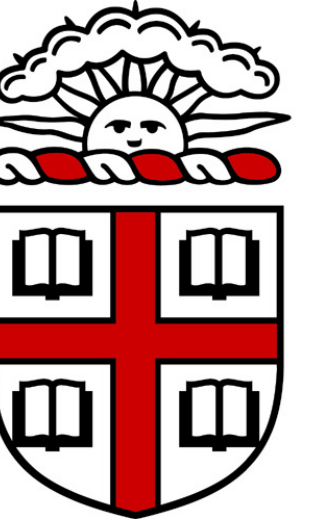


Inferring Router Statistics with IP Timestamps

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The IP Timestamp Option

- Standard IP option defined by RFC's 791 and 781.
- Requests that devices record a timestamp – milliseconds since midnight UT – in the options space of the packet.
- Three modes: devices should record only timestamps (space for nine is available), IP addresses as well as timestamps (space for four), or sender may pre-specify up to four IP address from which to request timestamps.

Hypothesis:

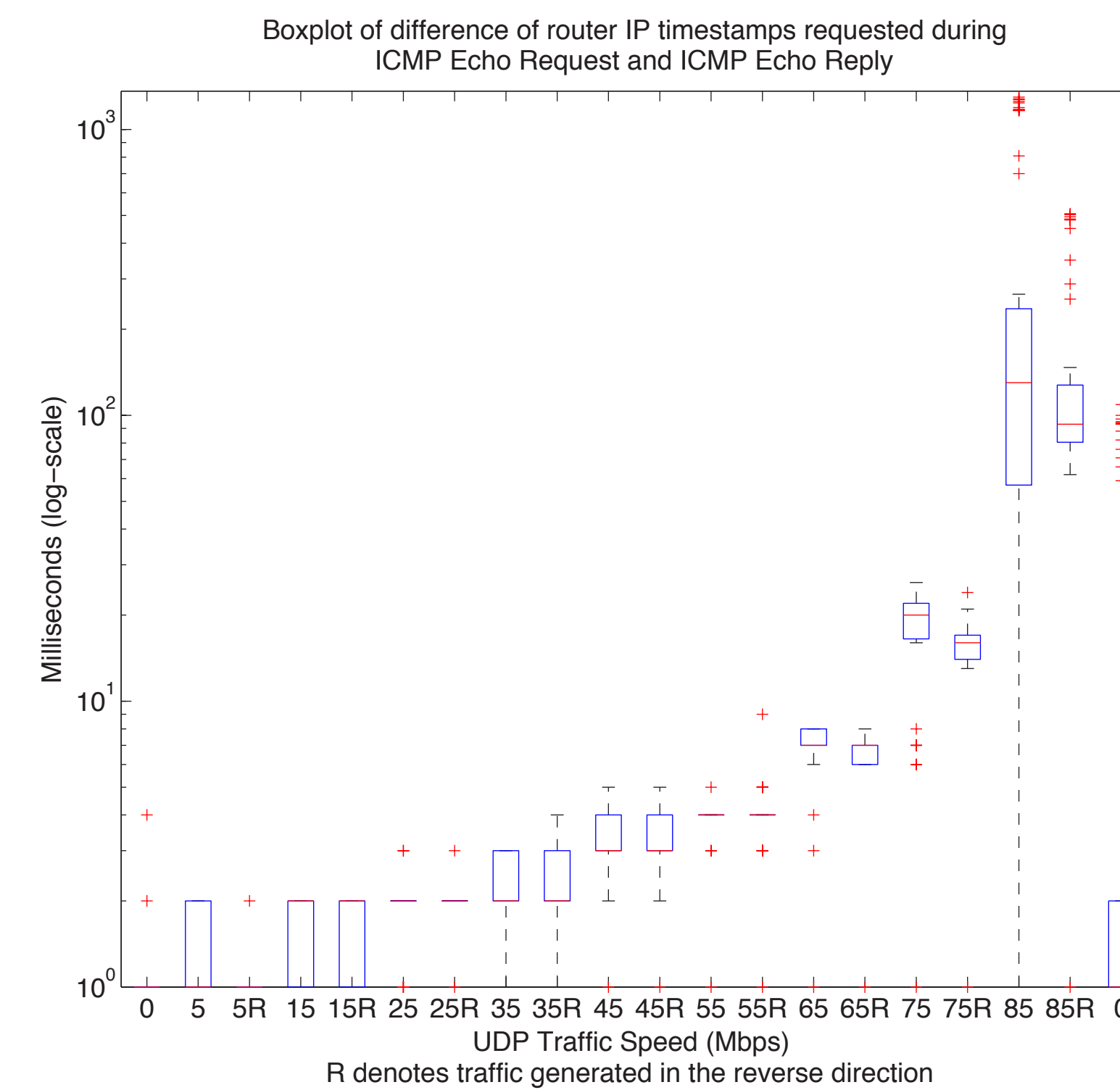
Link delay consists of four parts: propagation delay, transmission delay, processing delay, and queuing delay. The processing and queuing delays are dynamic properties of the router which seek to infer by measuring the variation across repeated IP timestamp requests.

