UMassAmherst

Informed Detour Selection Helps Reliability

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Internet Reliability Problem

- Internet service outage probability 1.5% – 3.3% (Paxson, Dahlin, etc)
  - Far short of 0.001% (99.999%, or five nines of reliability) observed in telephone networks

- <u>How can we improve?</u> Add **redundancy**
  - Server redundancy
    - CDNs (Akamai)
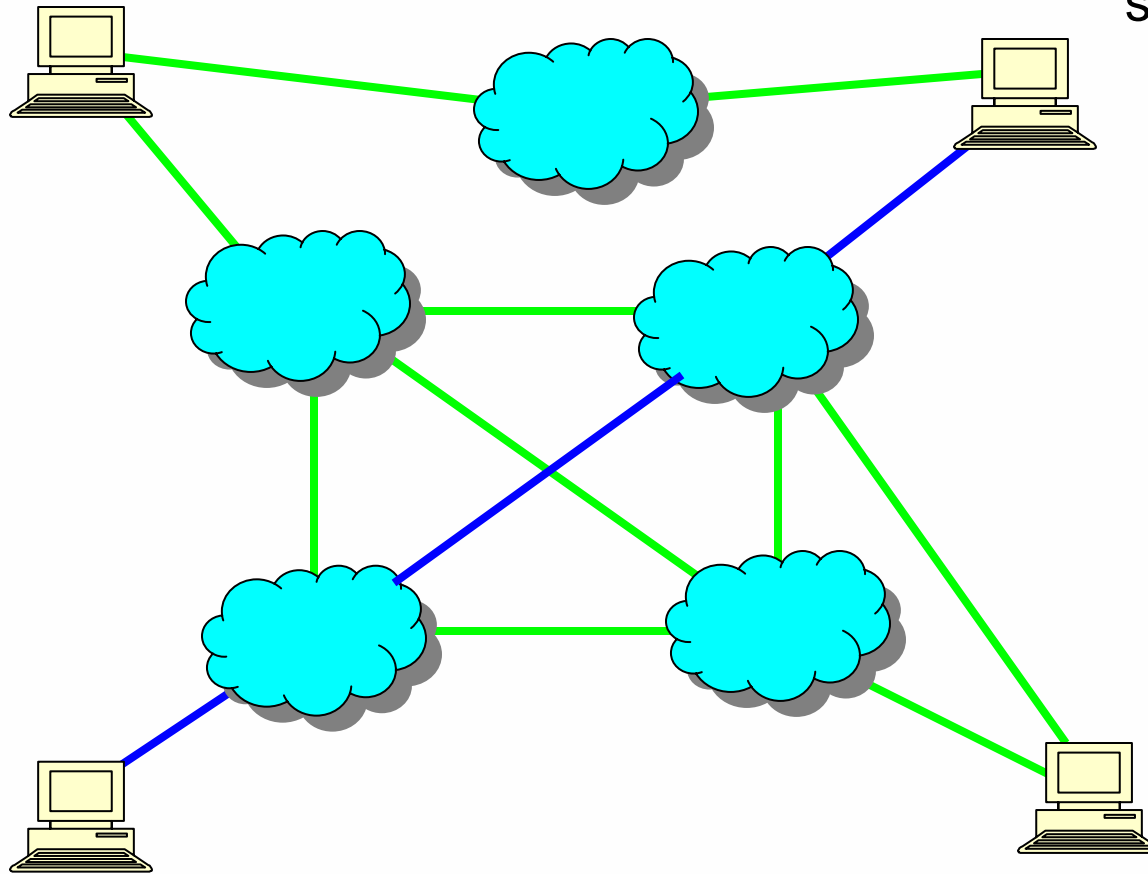 - **Path redundancy**

