Measuring Bandwidth

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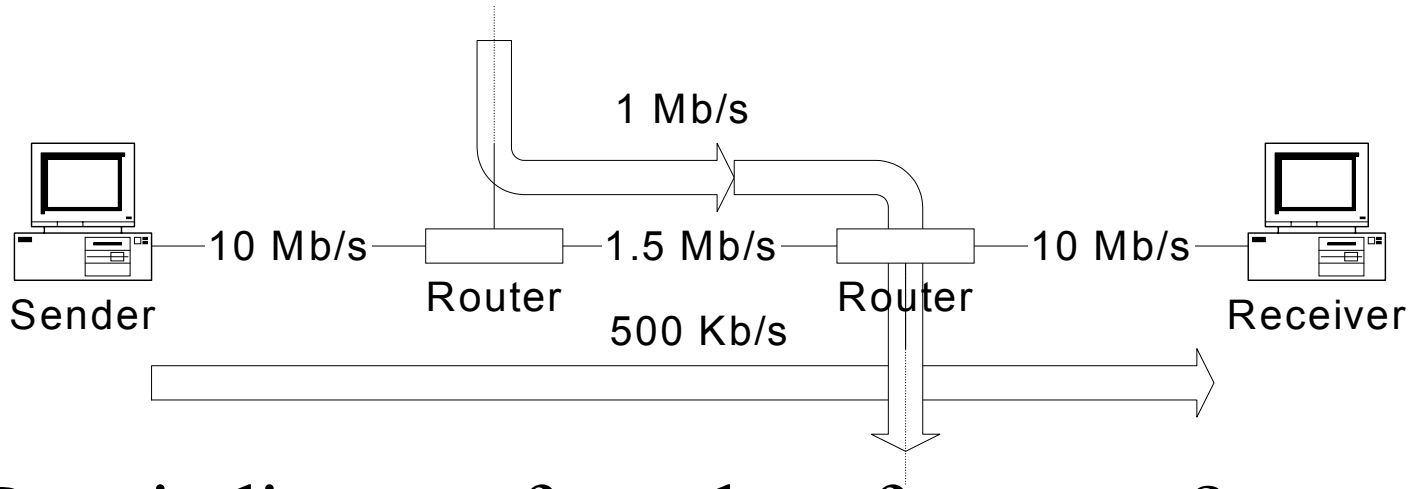
Motivation

- Bandwidth can't be determined statically
  - Too many link capacities, more every day
  - Too much routing instability: 1/3 last < 1 day
- More bandwidth λ more performance
- Adaptive applications need to know
- Current techniques have problems