IP Packet Handling

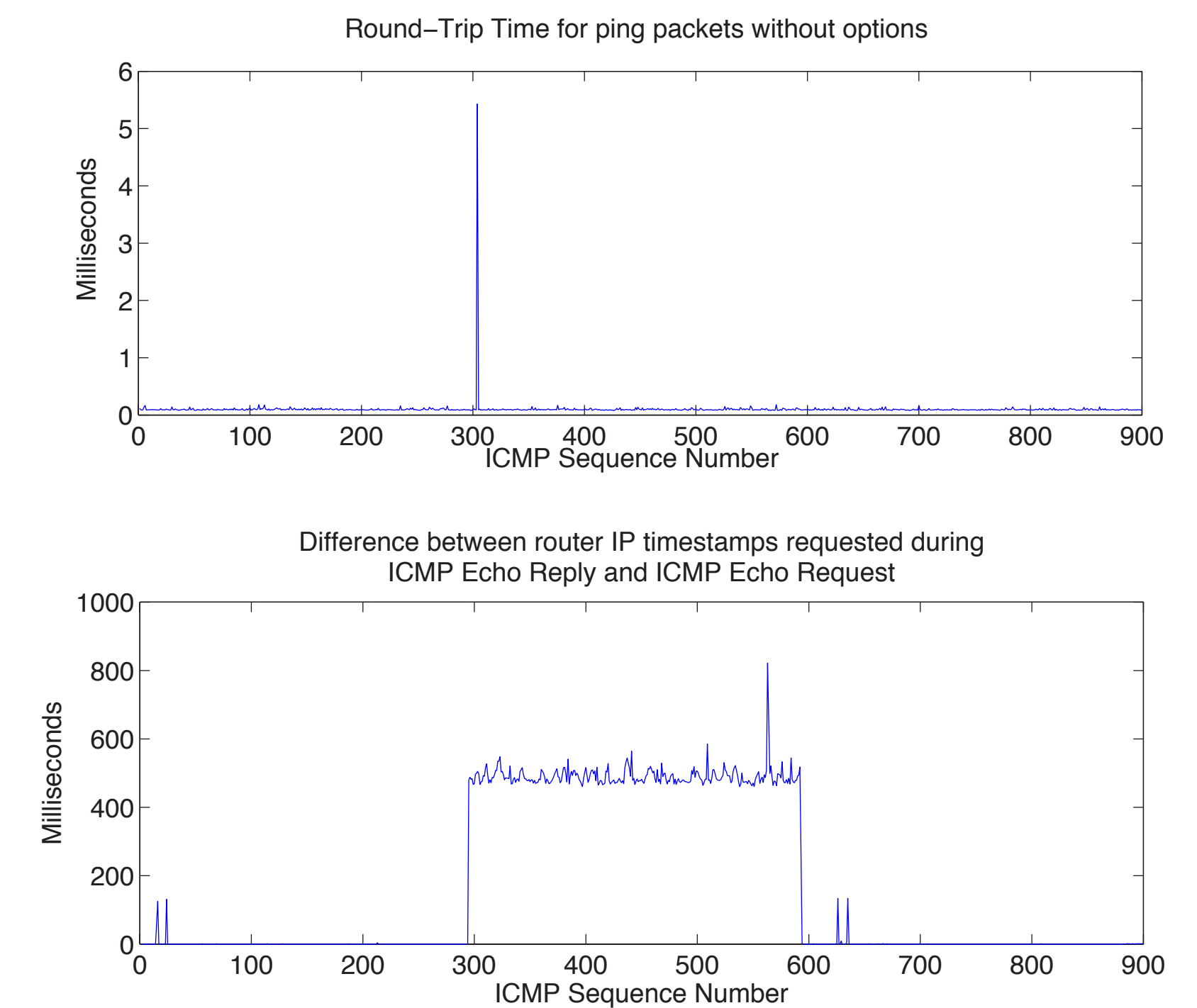
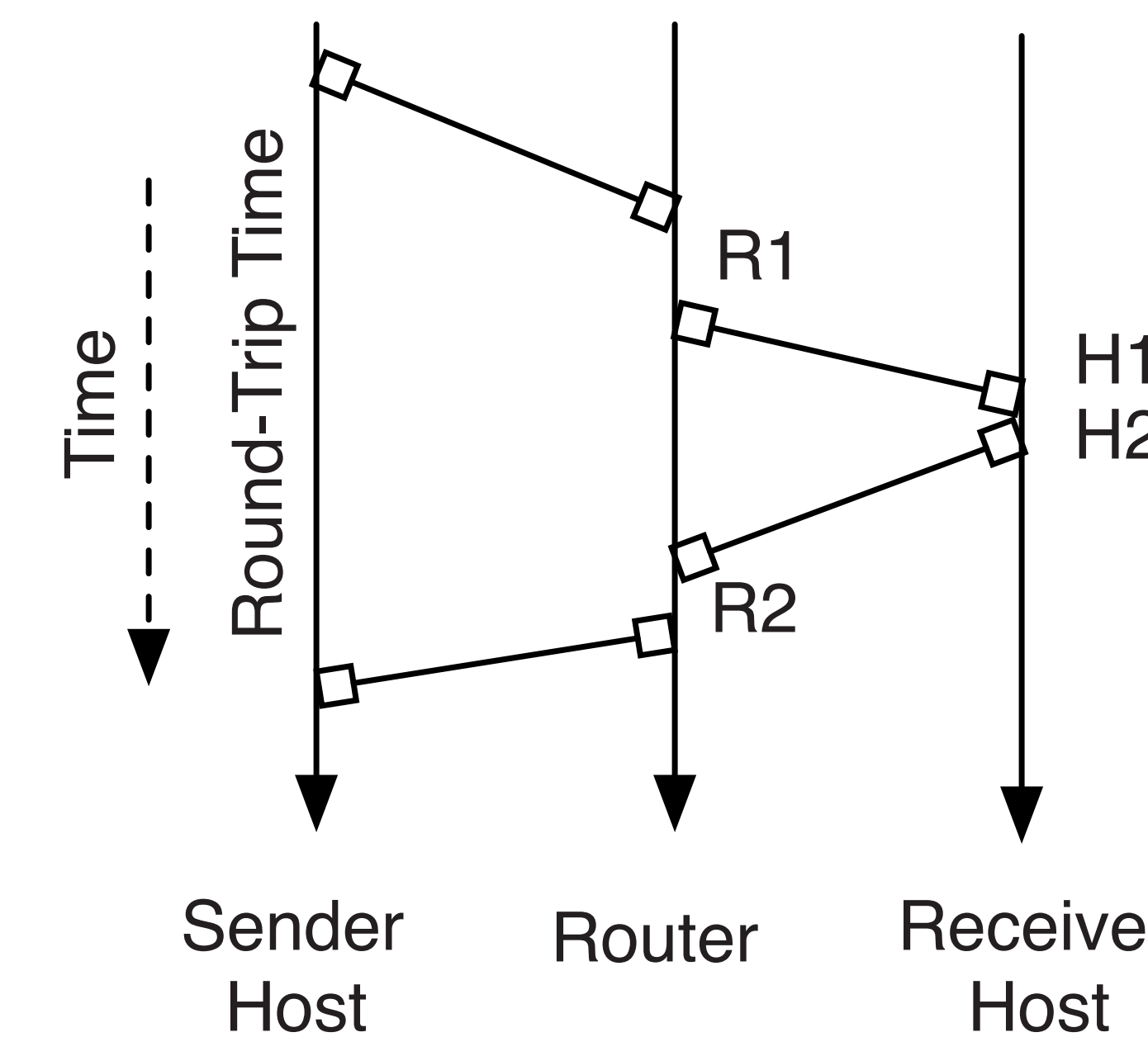
- Router line cards detect the use of IP options and punt such packets to the CPU for additional processing.
- Router may have a single CPU (most common) or a CPU per line card, depending on model.