Path Redundancy

intermediary 1
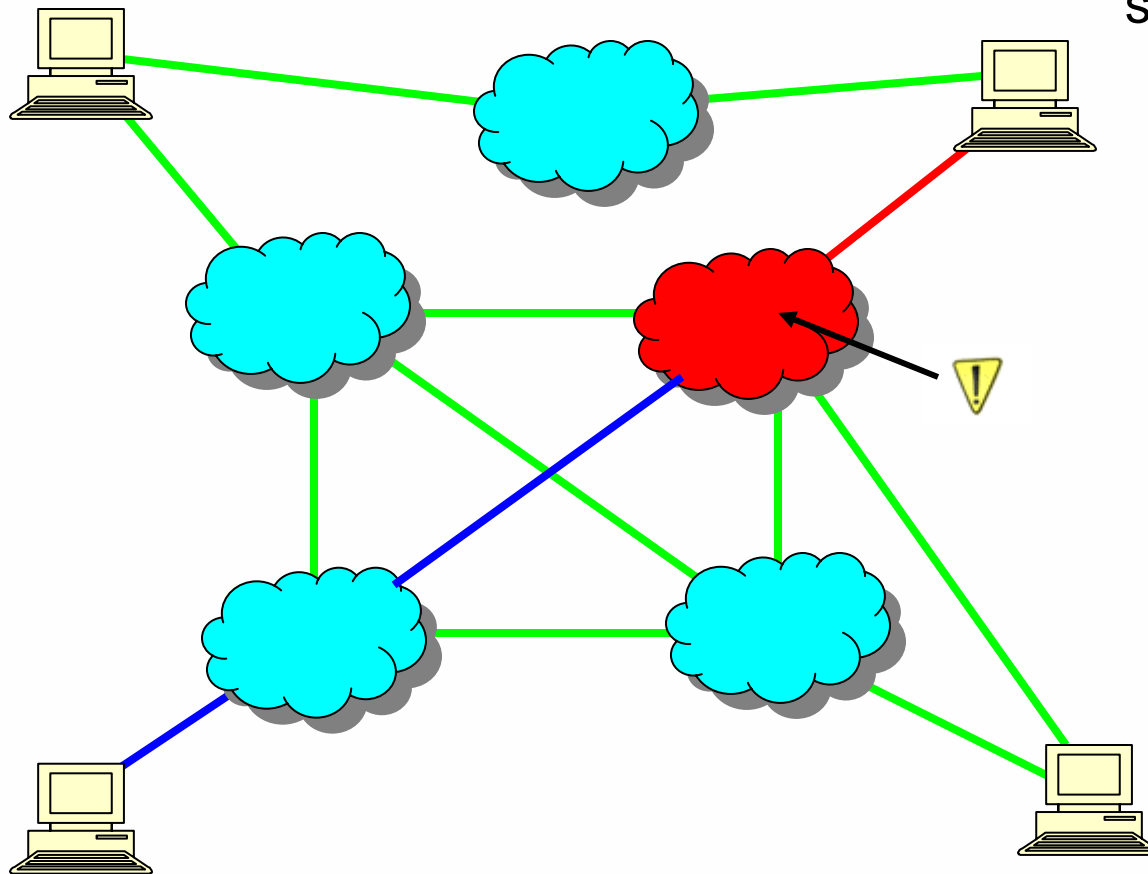
server

client

intermediary 2

Path Redundancy

intermediary 1

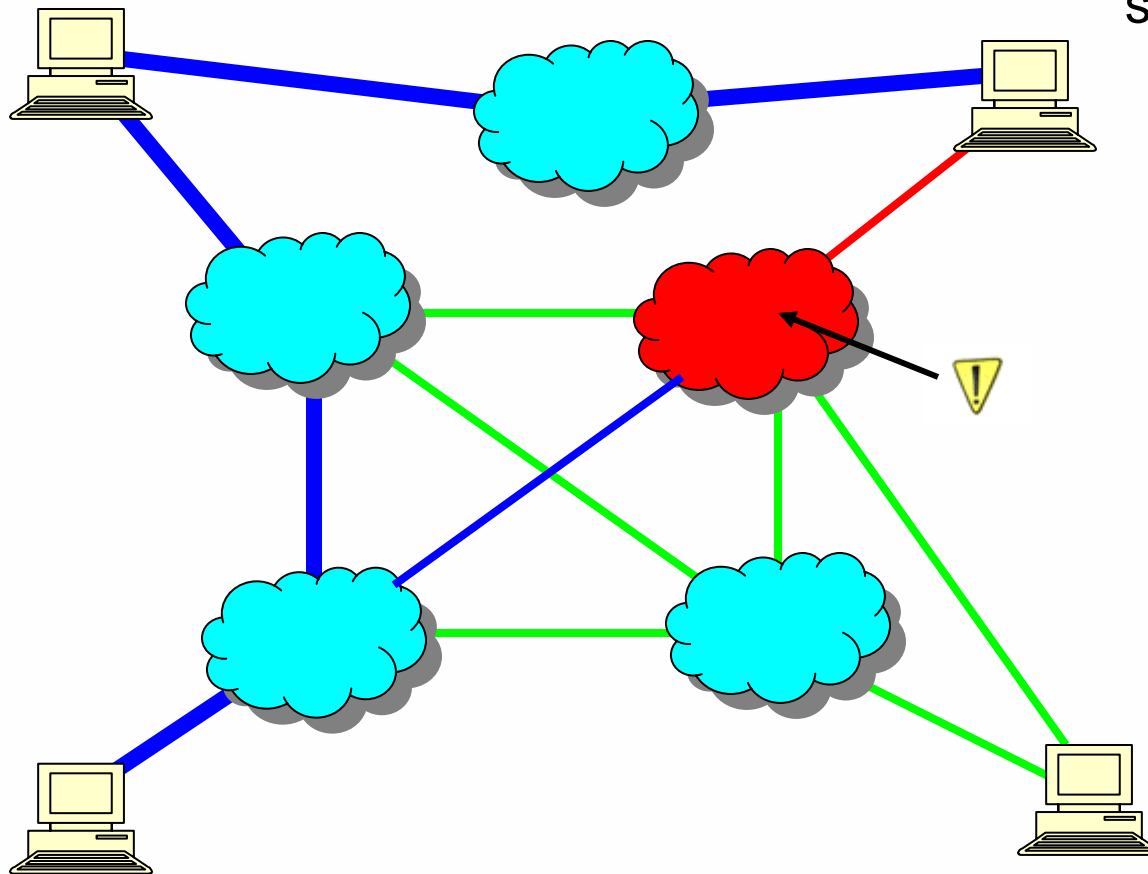server

client

intermediary 2

Path Redundancy

