

# Introduction to Networking and Systems Measurements

## Measurement Pitfalls



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# Common Measurement Pitfalls

- What are the hidden assumptions?
- What did you not notice (in the system, setup, ....)?
- What can your tool do?
- Vantage points
- Latency pitfalls
- BW pitfalls
- Reading the results

# Hidden Assumptions - Examples

- The path from A to B is the same (reverse) as the path from B to A
- There is no packet reordering
- Device throughput is the same for all packet sizes
- Test packets will experience the same effects as application's traffic
- The effect of DNS lookup is negligible
- The measurement tool has negligible overhead
- Previous work was correct

# System and Setup

## Did you notices that....

- There are other jobs running on the same core
- ICMP traffic is throttled by the OS
- CPU frequency scaling is enabled
- The CPU that you are using is not connected directly to the NIC
- Kernel version has been updated overnight
- The 2x40G NIC uses PCIe Gen 3 x8 (~60Gbps)
- There is a new Errata...

# What can your tool do? - Examples

- SSD can write at 450MB/s
  - Don't try to write data captured at 10Gbps
- The latency for reading CPU timestamp is ~tens of cycles
  - Don't try to use it to measure cache access time
- DAG resolution is 4ns
  - Don't try to measure the propagation delay through 1m fibre
- OSNT can only capture at low rate
  - Don't try to measure latency of 10Gbps flows

# Latency Pitfalls - Examples

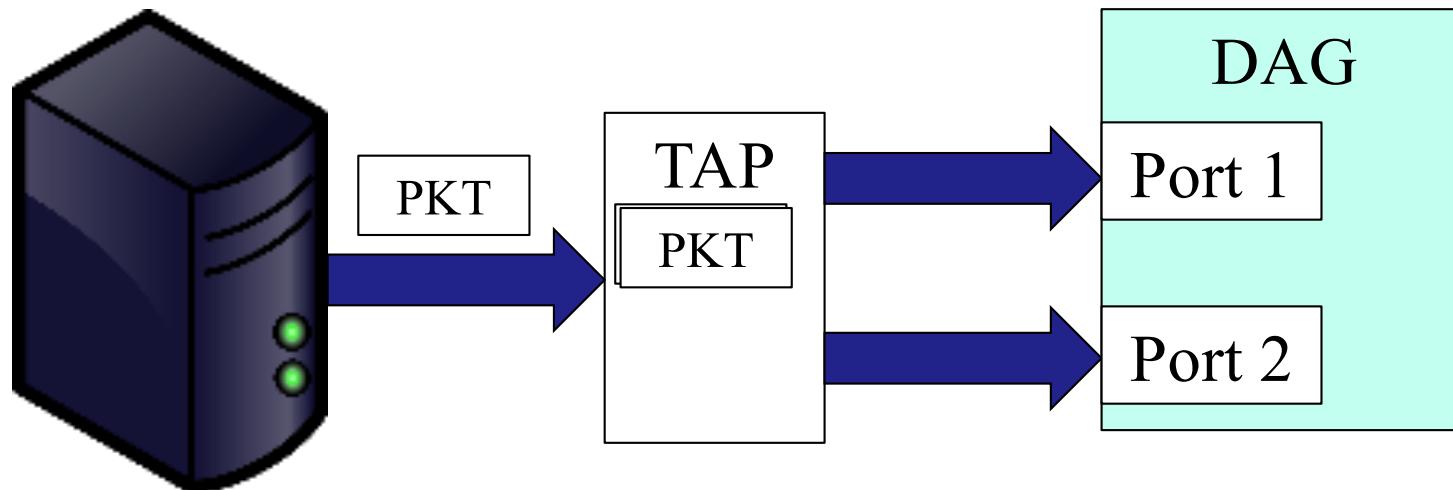
- What is the definition of “latency”?
  - Propagation delay? Inter packet gap? Round trip time? Flow completion time?
- How was the latency measured?
  - Start of packet to start of packet? Start of packet to end of packet?
  - Single packet? Packet-pair? Packet-train?
- Where was the timestamp taken?
  - ...and how did it affect the measurement?
- Resolution, precision and accuracy...

# Bandwidth Pitfalls - Examples

- What is the definition of “bandwidth”?
  - Link capacity? Average throughput? Peak throughput?
- Controllability
  - Packet size? Protocol? QoS?
- What was the status of the network?
- Net neutrality?
- Did you pass through the bottlenecks?
- Resolution, precision and accuracy...