Conclusions and Next Steps

- IP timestamps improve upon statistics gathered by traceroute, which cannot collect timings from egress interfaces, and provide an alternative method to probe routers which do not respond to traceroute-style packets or when the response is filtered.
- At least three queues affect timestamp processing time: CPU, ingress, and egress. Separating the effects by measuring successive timestamps is the subject of ongoing work.
- Our goal is to perform measurements in wide-area IPv4 networks in order to infer statistics about links and routers to which we do not have administrative access.



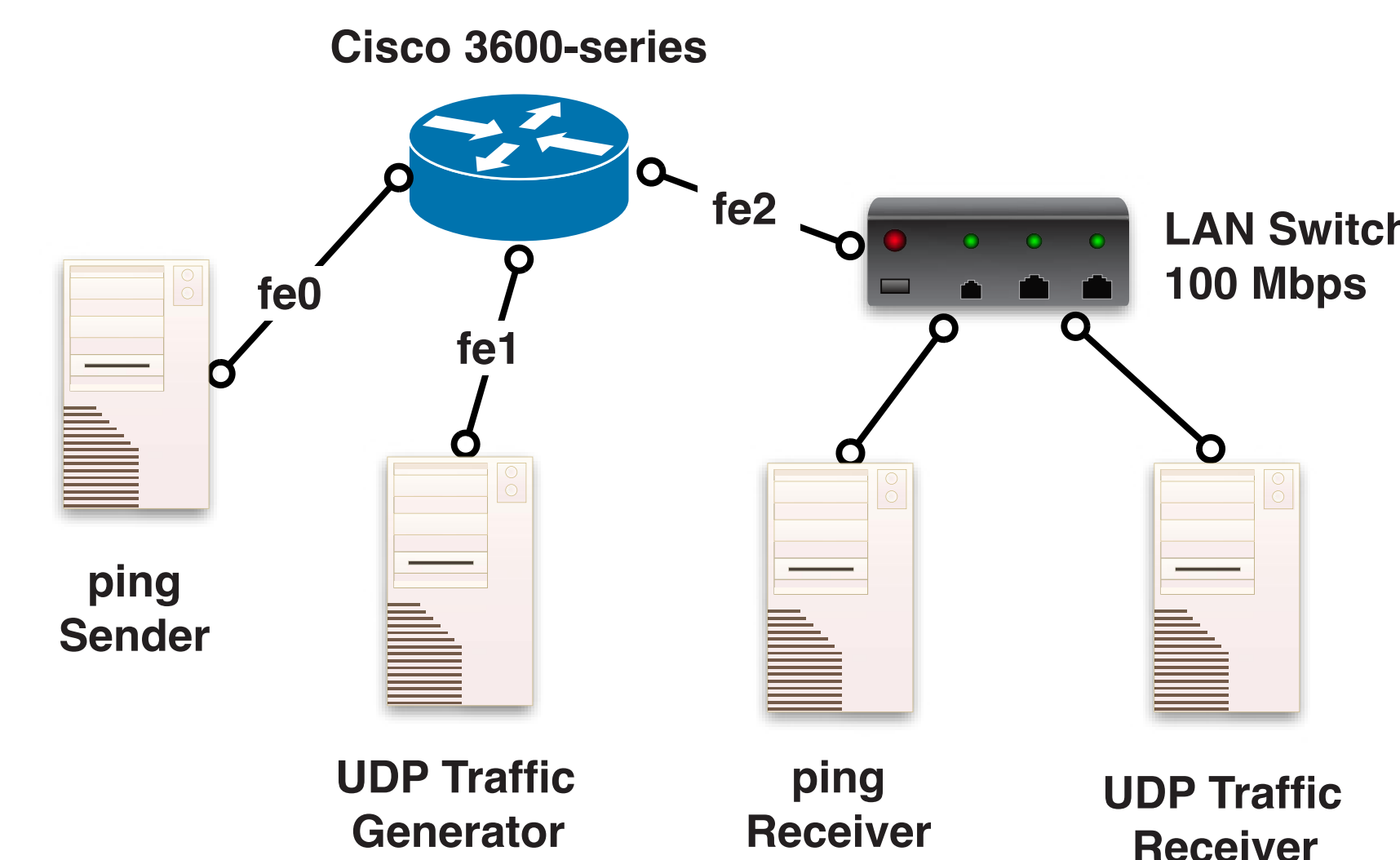
IP Timestamps Requested During Experiments



Measuring UDP Traffic

- For a Cisco 3600-series router, IP Timestamps are correlated with the rate of UDP traffic being processed.

- 100 Mbps network at Wisconsin Advanced Internet Lab configured with router and four Linux hosts. Receivers shared a router interface.