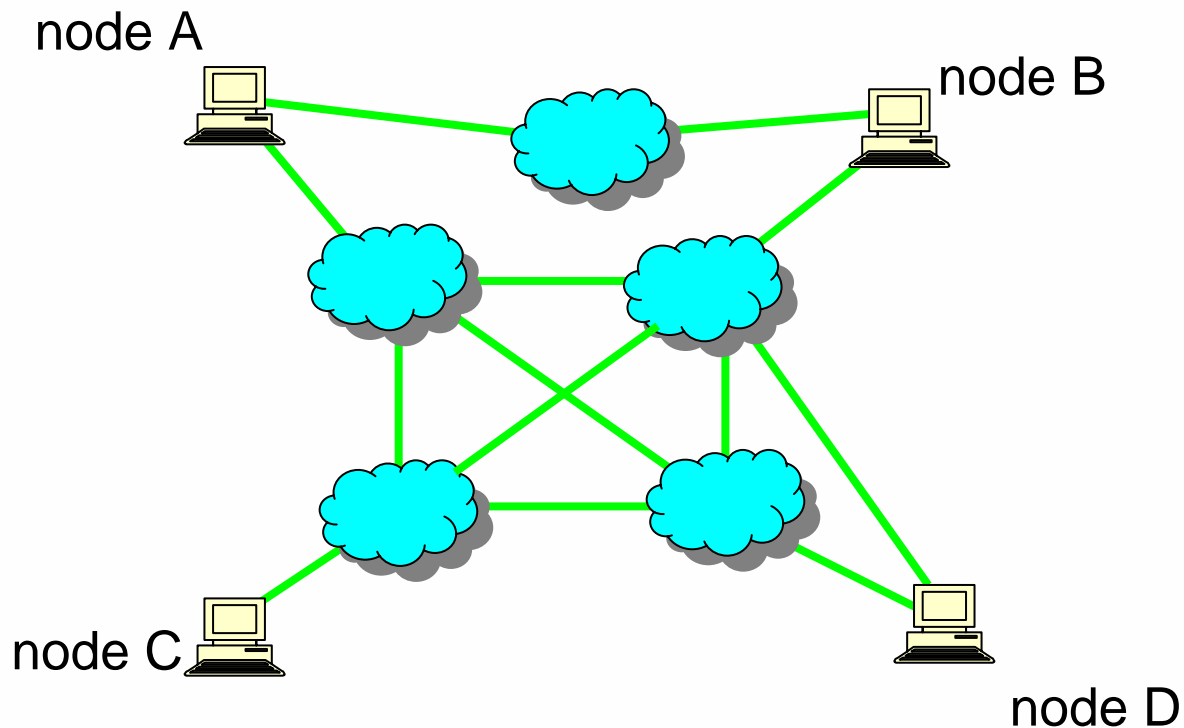intermediary 1

server

client

intermediary 2

Outline

- Introduction and motivation
- Previous work
- Our proposal
- Experimental validation
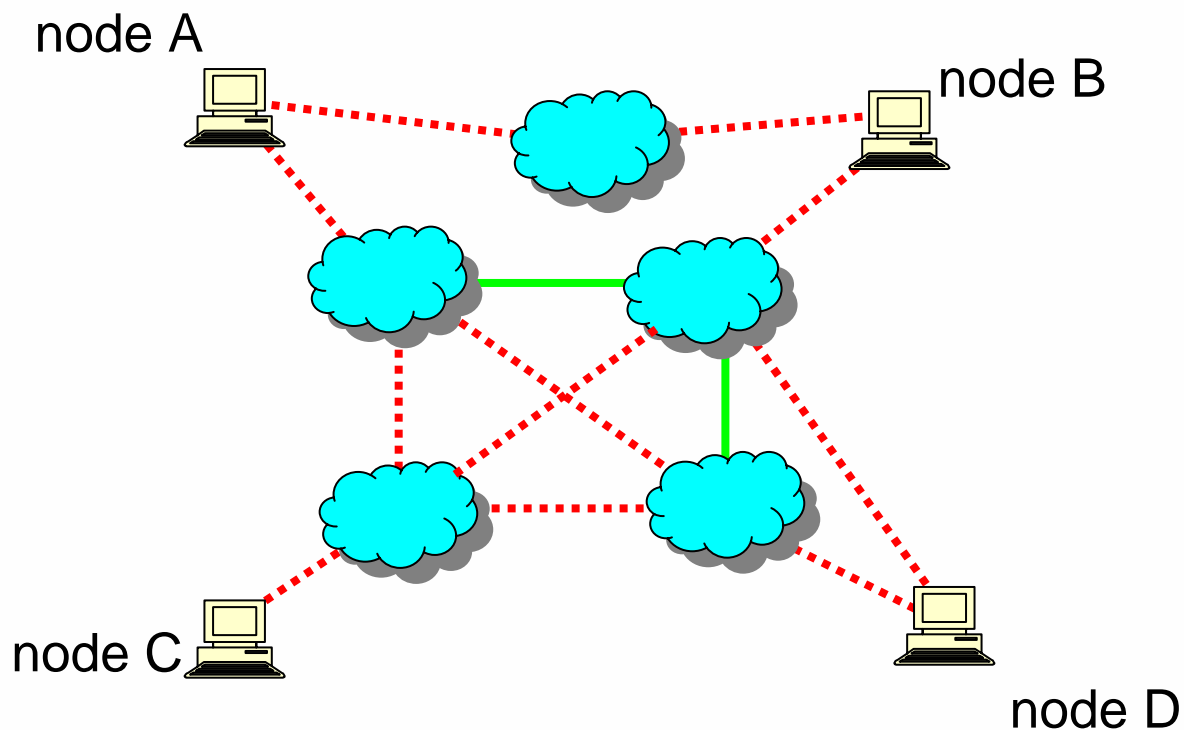- Discussion
- Conclusion