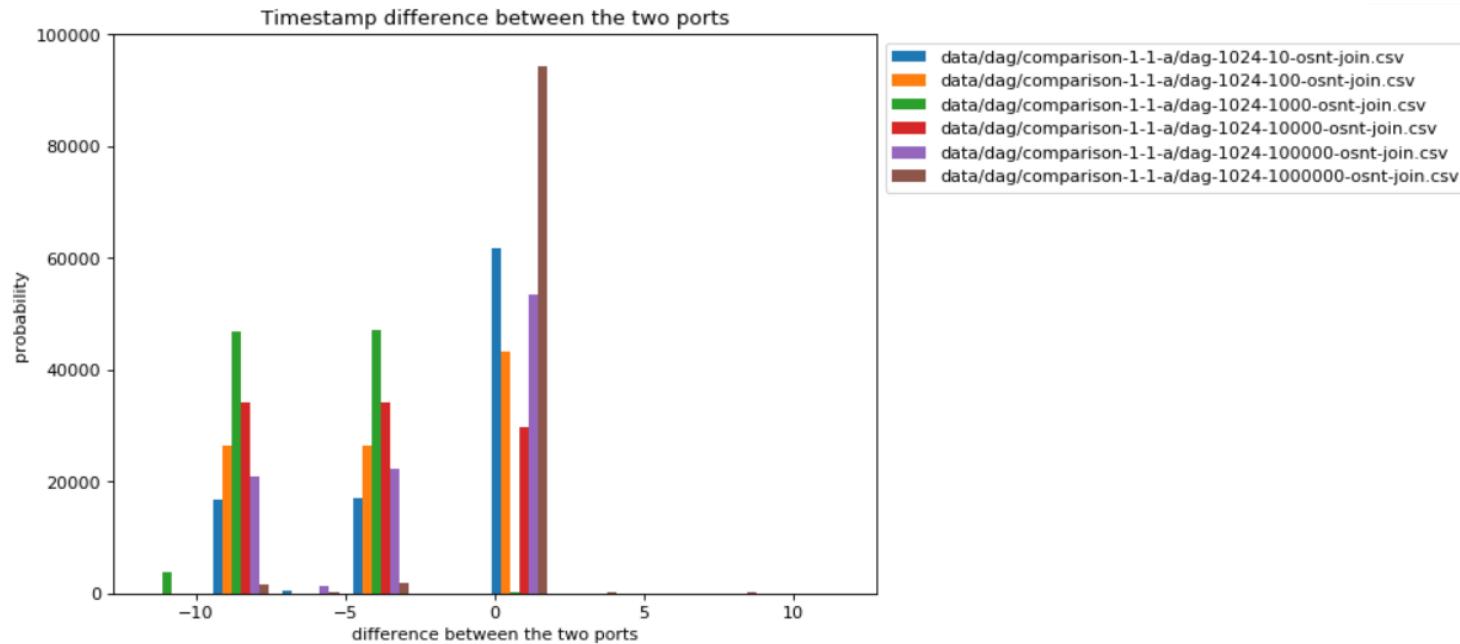
# Example: Timestamp difference between ports

- Recall Lab 2, experiment 2.1 b
- Measuring the timestamp difference between 2 ports:



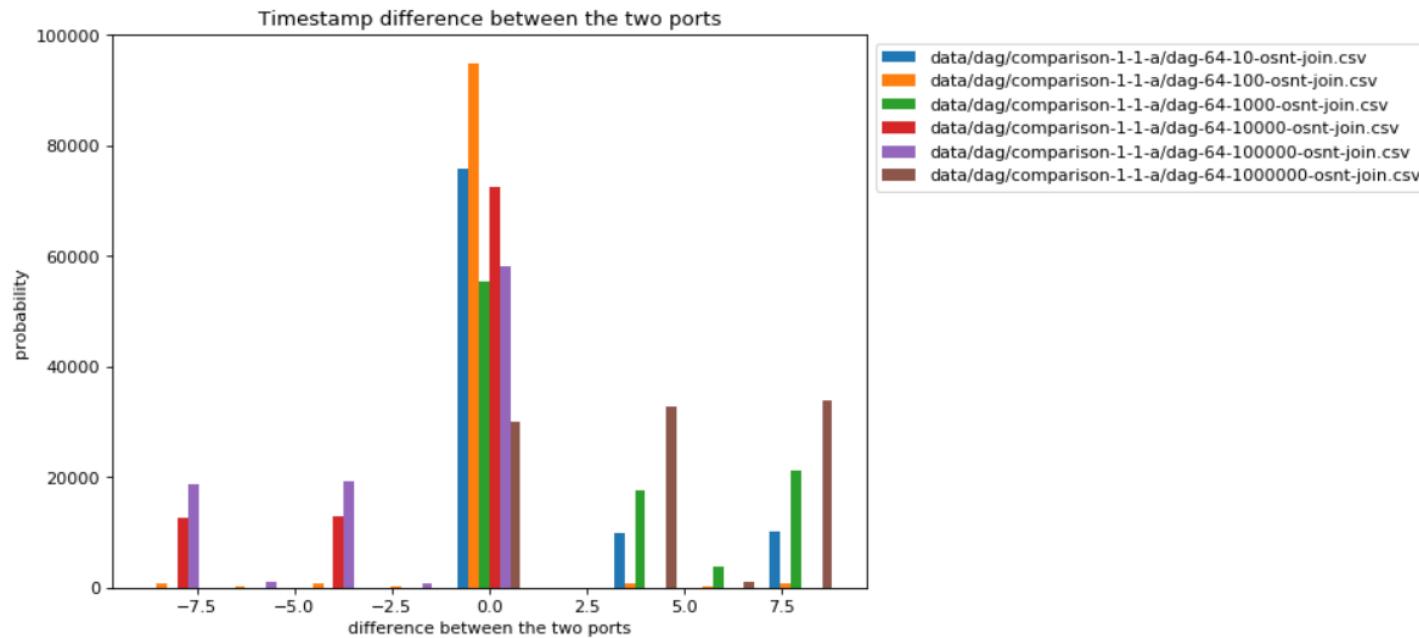
# Example: Timestamp difference between ports

- 100,000 packets, **1024B**
- Different Inter Packet Gaps (IPG)



