Introduction to Networking and Systems Measurements

Device and System Characterization

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Make No Assumptions

What is the goal?

- Functional validation?

- Performance testing?

- Characterization?

- Comparison?

- Detecting problems?

- Finding the bottlenecks?

Different goals $\Rightarrow$ different setup + experiments

What is the goal?

- **Functional validation, e.g.,:**
  - ➢ Can we send traffic from port A to port B?

- **Performance testing, e.g.,:**
  - ➢ What is the throughput of sending traffic from port A to port B?

"Beep Beep"

OR

Vantage Points

- Characterisation is limited by vantage points

- Single vantage point:
  - ➢ Round trip measurements, topology measurements

  OR
  - ➢ Passive measurements

- Two vantage points:
  - ➢ One way latency measurements, bandwidth measurements + everything a single vantage point can do

- Three vantage points?
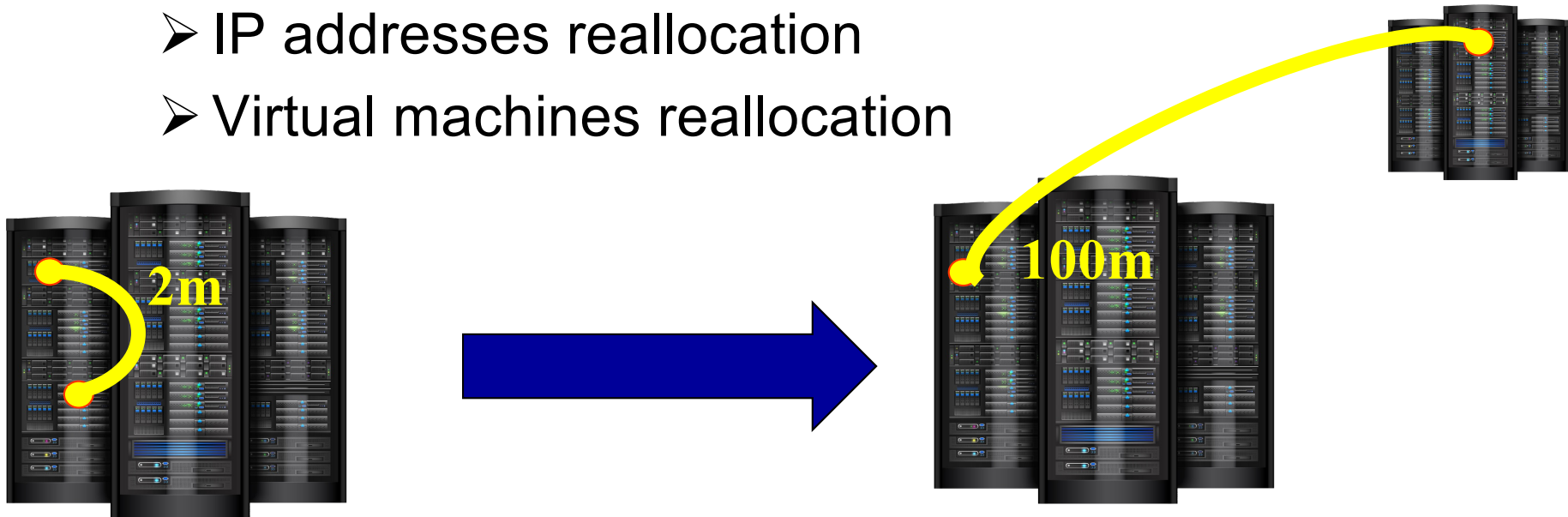
Vantage Points

- <Number> of vantage points is not sufficient
- <Location> of vantage points is important
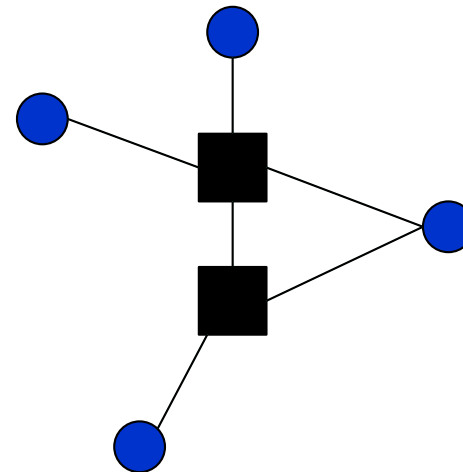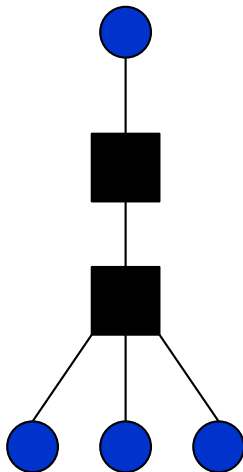
Vantage Points

- Is your vantage point static?

