



An Aspect of Topology Determination

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IP Telephony

Contact Centers

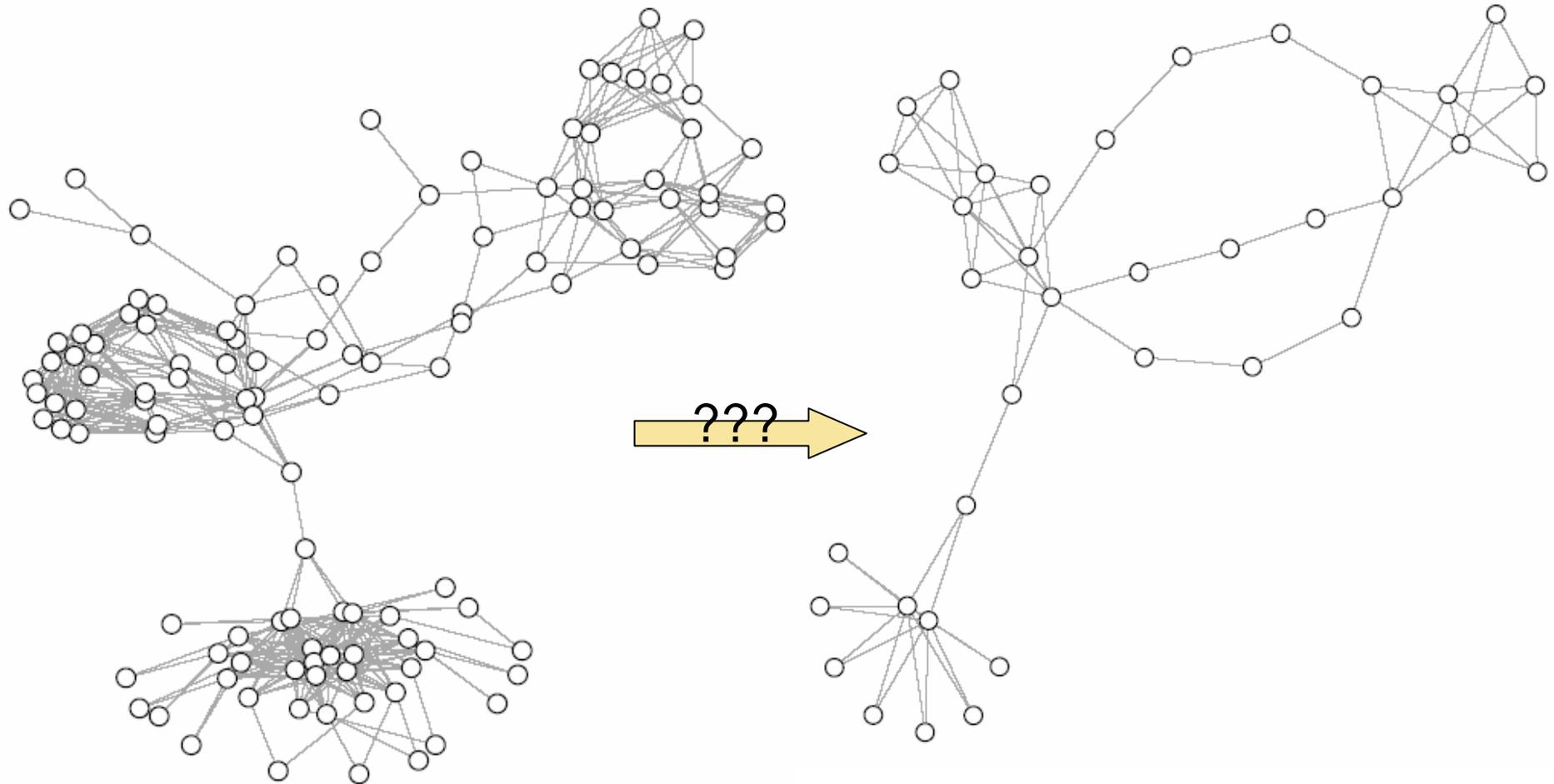
Mobility

Services

One network, two topologies

● >250 IP addresses

● 40 devices



Problem

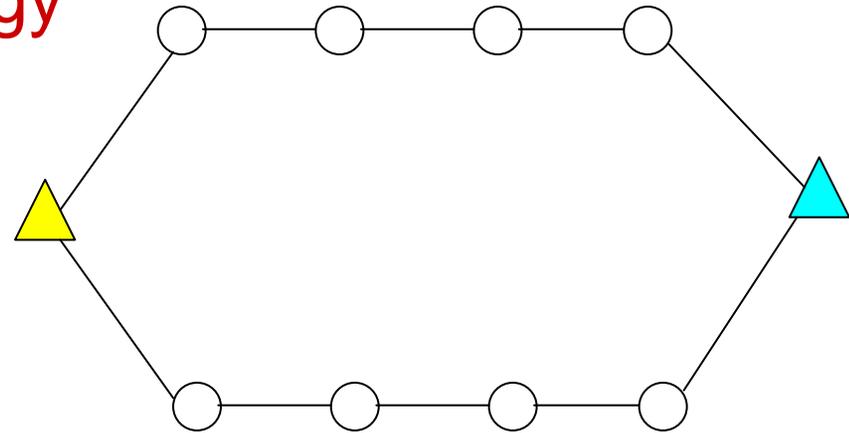
- Network path
 - important covariate for end to end performance analysis and trouble shooting
- Path information hard to obtain
 - Customer interview
 - Record route
- Traceroute is a good option
 - But its results hard to interpret
 - N interfaces, N IP addresses
- Identifying IP addresses that belong to the same physical device
 - Necessary for trouble shooting
 - Complements other tools
 - DNS, SNMP, telnet, traceroute