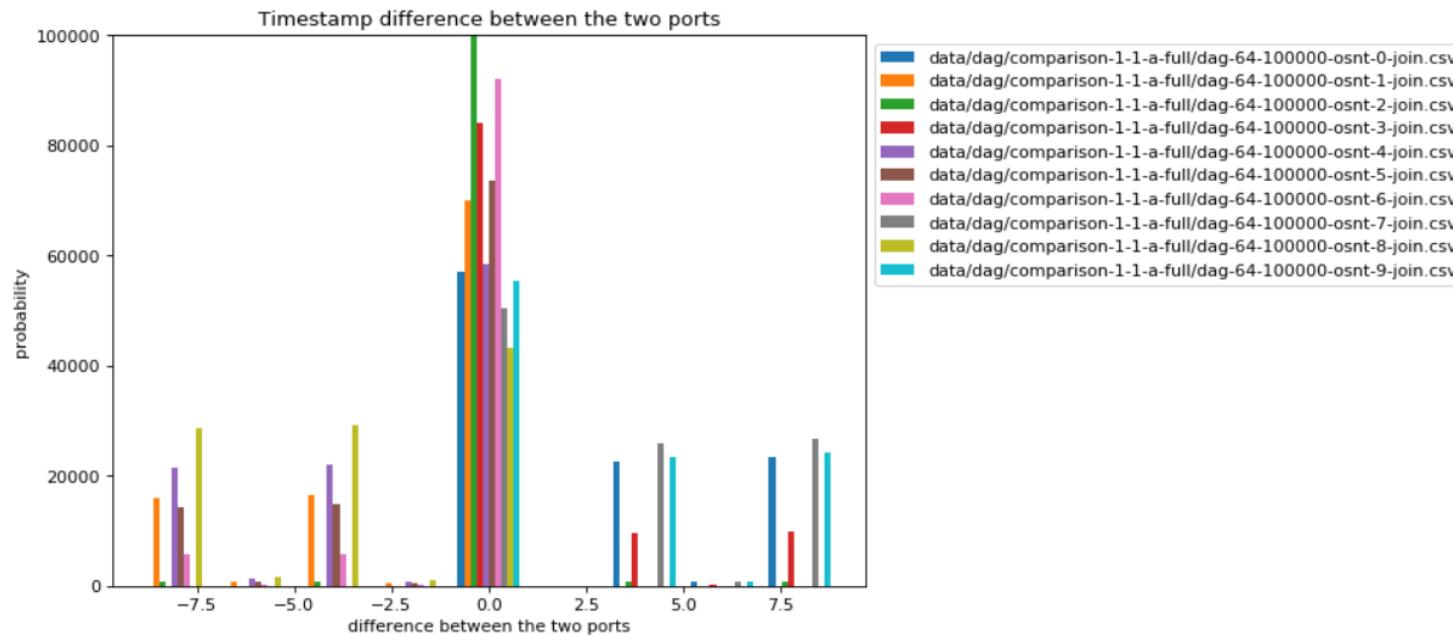
# Example: Timestamp difference between ports

- 100,000 packets, **64B**
- Different Inter Packet Gaps (IPG)



# Example: Timestamp difference between ports

- 100,000 packets, **64B**, running 10 times
- Same Inter Packet Gap (IPG)



# Example: Switch Throughput

- The reported iperf result for a NetFPGA reference switch is 9.4Gbps
- User complaint: I see only 8.9Gbps and packet drop in the switch

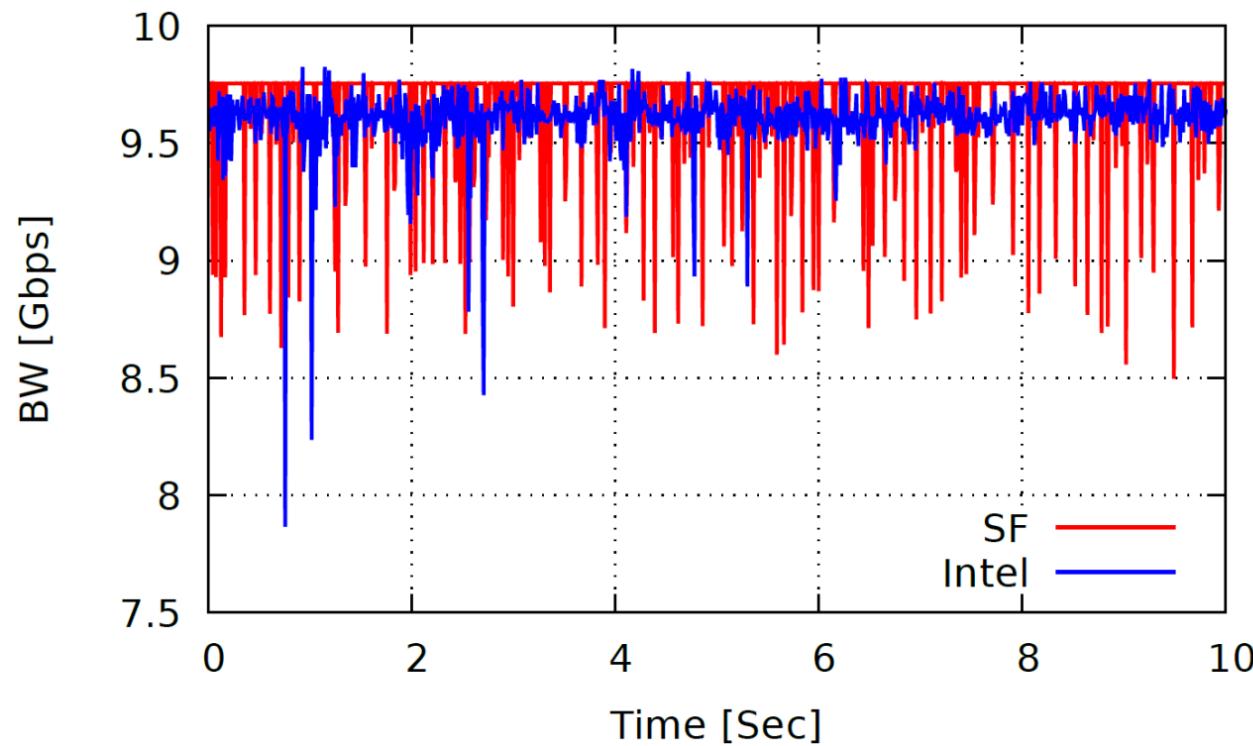
```
Connecting to host 10.0.0.13, port 5201
[ 4] local 10.0.0.12 port 54764 connected to 10.0.0.13 port 5201
[ ID] Interval          Transfer    Bandwidth     Retr  Cwnd
[ 4]  0.00-1.00    sec  1.02 GBytes   8.76 Gbits/sec   74  313 KBytes
[ 4]  1.00-2.00    sec  1.03 GBytes   8.86 Gbits/sec   34  198 KBytes
[ 4]  2.00-3.00    sec  1.03 GBytes   8.87 Gbits/sec   34  281 KBytes
[ 4]  3.00-4.00    sec  1.04 GBytes   8.92 Gbits/sec   34  238 KBytes
[ 4]  4.00-5.00    sec  1.04 GBytes   8.93 Gbits/sec   32  208 KBytes
[ 4]  5.00-6.00    sec  1.04 GBytes   8.92 Gbits/sec   29  187 KBytes
[ 4]  6.00-7.00    sec  1.04 GBytes   8.95 Gbits/sec   27  365 KBytes
[ 4]  7.00-8.00    sec  1.04 GBytes   8.94 Gbits/sec   28  233 KBytes
[ 4]  8.00-9.00    sec  1.03 GBytes   8.88 Gbits/sec   30  420 KBytes
[ 4]  9.00-10.00   sec  1.04 GBytes   8.96 Gbits/sec   33  423 KBytes
- - - - -
[ ID] Interval         Transfer    Bandwidth     Retr
[ 4]  0.00-10.00   sec  10.4 GBytes   8.90 Gbits/sec  355
[ 4]  0.00-10.00   sec  10.4 GBytes   8.90 Gbits/sec
                                                 sender
                                                 receiver
```