- Mobile vantage points: Mobile phones, laptops
  - Sometimes good if you seek to increase coverage

- But also (for example):
  - IP addresses reallocation
  - Virtual machines reallocation

2m

100m

What is the workload?

- **Synthetically generated, e.g.,**

  ➢ 128Byte IPv4 Packets

- **Protocol level, e.g.,**

  ➢ TCP flows

- **Application level, e.g.,**

  ➢ Key-value store application

What is the workload?

- Everything matters!
- Packet size distribution
- Traffic rate
  - ➢ E.g., Average rate, peak rate,
- Traffic shape
  - ➢ E.g. bursts
- Payload
 - ➢ Some payloads are more likely to cause errors than others
- Protocol
- ….

Example

- What can we learn about the internals of a switch using latency measurements and 3 vantage points?

- Assuming a sterile environment

Port 1

Port 2

Port 3
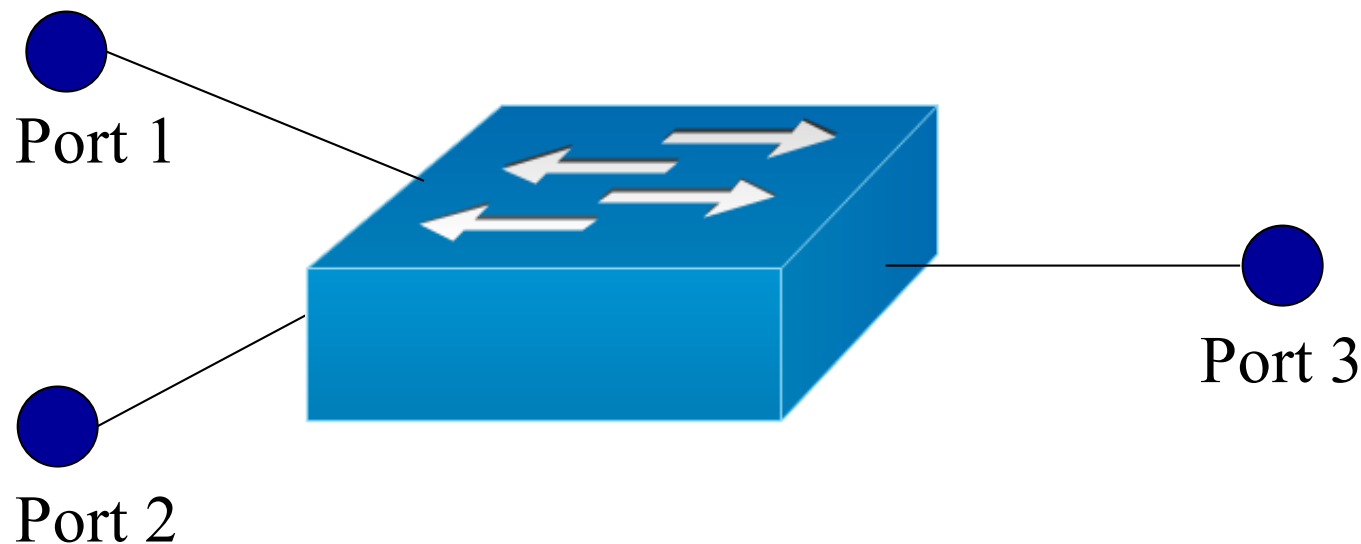
Example

- ## What is the basic latency of the switch?

  ➤ Send packets from port 1 to port 2, measure the latency

- ## Is the switch design symmetric?

  ➤ Send packets from port 2 to port 1, measure the latency

- ## Is the switch design identical for all ports?

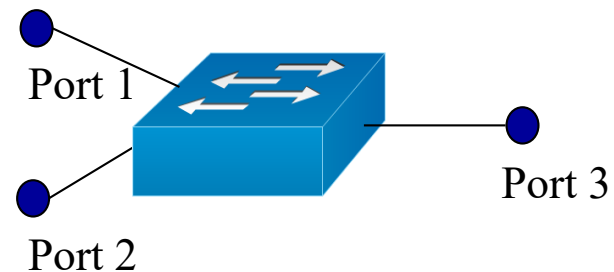 ➤ Send packets from port X to port Y, measure the latency for all combinations

Port 1

Port 2

Port 3
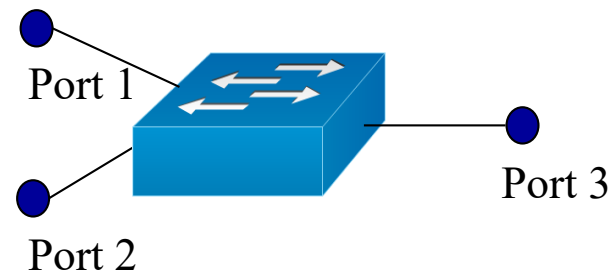
Example

- ## What type of switch is it?