From traceroute to topology

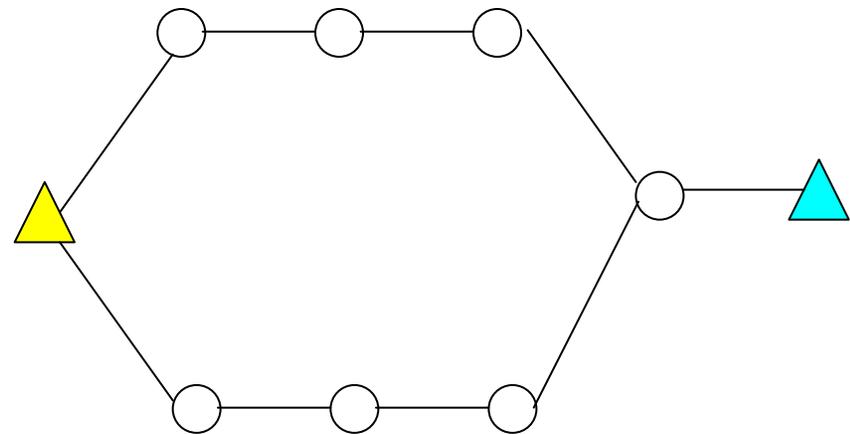
tr ↓

21.56.52.38	21.56.52.38
21.56.52.37	22.152.2.153
22.152.15.7	21.56.74.9
21.56.74.10	23.181.201.90
21.60.1.50	21.60.1.1
21.60.1.2	21.60.1.2