# Example: Switch Throughput

- Debug: Have you tried changing rx-usec?
- User: no more packet drop in the switch!
- ...but bandwidth is down to 7.5Gbps...
  
- New insight: NIC used on reference setup (Solarflare) is different than the NIC used by user (Intel)
- (skipping a few steps forward)

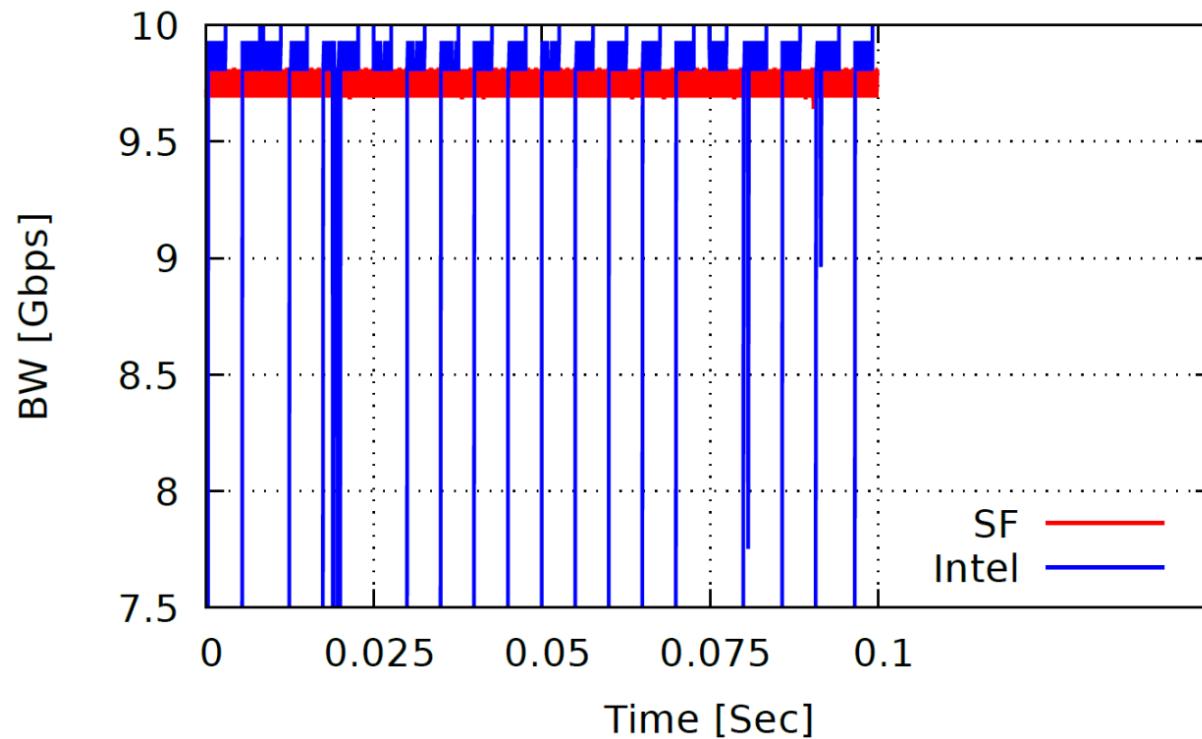
# Example: Switch Throughput

- Switch throughput over time (10ms sampling resolution)