Choosing intermeds: aggressive probing

- Aggressive monitoring of complete overlay graph
  - Example: RON (Resilient Overlay Network)

Choosing intermeds: aggressive probing

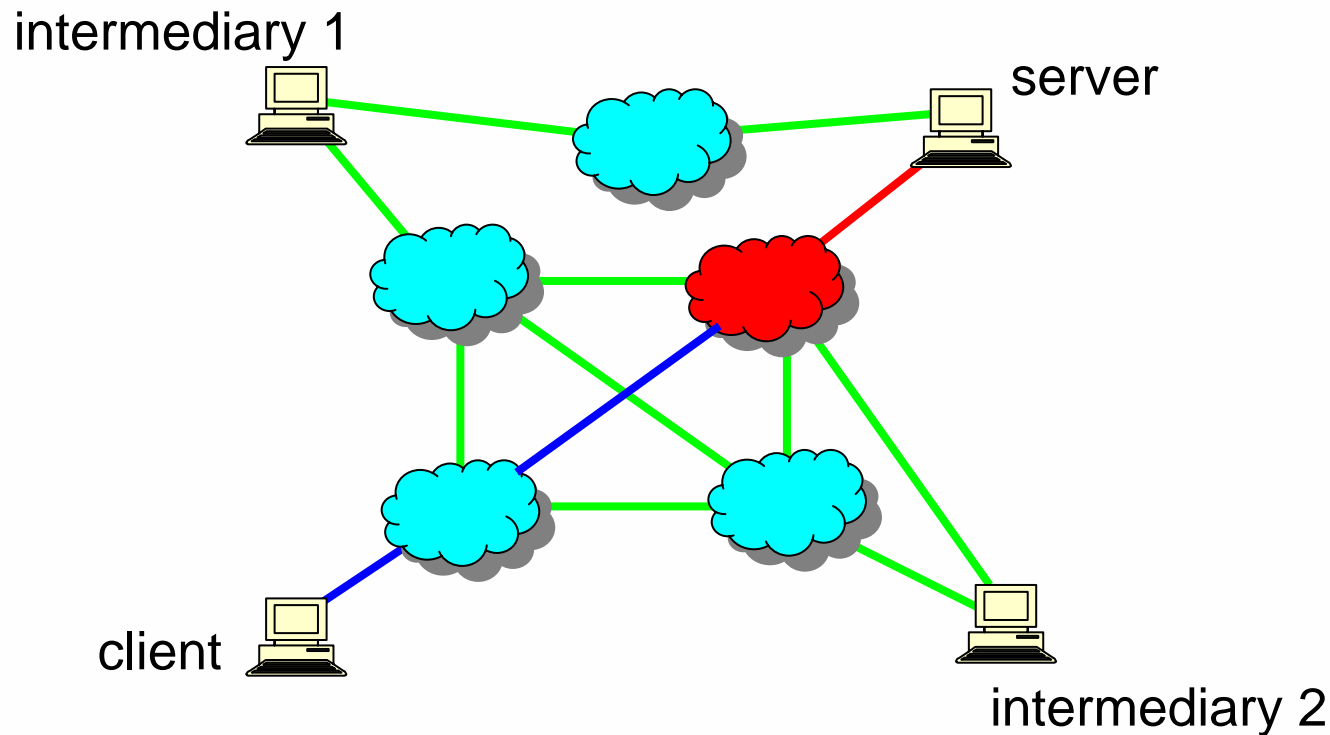- Aggressive monitoring of complete overlay graph
  - Example: RON (Resilient Overlay Network)
- Problem: monitoring overhead $\Rightarrow$ lack of scaling

node A
node B
node C
node D

Choosing intermeds: random choice

- Choose intermediaries randomly
  - No path monitoring, assume uncorrelated paths
  - Example: SOSR (Scalable One-hop Source Routing)