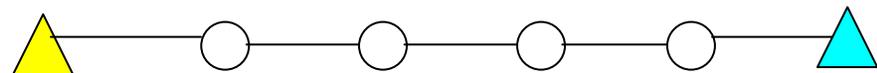
↑



or

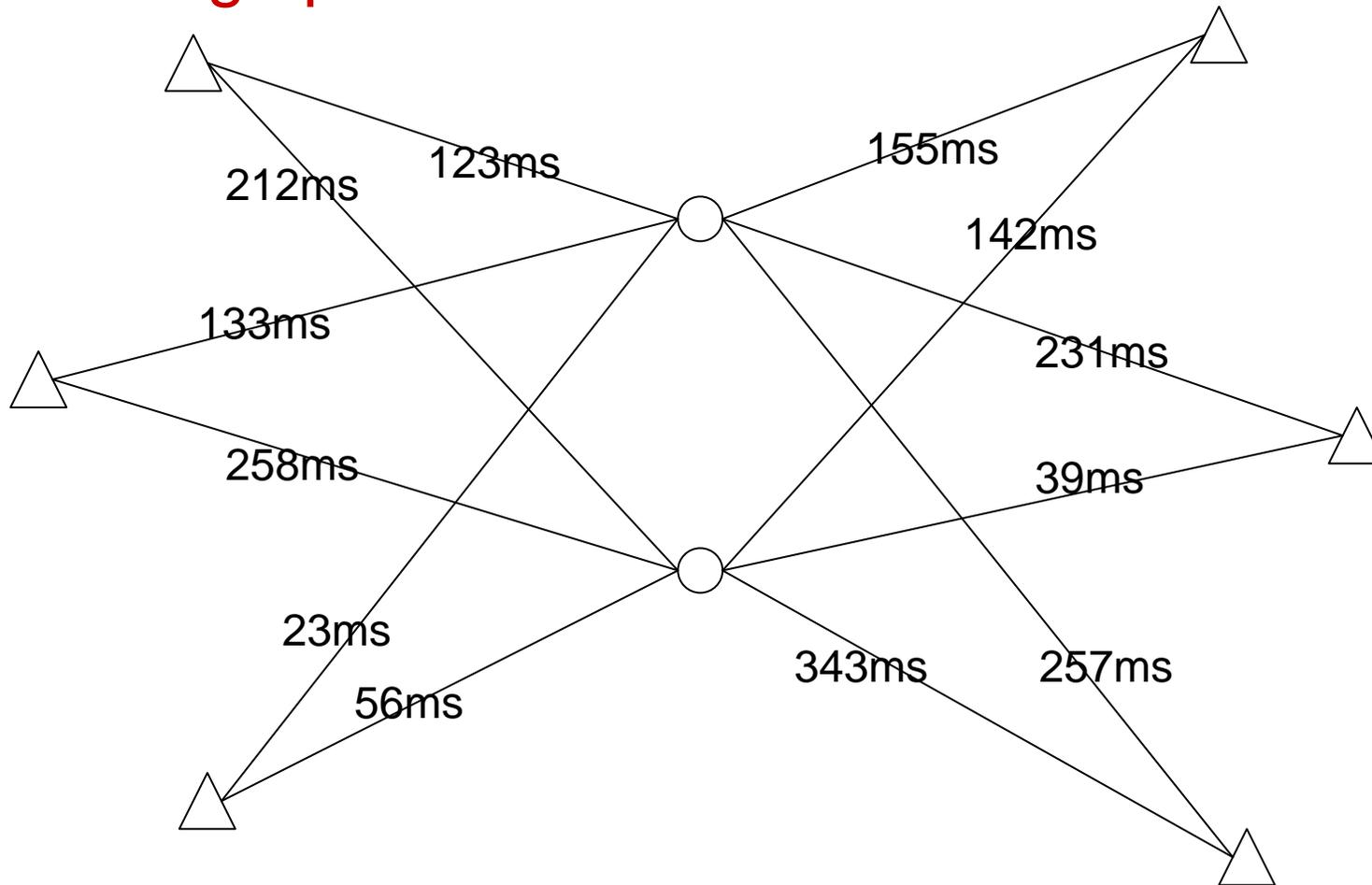


or

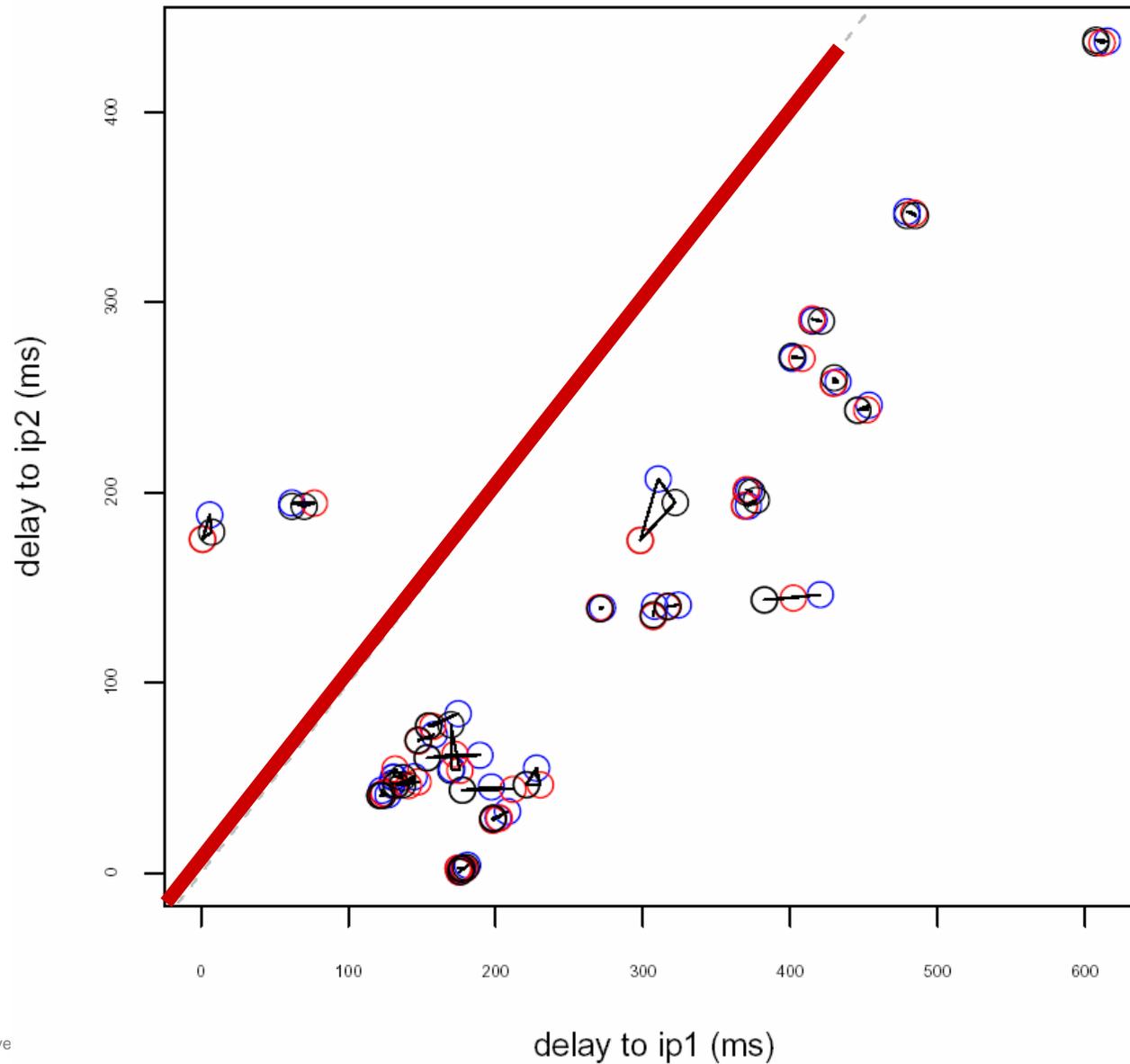


?

