

The Effect of Layer-2 Switches on Pathchar-like Tools

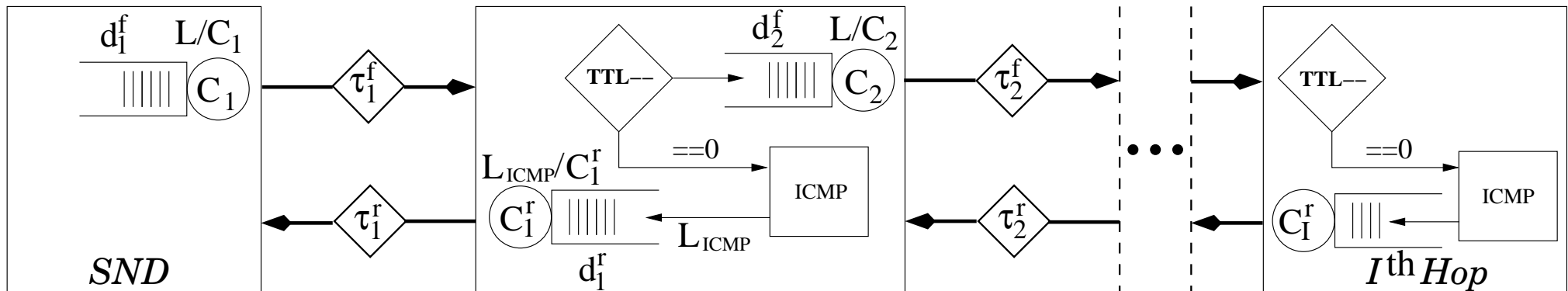
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Overview of pathchar-like tools

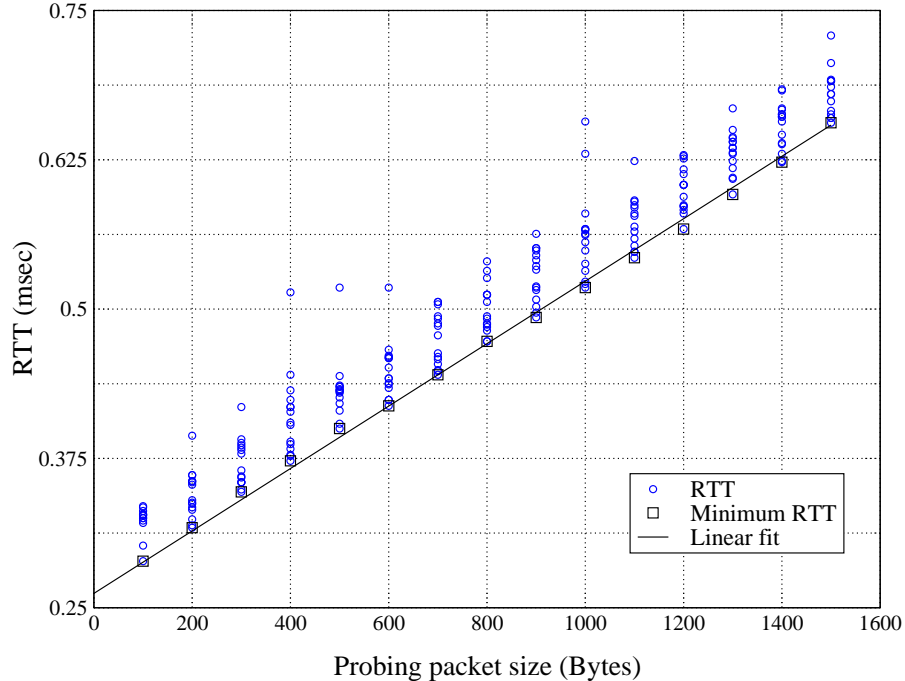
- *pathchar, pchar, clink* - Objective : estimate link capacities
- They all use the Variable Packet Size (VPS) probing methodology
- Estimate Round Trip Time (RTT) up to hop I