intermediary 1

server

client

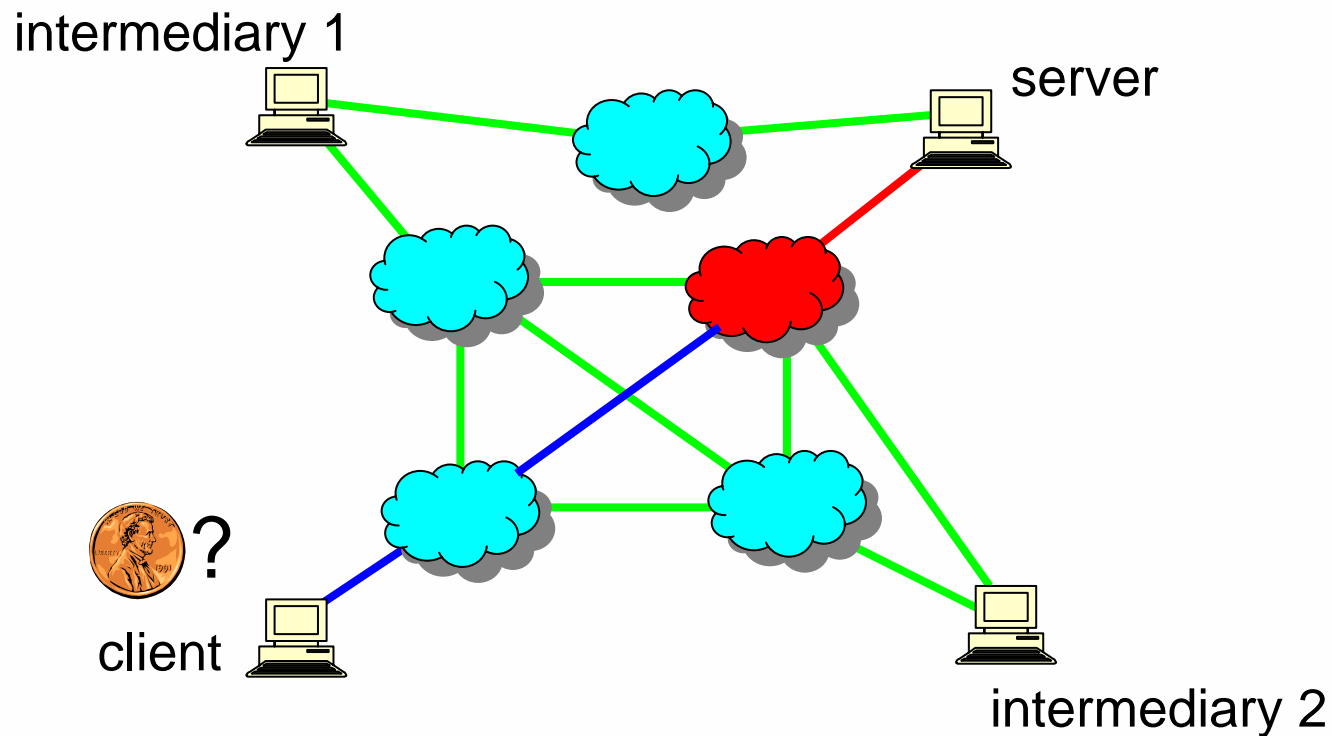intermediary 2

Choosing intermeds: random choice

- Choose intermediaries randomly
  - No path monitoring, assume uncorrelated paths
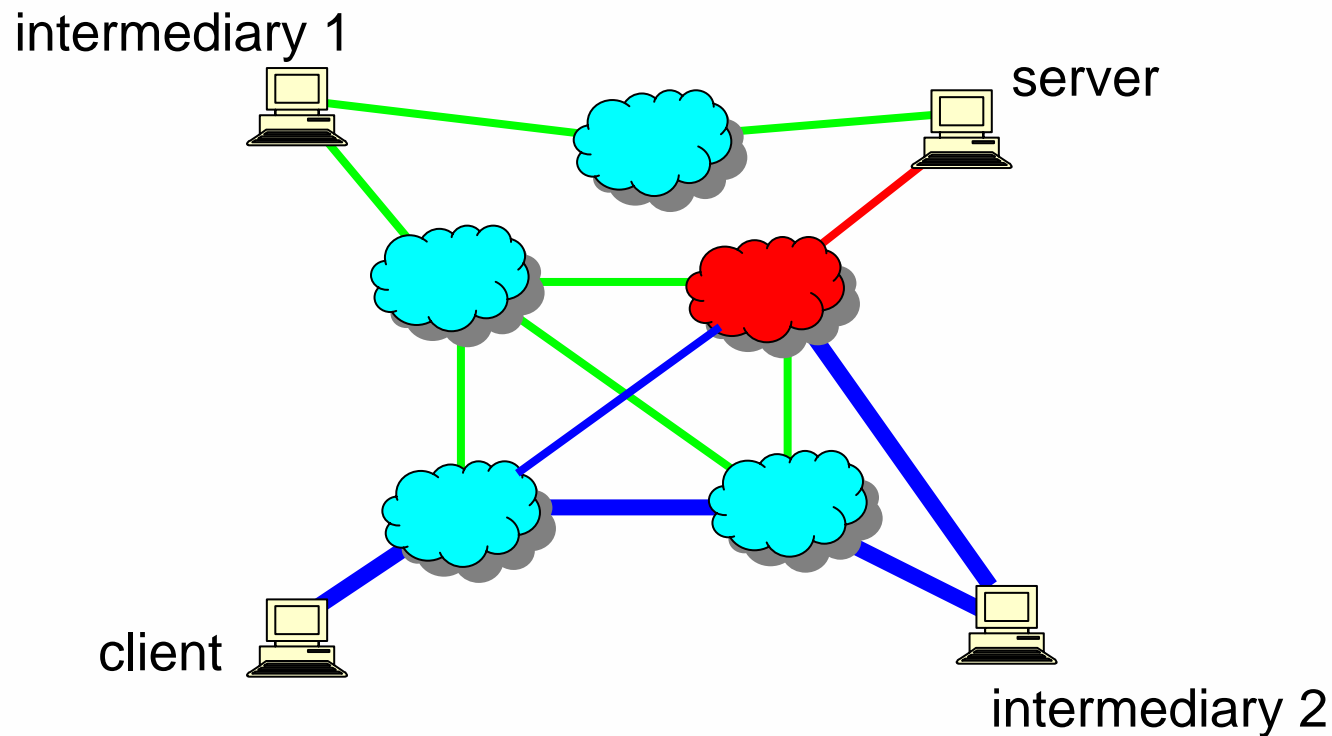 - Example: SOSR (Scalable One-hop Source Routing)