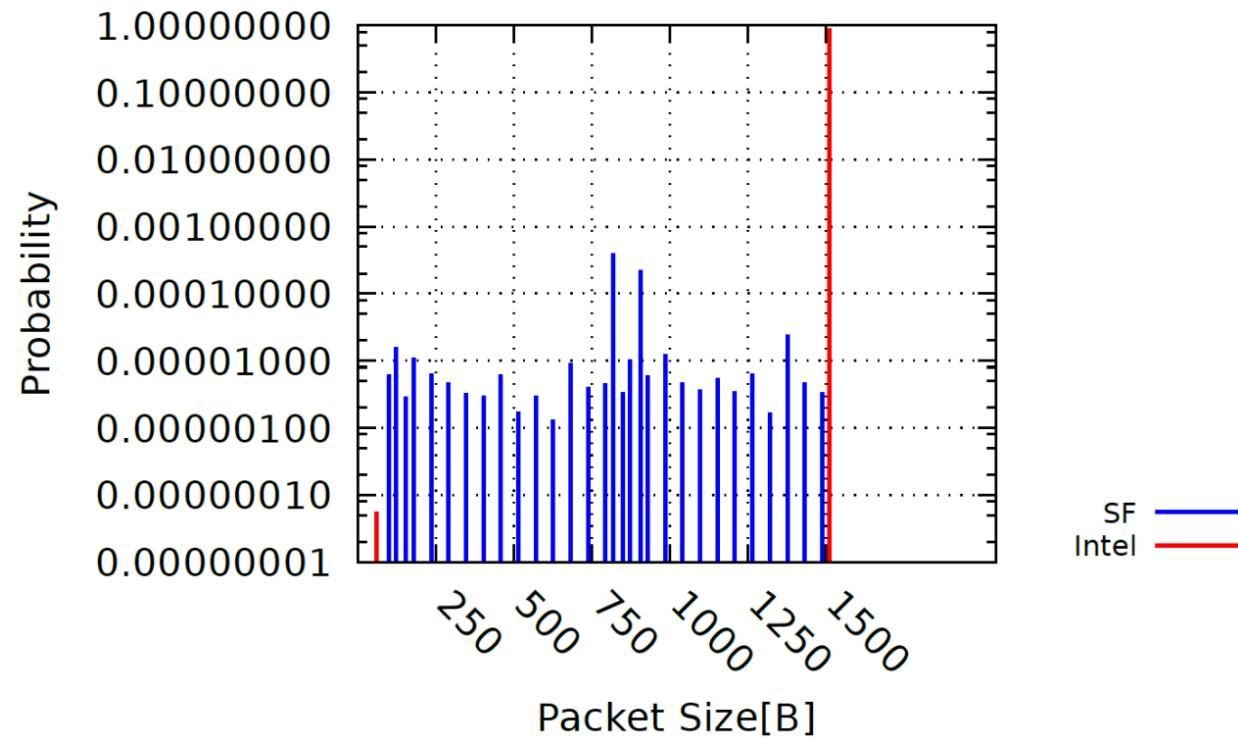
# Example: Switch Throughput

- Switch throughput over time (100 $\mu$ s sampling resolution)



# Example: Switch Throughput

- What else is different?



# Example: TSC Access

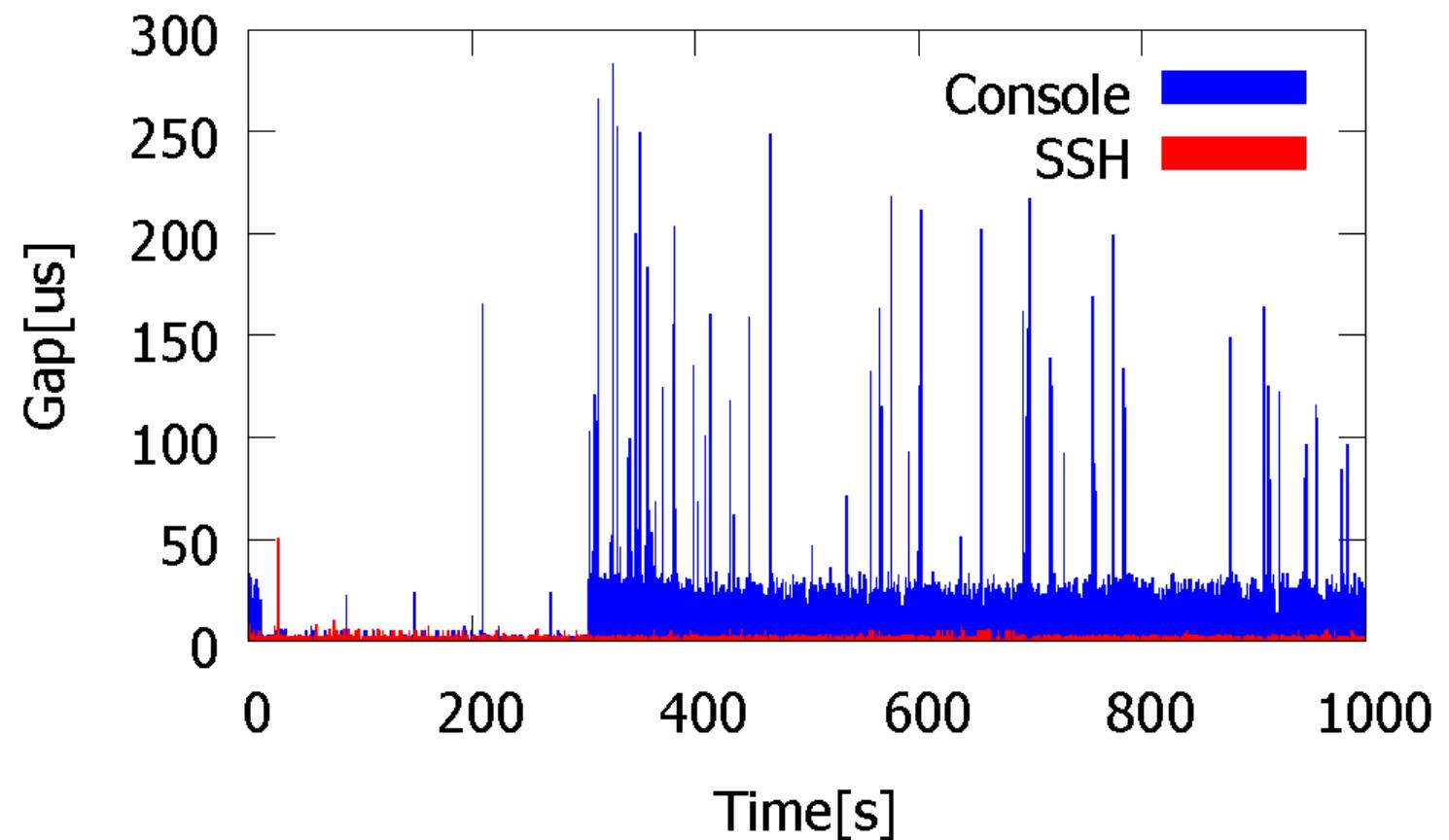
- Goals:
  - Evaluate the accuracy & precision of time-taking using CPU time stamp counter (TSC)
- Methodology:
  - Read TSC twice
  - Measure the time-gap between the two consecutive reads
- Results:
  - Min/Median/99.9%: 9ns/10ns/11ns