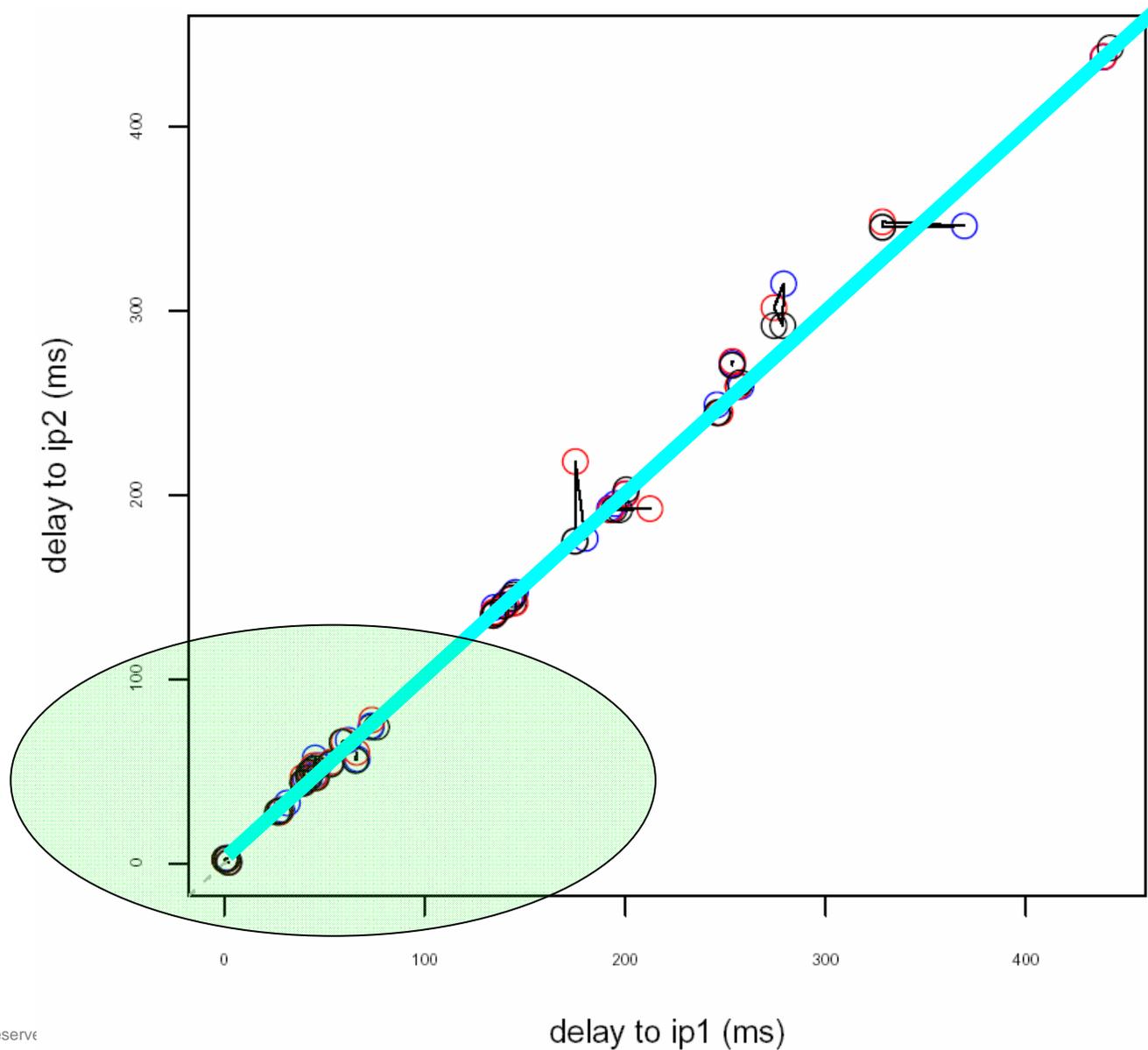
How to differentiate/identify devices? Pinging from vantage points