Choosing intermeds: random choice

- Choose intermediaries randomly
  - No path monitoring, assume non-overlapped paths
  - Example: SOSR (Scalable One-hop Source Routing)
- Problem: overlapped paths $\Rightarrow$ choose invalid detour

intermediary 1

server

client

intermediary 2

Our Proposal

- Rank intermediaries by overlap with S-D path
  - Want less overlap
- No need to aggressively monitor: AS/PoP-level paths static over 24 hours
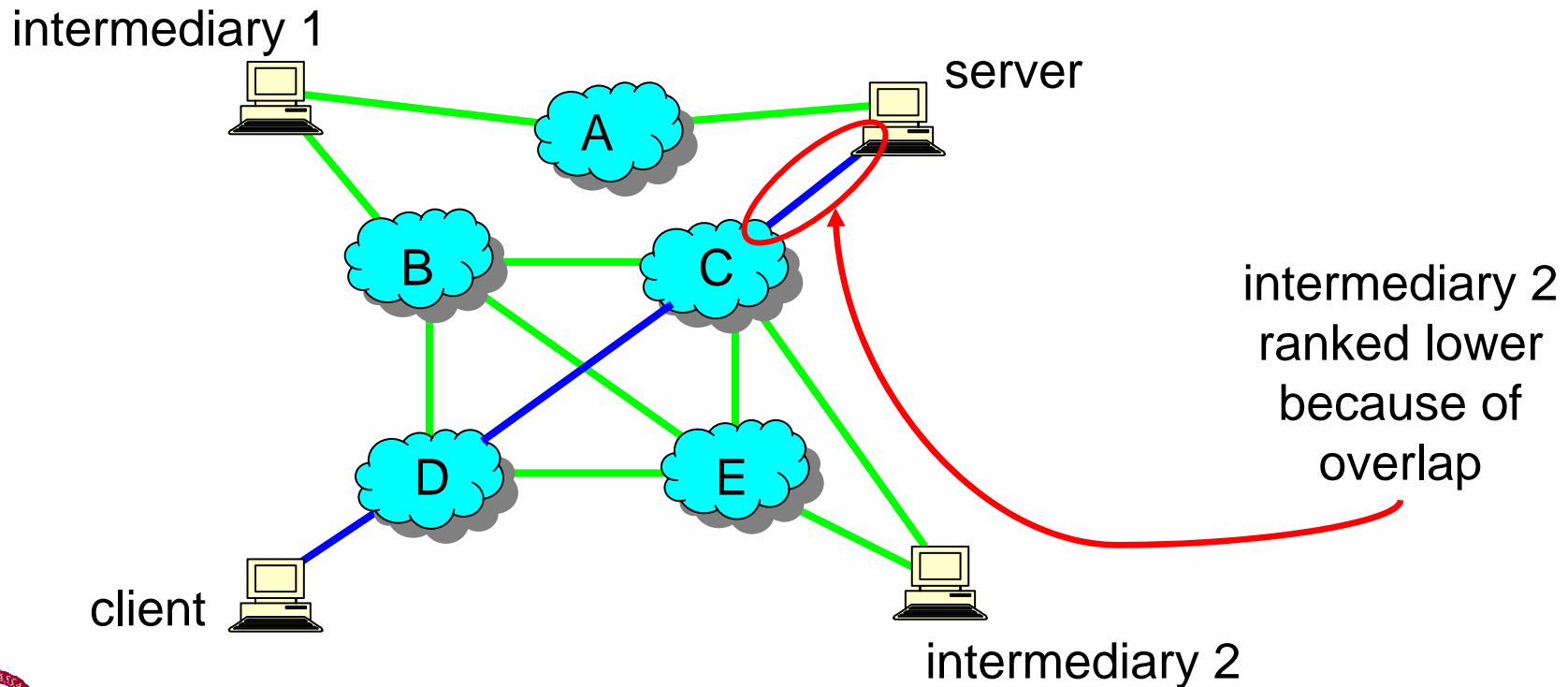
Our Proposal