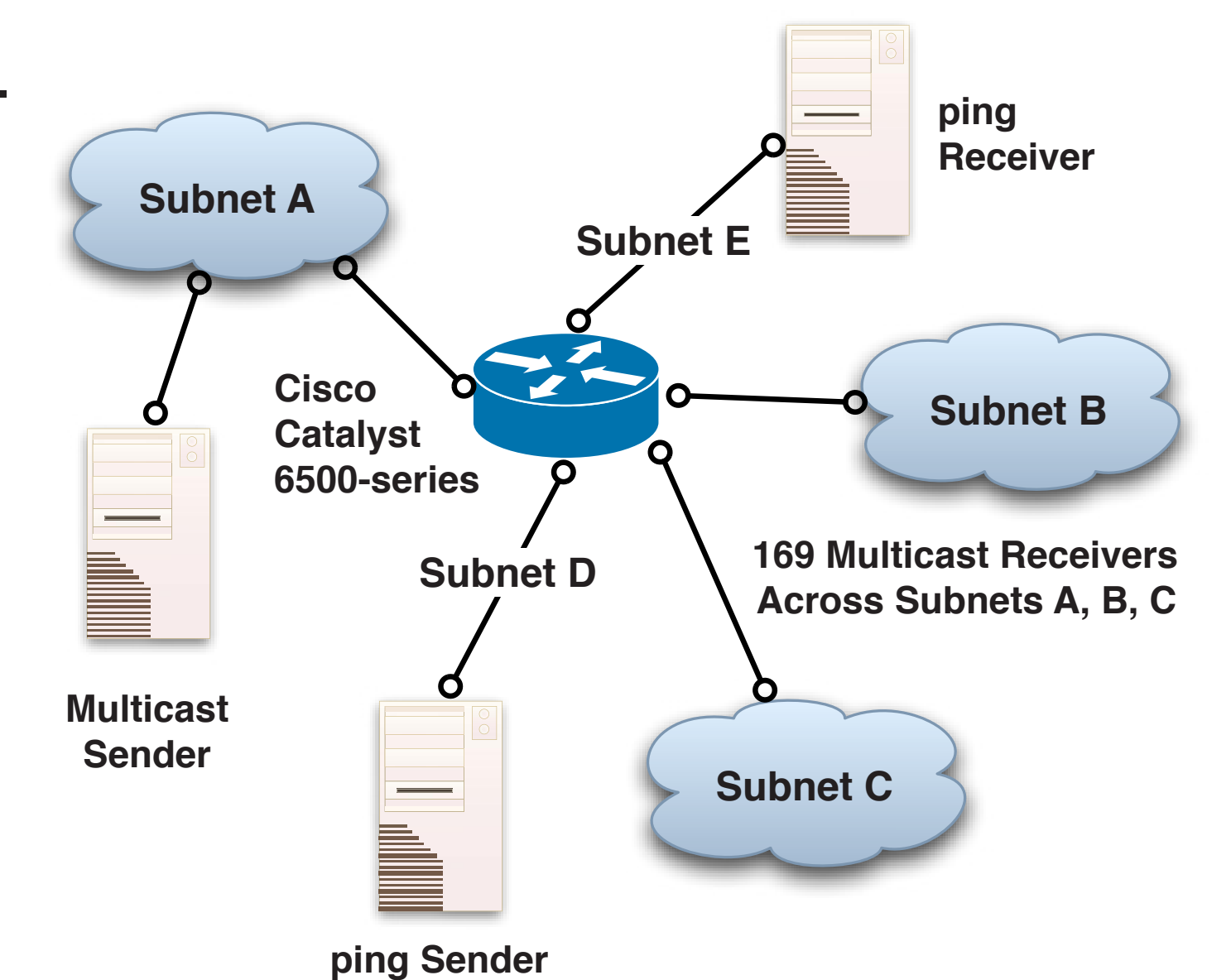


- Sent 2400 ICMP Echo Requests from ping sender to receiver during 20 minute experiment. Packets were alternately sent with and without IP Timestamp option.
- After 60 seconds, sent UDP traffic at a constant rate of 5 Mbps. A minute later, the flow of UDP traffic was reversed for 60 seconds. Flow returned to original direction but at increased rate of 10 Mbps. The flow was similarly reversed after one minute. This pattern continued at 25, 35, ... , 85 Mbps.
- During the experiment, ping packets without IP options did not have increased RTTs. However, the distribution of $R2-R1$ is correlated with the UDP traffic rate.

Detecting Multicast Traffic

- For a Cisco Catalyst 6509, IP Timestamps are correlated with processing of multicast traffic on any subnet.

- Campus router configured with five 1 Gbps subnets, including one multicast sender, 169 multicast receivers (subnets A, B, and C), and two measurement hosts on separate subnets.



- Sent 1800 ICMP Echo Requests from ping sender to receiver during 15 minute experiment. Packets were alternately sent with and without IP Timestamp option.
- Between minutes 5 and 10, generated 8 Mbps of constant UDP multicast traffic.
- Plotting the difference in timestamps $R2-R1$ against the ICMP sequence number, we can recover the timing of the traffic.
- Router reported no buffer misses during the experiment, but CPU usage rose from 3% to 13%. Sending UDP multicast traffic at any rate above 4 Mbps produces the same response.