Comparing two IPs: reject



Comparing two IPs: accept



Inferring distances between devices

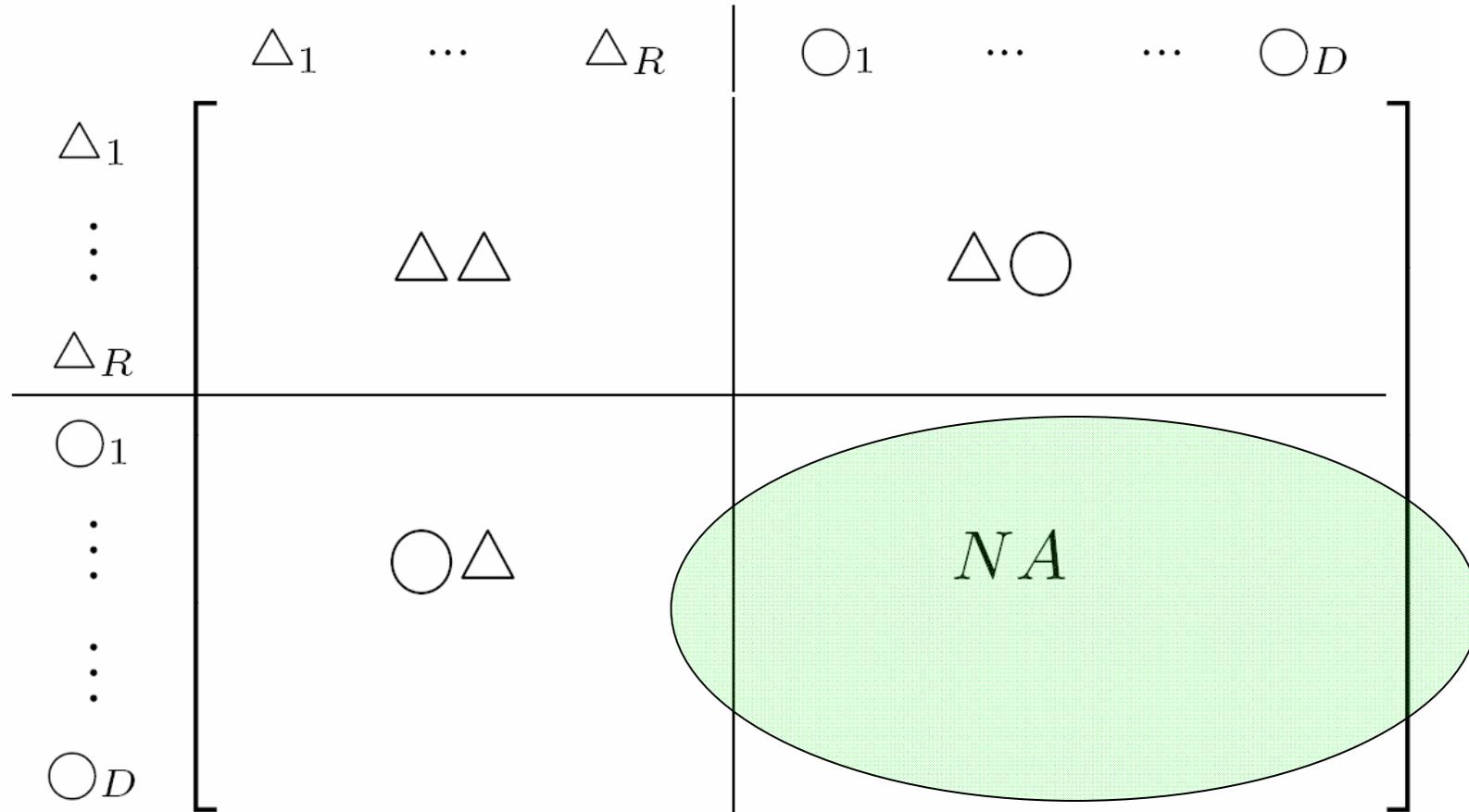
$$D_{\Delta_k \circ_i} = a_i + \epsilon$$

$$D_{\Delta_k \circ_j} = b_j + \epsilon$$

$$H_0 : a_i = b_j$$

- Weighted robust regression
 - Weight by distance to endpoint
 - Minimum of round trip observations from each endpoint
 - Test against 0-1 line

Alternatively



$$D_{\bigcirc_i \bigcirc_j} \sim \sum_{k=1}^R w (D_{\Delta_k \bigcirc_i} - D_{\Delta_k \bigcirc_j})^2$$

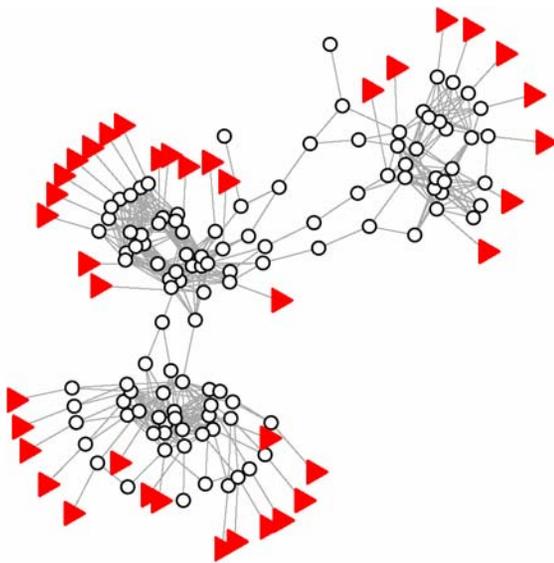
Results

- Using
 - 40 endpoints ping each IP address 3 times
- Getting
 - 94% correct identification of all known pairs
 - ~0% mis identification of all known non-pairs with enough endpoints