- Rank intermediaries by overlap with S-D path
  - Want less overlap
- No need to aggressively monitor: AS/PoP-level paths static over 24 hours

intermediary 1

server

A

B

C

intermediary 2 ranked lower because of overlap

D

E

client
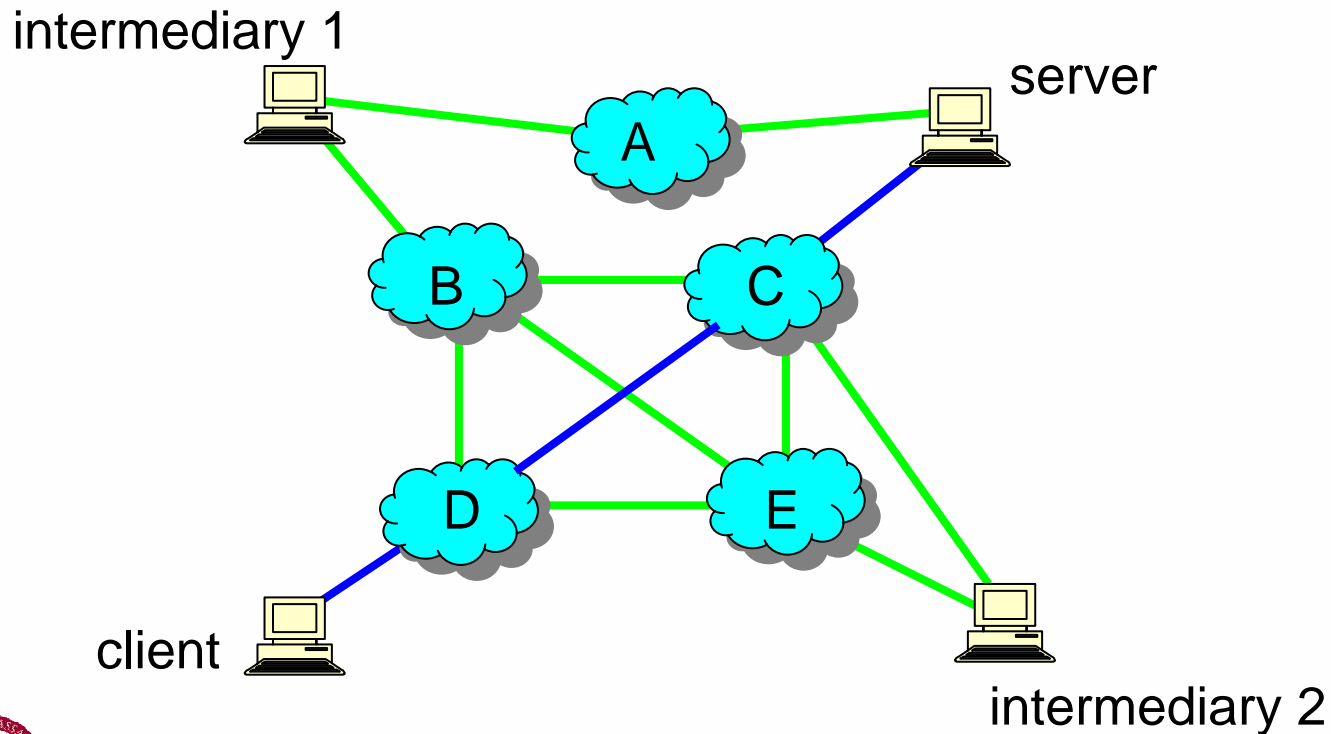
intermediary 2

Experimental Methodology

- Validation study

- PlanetLab-based experiment
  - Monitor 4,269 paths from 46 PL nodes to set of Internet routers for 379 hours
  - Each path monitored by one PL node
    - Ping every 15 seconds, failure if two pings missed
    - Intermediaries ping failed destination every 15 seconds during failure

