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"
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
What is the workload?

- Synthetically generated, e.g.,
  - 128B 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

Networking and Systems Measurements (L50)
Example

- What can we learn about the internals of a switch using latency measurements and 3 vantage points?
- Assuming a sterile environment
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
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?
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….
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?
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
Example 2

- Mellanox Spectrum vs Broadcom Tomahawk
  - Tolly report, 2016

- Bandwidth distribution, 3→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 let's 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 isn’t necessarily better.
- Prefer:
  - Fewer Measurements and Better methodology
  - Detailed measurements
  - Reproducibility
  - Understanding the results
  - Become an expert of your work