can have 100,000’s servers (PM)
- about 5x as many VMs
- how to place VMs to PMs?
How to pack VMs

• On each Physical Machine, want to make best use of:
  • Physical Memory, Number of Cores, Local Storage, and Physical NIC usage
  • VM’s communicate with one another, so want to optimize network traffic as well.
Algorithms

- MinMax
- Random Placement
- Mixed-Integer Model

Practical Algorithms:

- Greedy Network and greedy fill
- Simulated Annealing
Simulated Annealing Variants

- SA-C: Uses CPU utilization
- SA-CN: Uses CPU and NIC
- SA-CNTM: CN+Traffic Awareness (VM xVM)
- SA All: add in full network topology