# Example: TSC Access

```
1 while (!done)
2 {
3     //Read TSC twice, one immediately after the other
4     do_rdtscp(tsc, cpu);
5     do_rdtscp(tsc2,cpu2);
6     //If the gap between the two reads is above a
7     //certain threshold, save it
8     if ((tsc2 - tsc > threshold) && (cpu == cpu2))
9         buffer[samples++] = tsc2-tsc;
}
```

# Example: TSC Access

What happens over time?



# Example: TSC Access

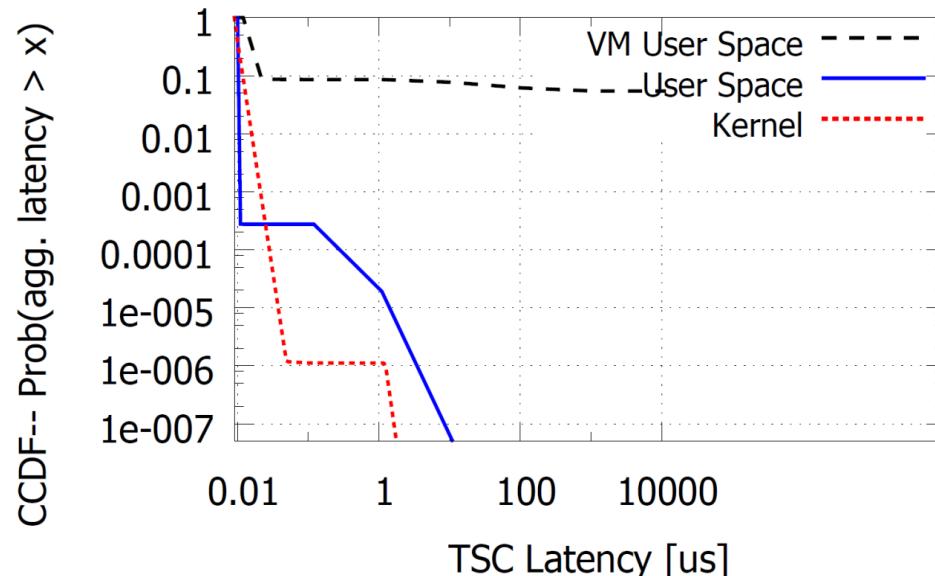
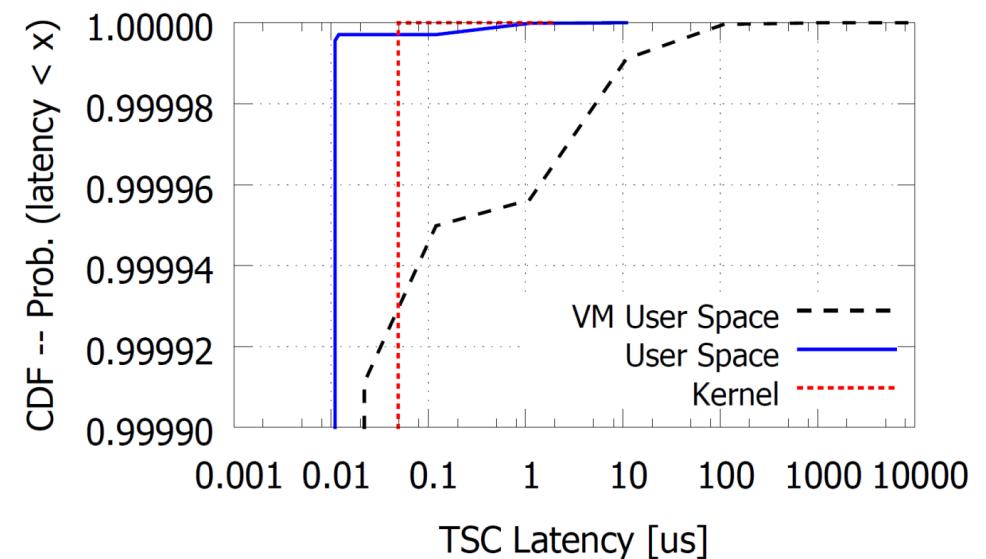
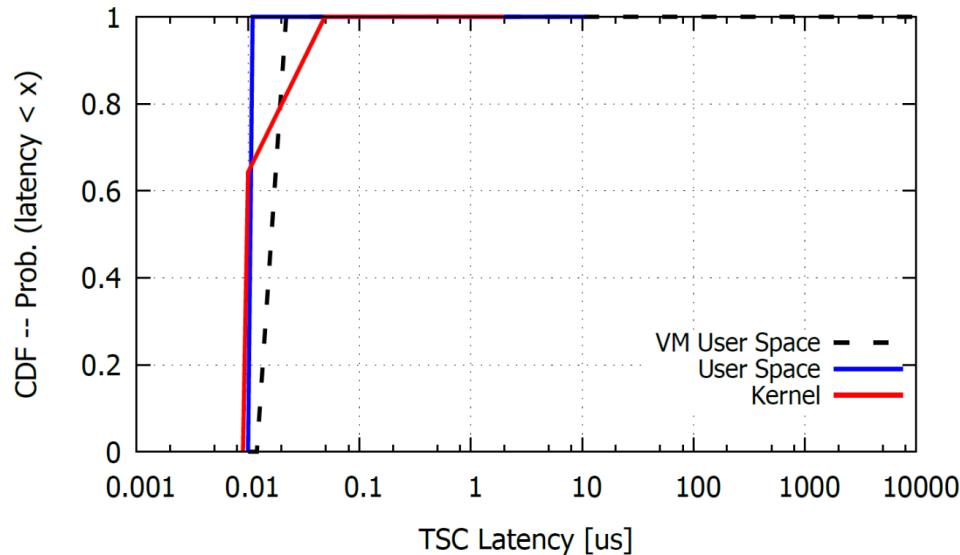
- Source data:

X ≤	User space Events
10	91428291492
11	404700
12	268521
22	268291
120	267465
1097	10768
10869	1

X ≤	Kernel Events
9	11117819727
10	3973891503
49	287
53	201
98	90
1155	86
1184	85
1241	77
1982	1

---

# Example: TSC Access



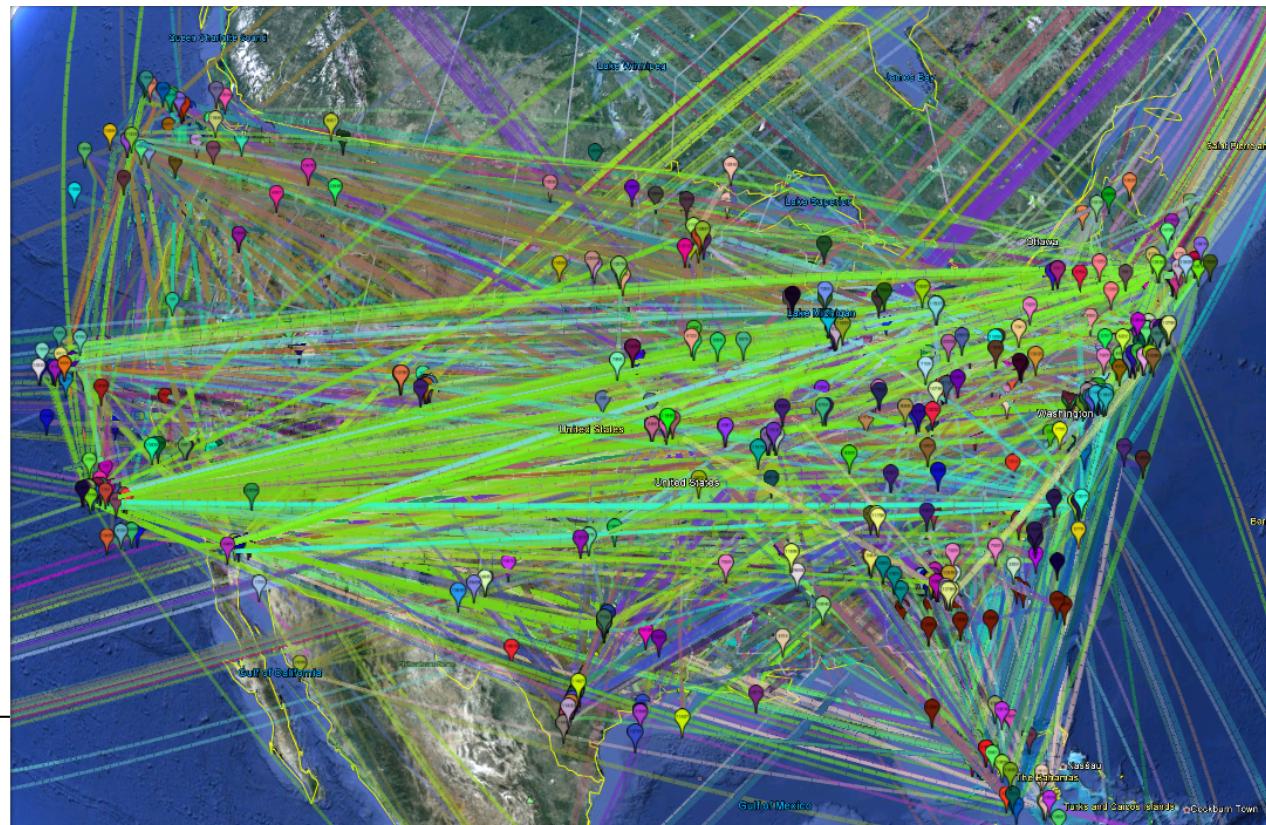
# Example: Topology Measurements

- Goal:
  - Build a map of network connectivity that assigns IP addresses to locations
- Method:
  - Simple option: name resolution
    - 4.69.166.1 ⇒ ae-119-3505.edge4.London1.Level3.net
    - But many times information is missing, not indicative or is inaccurate
  - Better option: use geolocation services
    - Most services claim to be over 99% accurate