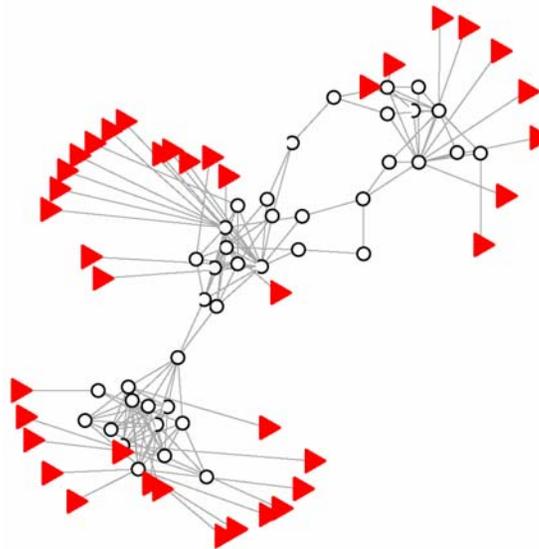
# of vantage points	3	5	10	15	20	30
Non-pairs identified as pairs	2.5% (650)	0.5%	0	0	0	0
Pairs identified as non-pairs	30% (230)	25%	13%	10%	9%	6.5%

Results

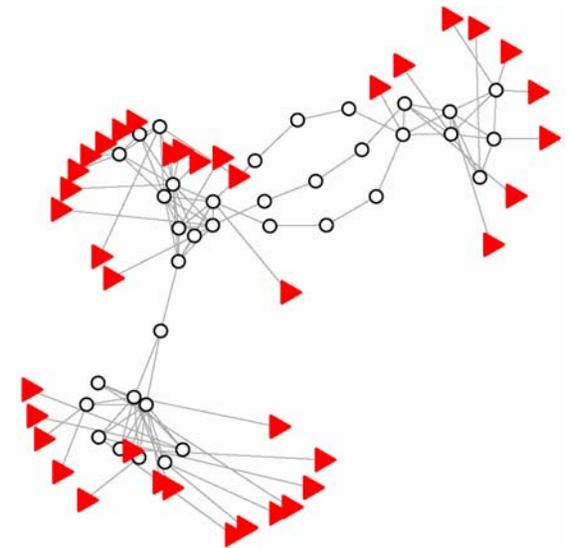
▲ Endpoints
○ IP/devices



IP topology