  - ➢ Send packets of various sizes from port 1 to port 2, measure the latency

  - ➢ A cut-through switch will have the same latency for all packet sizes, a store-and-forward switch will have a higher latency for bigger packet sizes

- ## Is the switch sensitive to throughput?

  - ➢ Send packets at full line rate from port 1 to port 2, measure the latency

  - ➢ Do the results change over time?
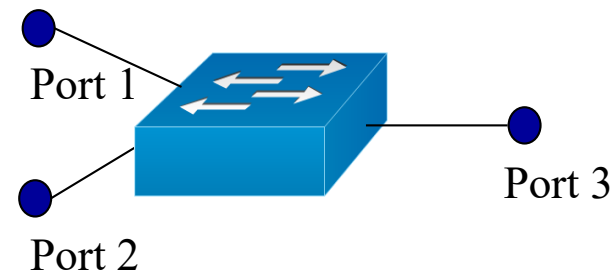
Port 1

Port 3

Port 2

Example

- **What can learn about the output queueing and output scheduling of the switch?**

  ➤ Send packets at port 1 to port 3, measure the latency
  And at the same time

  ➤ Send packets at port 2 to port 3, measure the latency

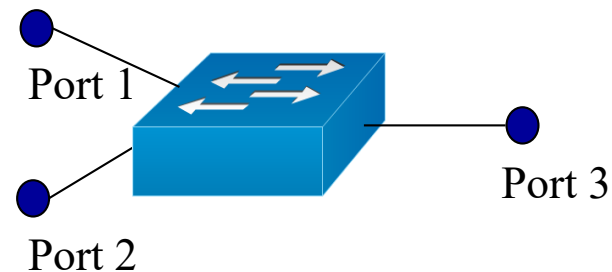 ➤ Vary the packet rate and discover more….
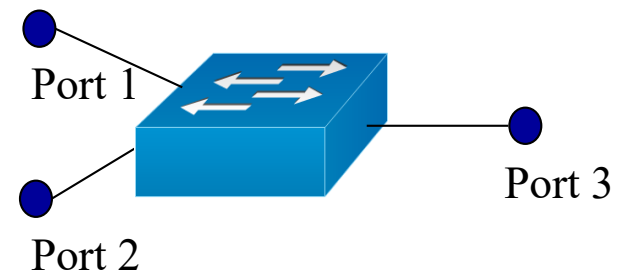
Port 1

Port 2

Port 3

Example

- What can learn about the input queueing and input scheduling of the switch?

  - Send packets at port 1 to port 3, measure the latency
    And at the same time

  - Send packets at port 2 to port 4

  - Vary the packet rate and discover more….

  - Why is sending from port 2 to port 1 a bad idea?

Port 1

Port 2

Port 3

Example

- What can we learn about the internals of a switch using latency measurements and 3 vantage points?

- A lot!

- This was just a small subset

Port 1

Port 2

Port 3

Example 2

- **Mellanox Spectrum vs Broadcom Tomahawk**

  - Tolly report, 2016
    http://www.mellanox.com/related-docs/products/tolly-report-performance-evaluation-2016-march.pdf

- **Bandwidth distribution, 3$\rightarrow$1 scenario**

  - Source ports 25,26,27, Destination port 31
    33% BW from each port, on both devices

  - Source ports 24,25,26, Destination port 31
    33% BW from each port, on Spectrum
    25% from ports 25,26, **50**% from port 24 on Tomahawk

- **What does it mean?**

Synchronization

- **Recall Lecture 3**

- **Synchronization of time between multiple machines**

  ➢ E.g., allow one-way latency measurements

- **Synchronization of measurements**

  ➢ Can you trigger multiple vantage points to start an experiment at once?

    • E.g. what happens if you measure congestion effects without triggering at once?

Tools Selection

- When to use hardware tools? When to use software tools?

- You don't always have omniscient control over resources
  - You may not even have permissions for some basic tools

- What can you do?
  - Similar tools using different protocols
  - Write your own tools
  - Redesign your experiment

So lets start measuring!

- Wait!

- What is your goal?

- What do you know about your experimentation environment?

- Have you collected metadata?

- Are you aware of any limitations to the environment / tests / DUT / usage / …?

- Is your experiment reproducible?

Advice

- Getting measurements right is *HARD*
- More is rarely better
- Prefer:
  - ➢ Fewer Measurements and Better methodology
  - ➢ Detailed measurements
  - ➢ Reproducibility
  - ➢ Understanding the results
  - ➢ Become an expert of your work