Experimental Methodology

- Use collected data and PoP path data (from iPlane) to simulate recovery from detected failures
  - Random and informed choices of intermediaries
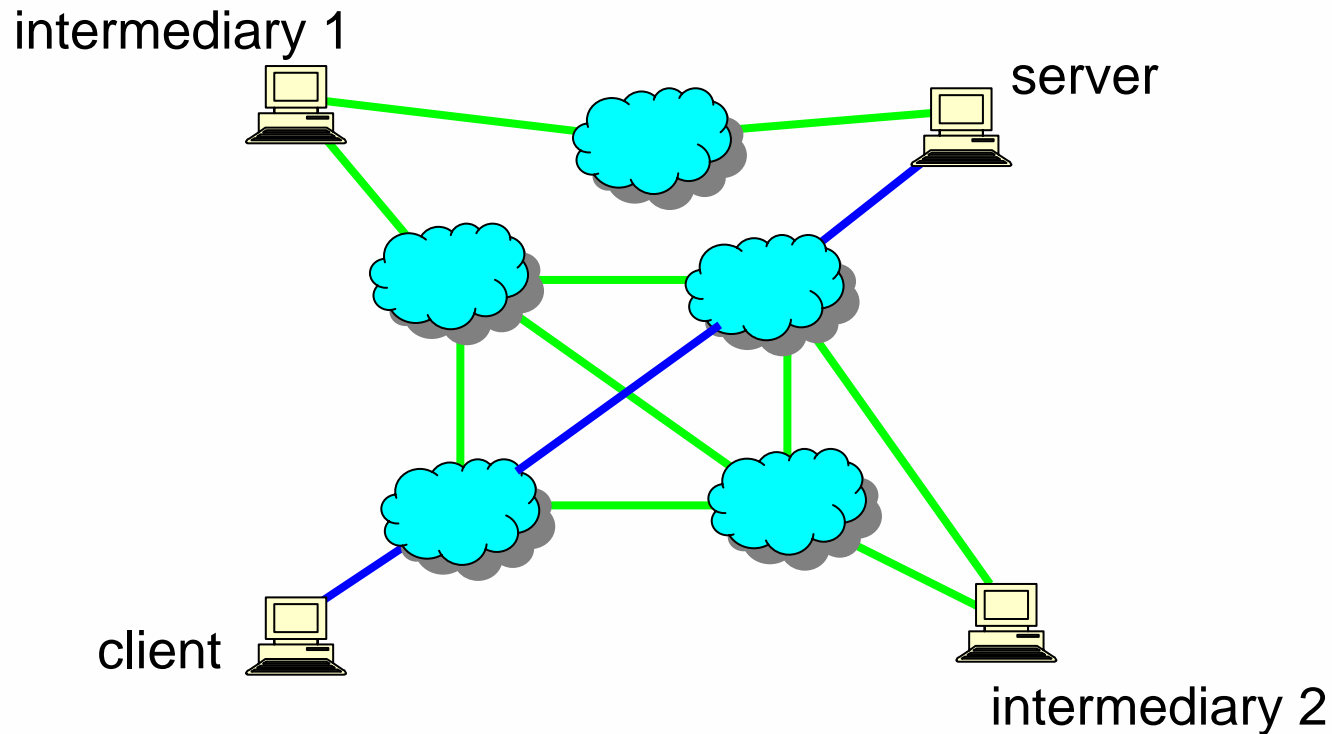
Experiment

- $\approx$ 55,000 path outage events
- Mean outage duration: $\approx$ 22 minutes
- Median outage duration: 2 minutes
- Longest outage: over 6 days
- Aggregate path outage probability: 1.48%
- Each client had access to between 83 and 97 intermediaries

Improving Path Outage

- Impact of intermediary selection methods on path outage

Number of intermediaries	Random (SOSR)	Common PoP count	Common link count
0	1.48%	1.48%	1.48%
1	1.30%	0.76%	0.74%
2	1.15%	0.65%	0.65%
3	1.02%	0.57%	0.57%
4	1.02%	0.52%	0.53%
5	1.02%	0.52%	0.53%

Improving Path Outage

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- Informed methods reduce outage probability by **half**!

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Discussion

- Why did informed selection outperform random?
  - Paths not independent

- Reasons for path correlations
  - PlanetLab design: universities on Internet2
  - Geography

- No knowledge of failure locations in study
- But can examine how close the sets of responding intermediaries are to what is *expected*
- If paths from intermediary set A are independent:

$$P(X \in A) \approx P(X \in A \mid X \text{ has valid path})$$

PlanetLab Design

- On average across failures, for intermediary X:
  - P(X at university) = 92.0%
  - P(X at university | X has valid path) = 91.6%

- Connectivity failures not correlated between universities

Geography

- On average across failures, for intermediary X:
  - Paths originating in the US
    - P(X in US) = 71.6%
    - P(X in US | X has valid path) = 59.8%
  - Paths originating in Asia
    - P(X in Asia) = 7.2%
    - P(X in Asia | X has valid path) = 3.7%
  - Path originating in Europe
    - P(X in Europe) = 20.8%
    - P(X in Europe | X has valid path) = 26.7%

- Thus, evidence of geographic correlation

Path Outage revisited

- Effect of restricting random selection to intermediaries outside of vantage point geographical area

Num intermeds	Random (SOSR)	Common PoP count	Common link count	Geog. random
0	1.48%	1.48%	1.48%	1.48%
1	1.30%	0.76%	0.74%	1.26%
2	1.15%	0.65%	0.65%	1.09%
3	1.02%	0.57%	0.57%	0.95%
4	1.02%	0.52%	0.53%	0.84%
5	1.02%	0.52%	0.53%	0.75%

Conclusions

- Demonstrated potential improvement using informed detour selection in reliability over random selection in SOSR
  - Biasing SOSR random selection outside own geographical area captures some benefit of informed method

- Future work
  - Implement informed detour selection mechanism
  - Evaluate path estimation services (Rocketfuel, iPlane)
  - Examine whether fresher path information helps

Thanks!

Questions/Comments?