- Propagation delays τ
- Queuing delays d
- Serialization delays L/C

VPS methodology

- Assume that minimum RTT for each packet size does not include queuing delays



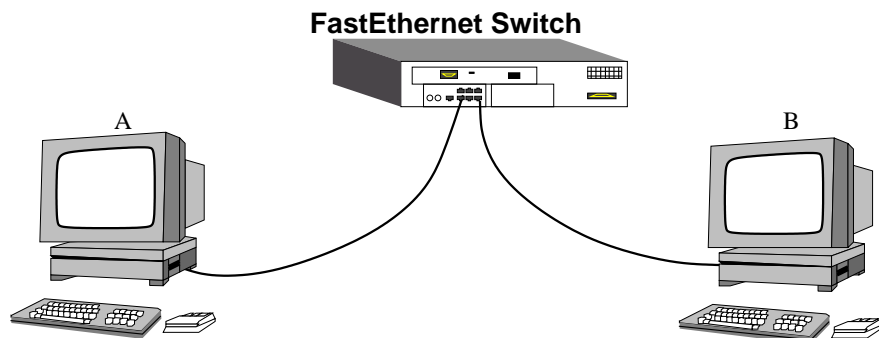
- Minimum RTT for packet size L up to hop I :

$$T_I(L) = \alpha_I + L \sum_{i=1}^I \frac{1}{C_i} = \alpha_I + L\beta_I$$

- Estimated capacity of hop I :

$$C_I = \frac{1}{\beta_I - \beta_{I-1}}$$

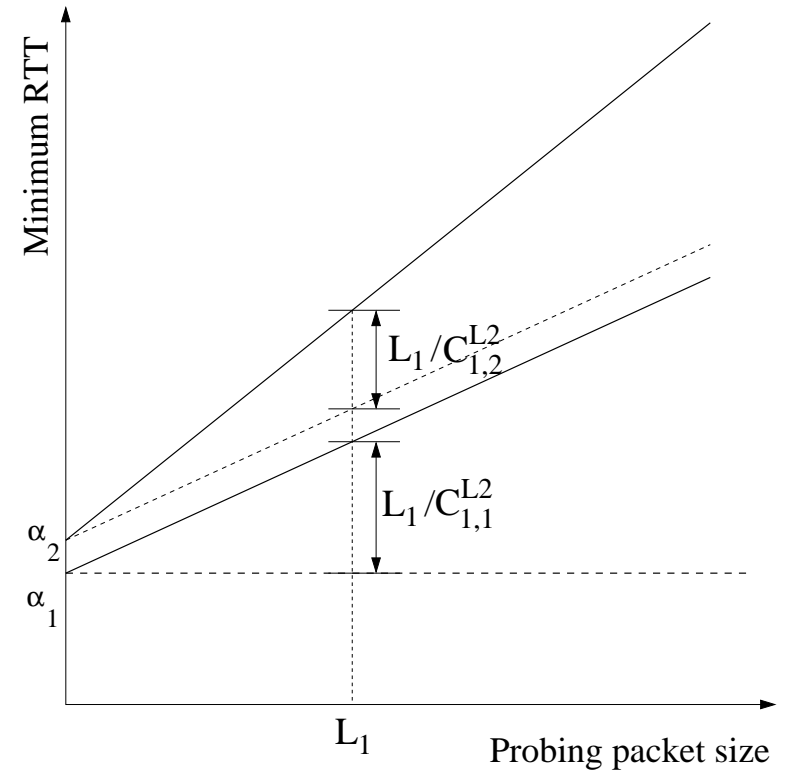
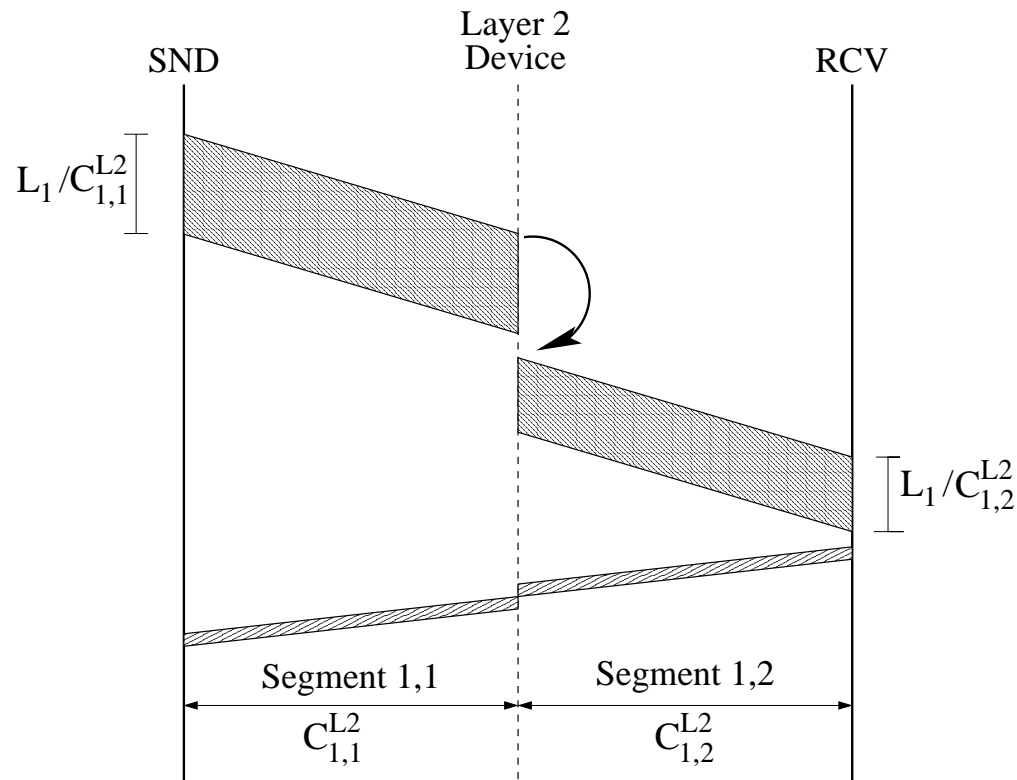
A single-hop path