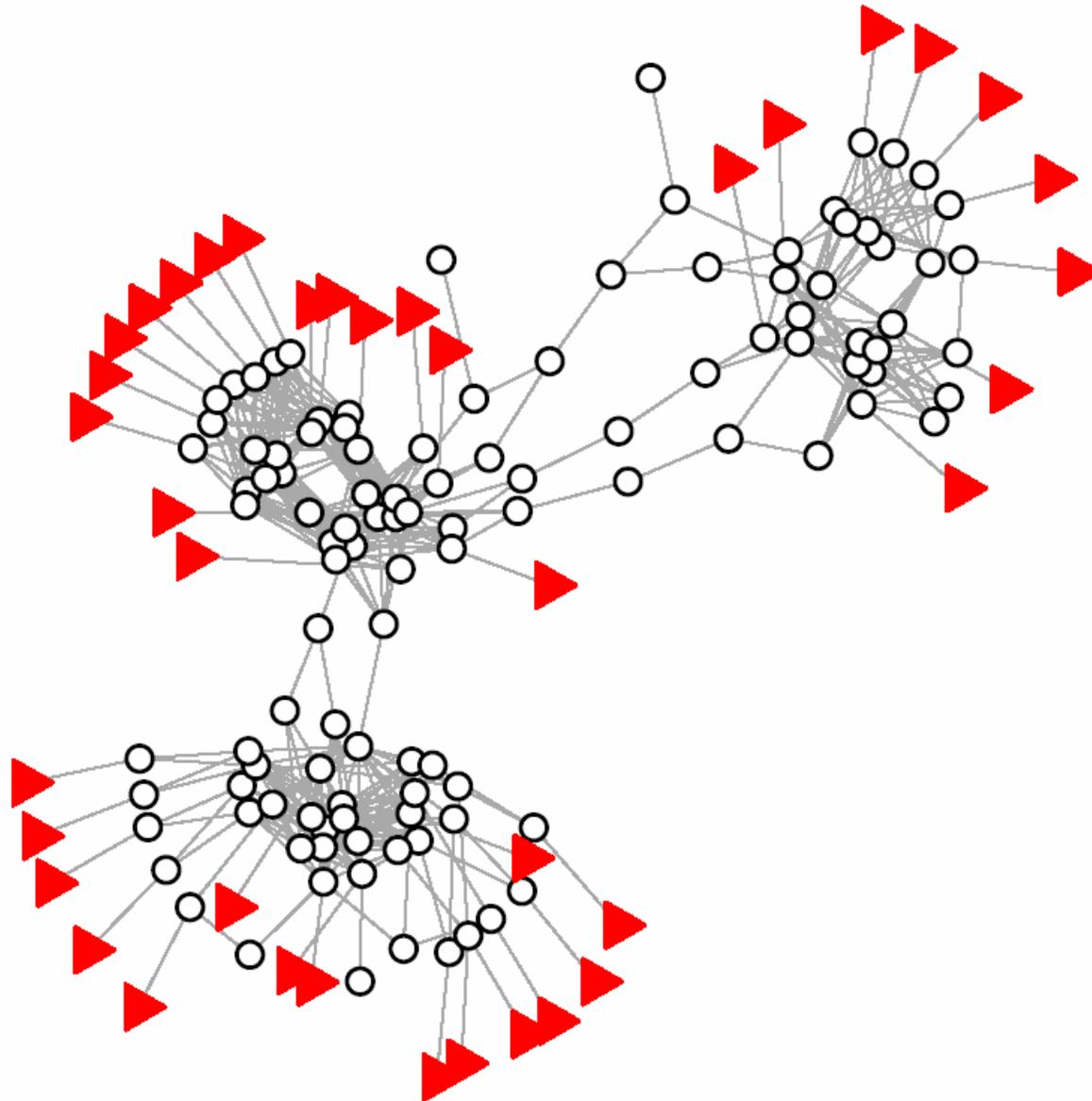


Estimated topology

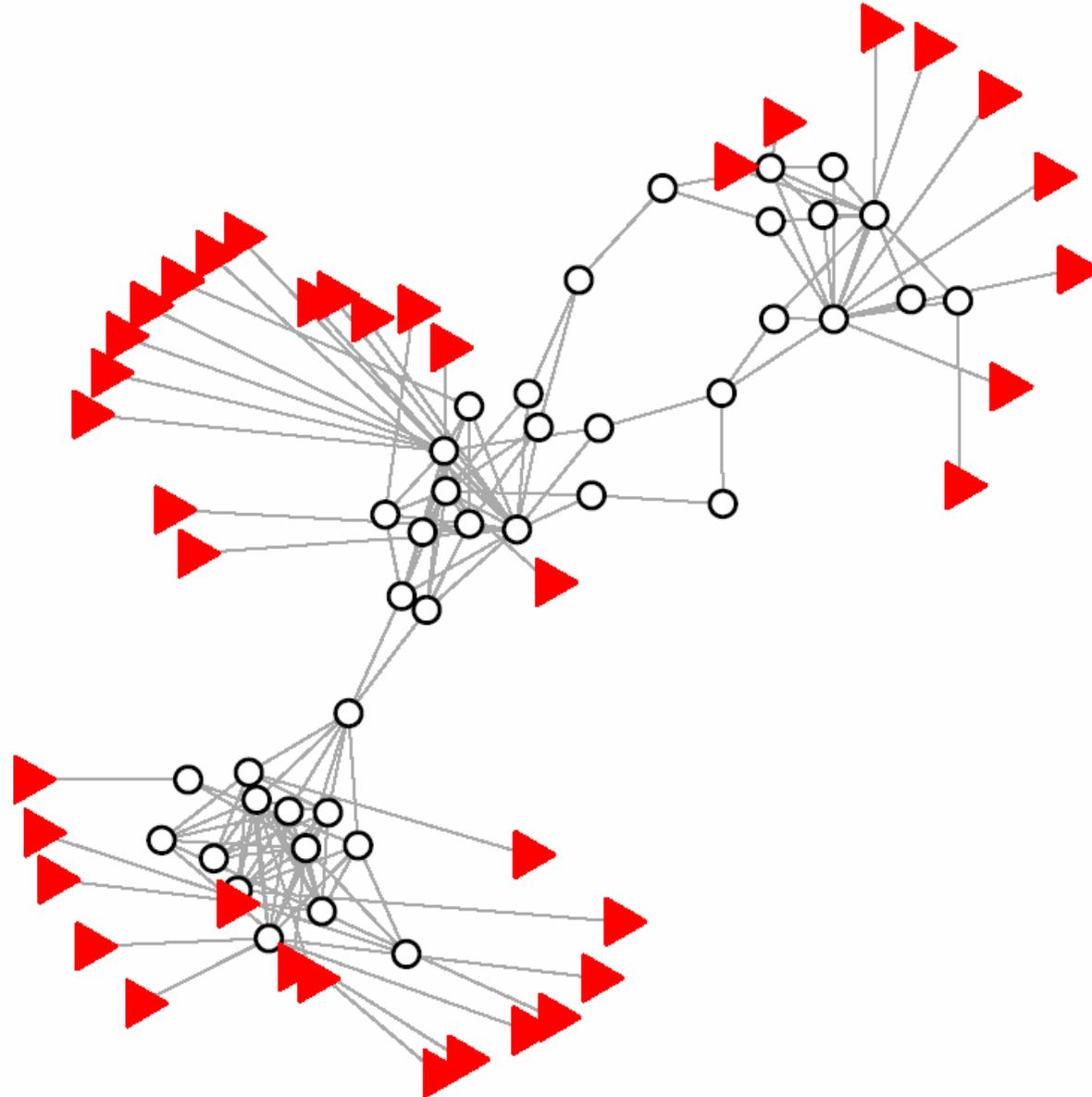


True device topology

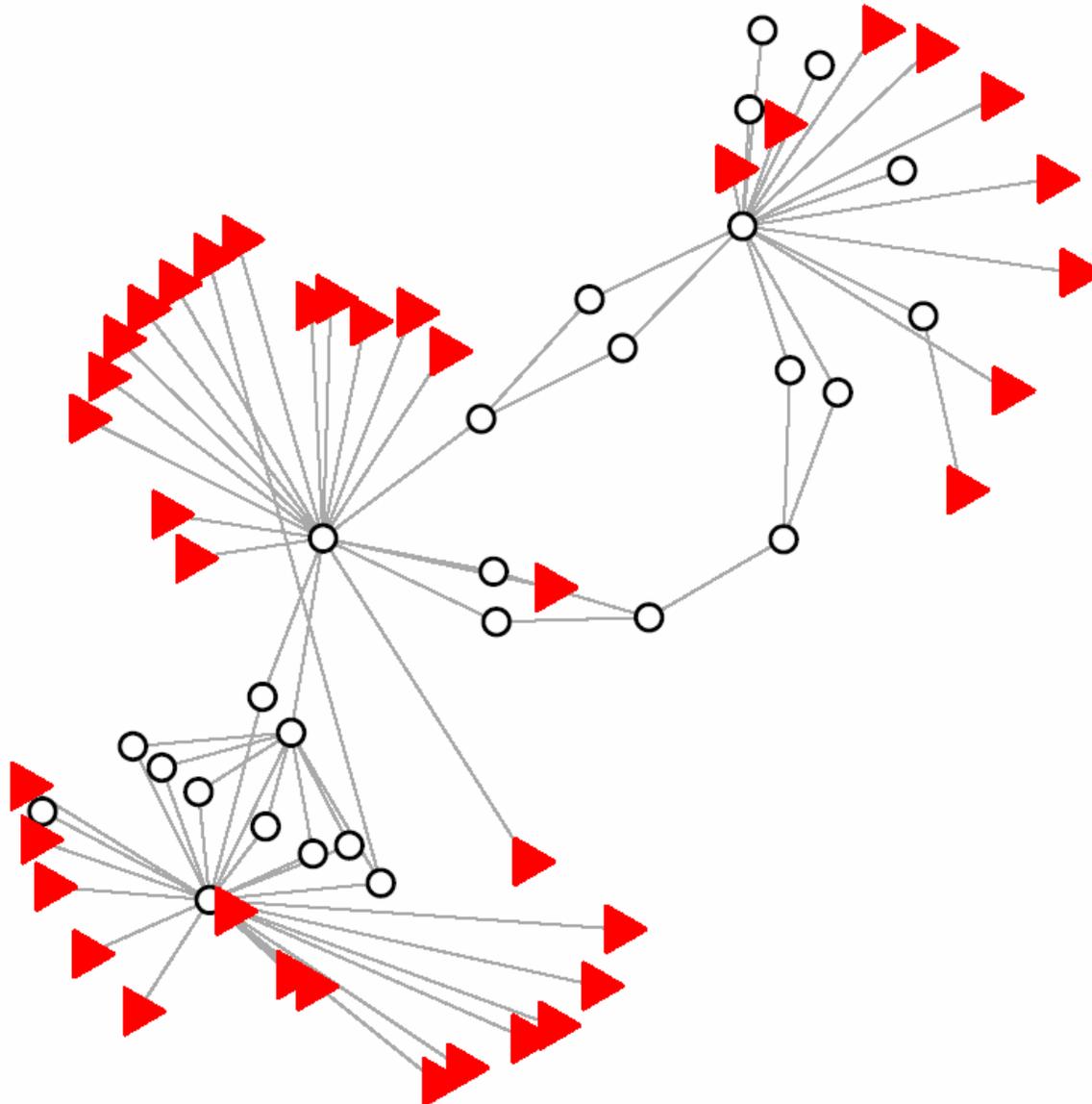
View network at different resolutions



View network at different resolutions



View network at different resolutions



Conclusion

- Using endpoints, we can reliably classify IP addresses into physical devices
- Placement of endpoints is important
 - Resolution depends on placement
 - Two devices in a room, vs,
 - Two devices on a campus
- Useful for network management, topology drawing