# Example: Topology Measurements

# Building a map of the network:

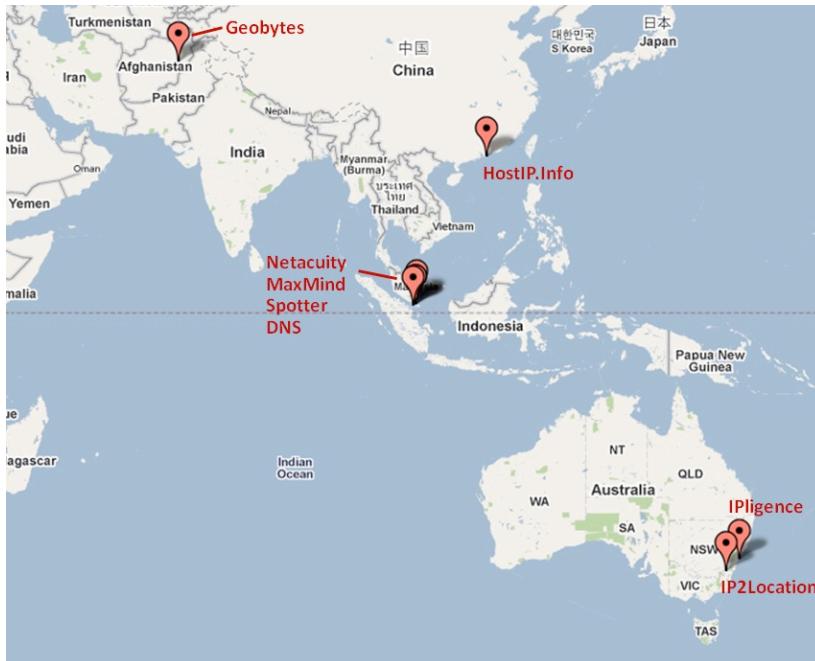
- Measurements for connectivity
  - Geolocation databases for location



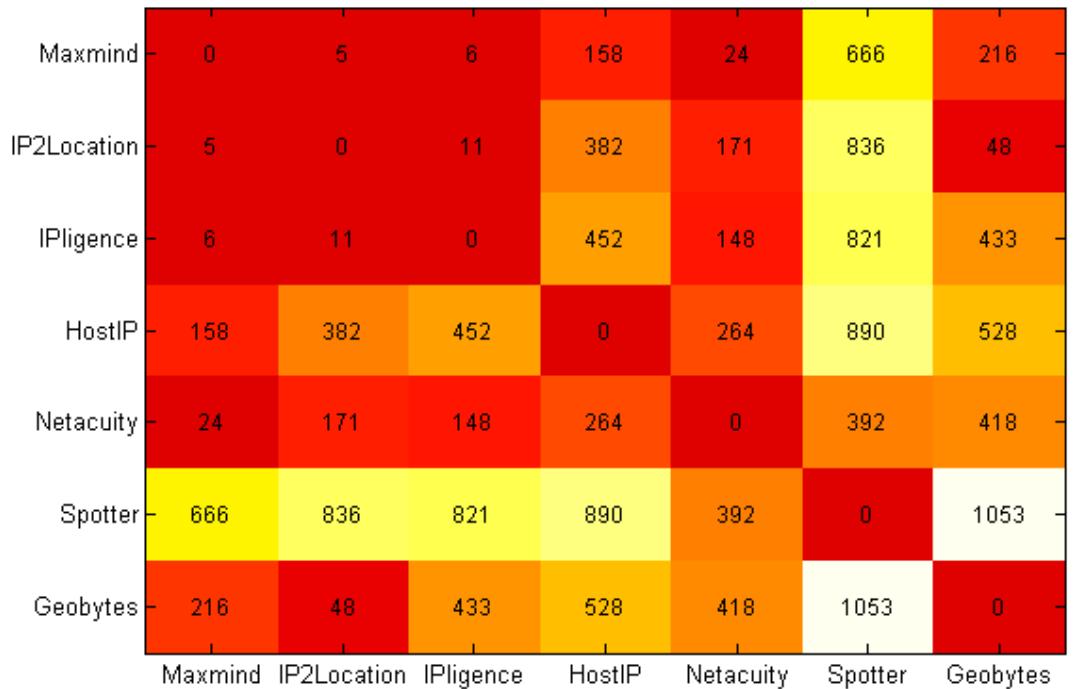
# Example: Topology Measurements

## What is your ground truth?

- Geolocation databases are over 99% accurate!



Verizon/MCI/UUNET (ASN 703)  
10-nodes PoP



Heatmap – Median distance between databases  
(2011)

# Validation

- Measurements need to be validated
- Don't make assertions!
- Use ground truth (where available)
- Compare different tools and methodologies
- Do the results make sense?
  - RTT can't be faster than traveling at the speed of light...
- Have I mentioned validation?



# Final Report - Recommendations

- Include all figures within the report
  - Use proper scale, adapt the template if need be
- Make sure that your environment does not affect the results
- Do not make assertions
  - Support your claims through experimentations
- Discuss your results in depth:
  - Compare and contrast results gained through different vantage points, using different tools, on different platforms etc
  - Provide side-by-side comparisons
  - Use the questions in the handouts as guiding examples
- Use the right terminology (accuracy, precision, resolution)
- Correct typos and grammar mistakes
- Make sure not to run out of budget
- Follow the instructions in the handout

# Course Summary

- This course covered measurements tools and measurement techniques
- But also “why out most basic assumptions are wrong”, “graphs lie”, “what you don’t know about your system”, ...
- Remember:
  - Constant vigilance
  - Look at the data, best-practice, think.
- Applies to all types of measurements