Available Vs. Bottleneck

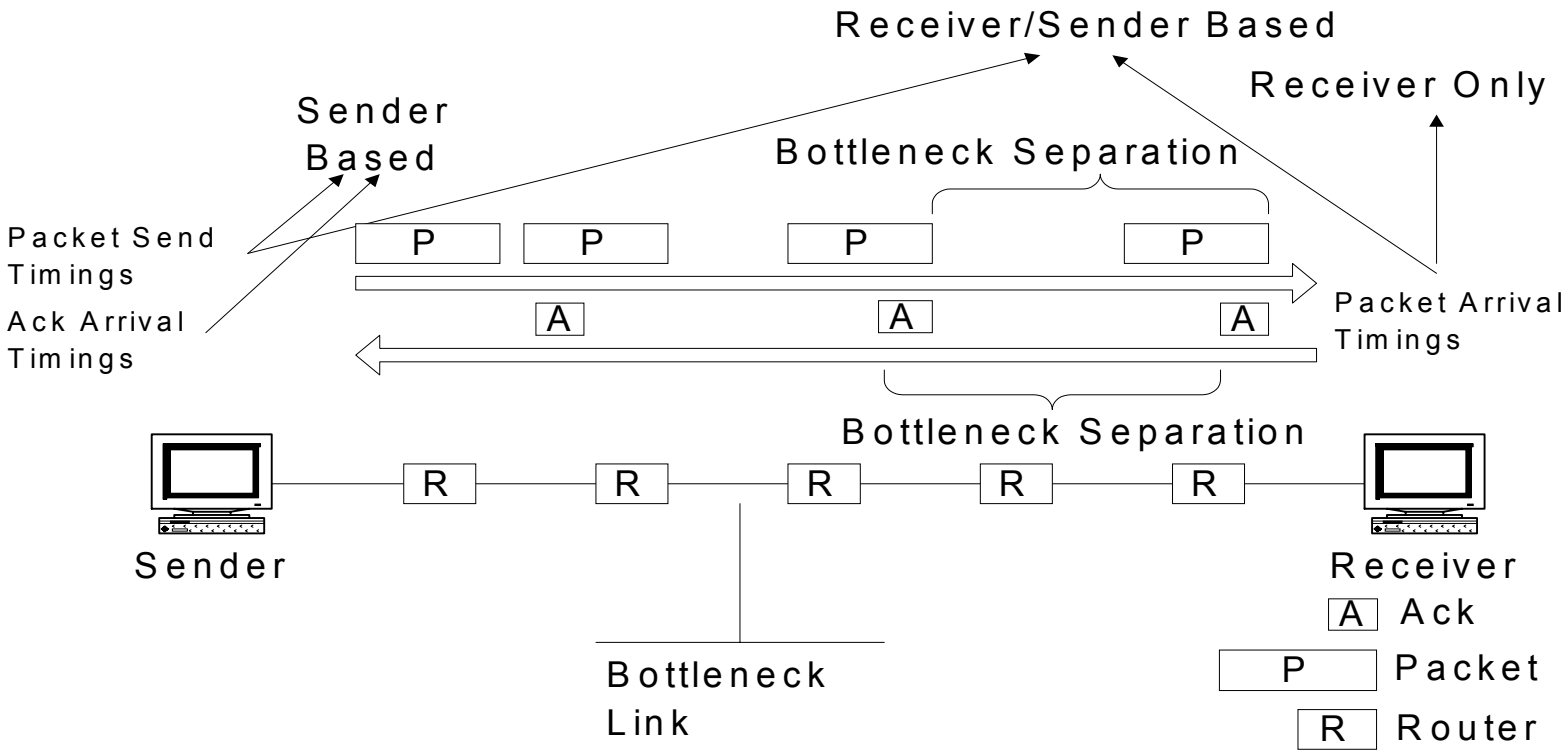


- Best indicator of good performance?
  - Bottleneck: stable, best min delay
  - Available: current, best average throughput
  - (Available / bottleneck): lowest variance
- Best metric depends on application

Prior Work

- TCP Throughput
  - Slow: Wait for TCP to finish slow start
  - Inaccurate:
    - drops cause TCP to slow down
    - slow sender gives low estimate
  - Only measures available bandwidth
- Pathchar
  - Slow: 144 seconds on 10-hop Ethernet network
  - Not scalable: sends 5 MB of data

Packet Pair



- Bandwidth = (Packet Size) / (Separation)
  - Can use existing traffic
  - Can converge after sending two packets

Innovations to Packet Pair

- Gradual Measurement
  - Use a packet window to measure bandwidth instantaneously
- Receiver-Only Packet Pair (ROPP)
  - High accuracy without deployment of special software.
- Potential Bandwidth Filtering (PBF)
  - Handle all possible packet sizes and rates

Receiver-Only Packet Pair (ROPP)

- Take measurements only at receiver.
- Avoid inaccuracy of Sender-Based Packet Pair
- Avoid having to deploy special software at two hosts
- Can only measure bandwidth in the download direction.

Potential Bandwidth Filtering (PBF)

- Problem:existing traffic may be unsuitable for Packet Pair
  - Small or slowly sent packets can mislead Packet Pair implementations
  - Example: TCP acknowledgements
- Solution: filter out small or slowly sent packets
  - PBF uses robust statistical methods to filter.

Simulation Results

- Accuracy of Receiver-Only Packet Pair

Timings Taken At	Error
Sender	1200.00%
Receiver/Sender	0.09%
Receiver	0.08%

- Accuracy of Potential Bandwidth

Timings Taken At	Filtering	Bandwidth	Error
Sender	Regular	10Mb/s	44.2%
Sender	PBF	10Mb/s	7.8%
Receiver/Sender	Regular	500Kb/s	435.0%
Receiver/Sender	PBF	500Kb/s	0.0%

Current and Future Work

- Simulate Pathchar algorithm
  - Compare speed, accuracy with Packet Pair
- Nettimer tool
  - Collects data from Internet
- Apply Nettimer
  - Scale bandwidth of video/voice applications
  - Choosing web servers/proxies

Conclusion

- Must measure bandwidth for performance, scalability
- Current techniques have problems
- Packet Pair is fast and accurate.
- Shown substantial improvements to existing Packet Pair
  - Accuracy
  - Flexible