Tool	Capacity estimate
<i>pathchar</i>	$49.0 \pm 1.5 \text{ Mbps}$
<i>clink</i>	$47.5 \pm 1.0 \text{ Mbps}$
<i>pchar</i>	$47.0 \pm 1.0 \text{ Mbps}$

- A and B have Fast Ethernet network interfaces
- Correct capacity $\simeq 97 \text{ Mbps}$ (IP layer)
- All these tools consistently underestimate the link capacity
- What went wrong?
 - The tool, or the estimation methodology?

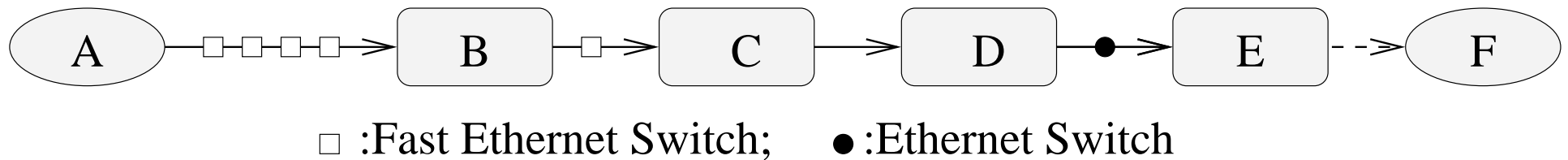
Effect of L2 store-and-forward switches



$$\beta_1 = \frac{1}{C_{1,1}^{L2}} + \frac{1}{C_{1,2}^{L2}}$$

$$\text{Estimated capacity} = \frac{1}{\frac{1}{C_{1,1}^{L2}} + \frac{1}{C_{1,2}^{L2}}} < \text{Correct capacity} = \min \{C_{1,1}^{L2}, C_{1,2}^{L2}\}$$

Experimental results at a UDel campus network path



L3 hop	Capacity	L2 segments	<i>pathchar</i>	<i>clink</i>	<i>pchar</i>
A to B	100Mbps	5 Fast-Ethernet	17.0 ± 0.0	17.0 ± 0.0	17.0 ± 0.4
B to C	100Mbps	2 Fast-Ethernet	62.2 ± 7.2	64.7 ± 9.3	62.3 ± 9.1
C to D	100Mbps	1 Fast-Ethernet	100.5 ± 15.0	100.3 ± 22.0	101.9 ± 26.0
D to E	10Mbps	2 Ethernet	5.75 ± 0.15	5.6 ± 0.1	5.7 ± 0.1
E to F	10Mbps	??	4.5 ± 0.1	3.7 ± 0.1	6.5 ± 0.6

Other sources of error in VPS tools

- Non-zero queuing delays
- Limited clock resolution
- Error propagation/amplification from the previous hop
- ICMP generation latency
 - For a detailed analysis, see Infocom 2003, San Francisco.

Thank you!