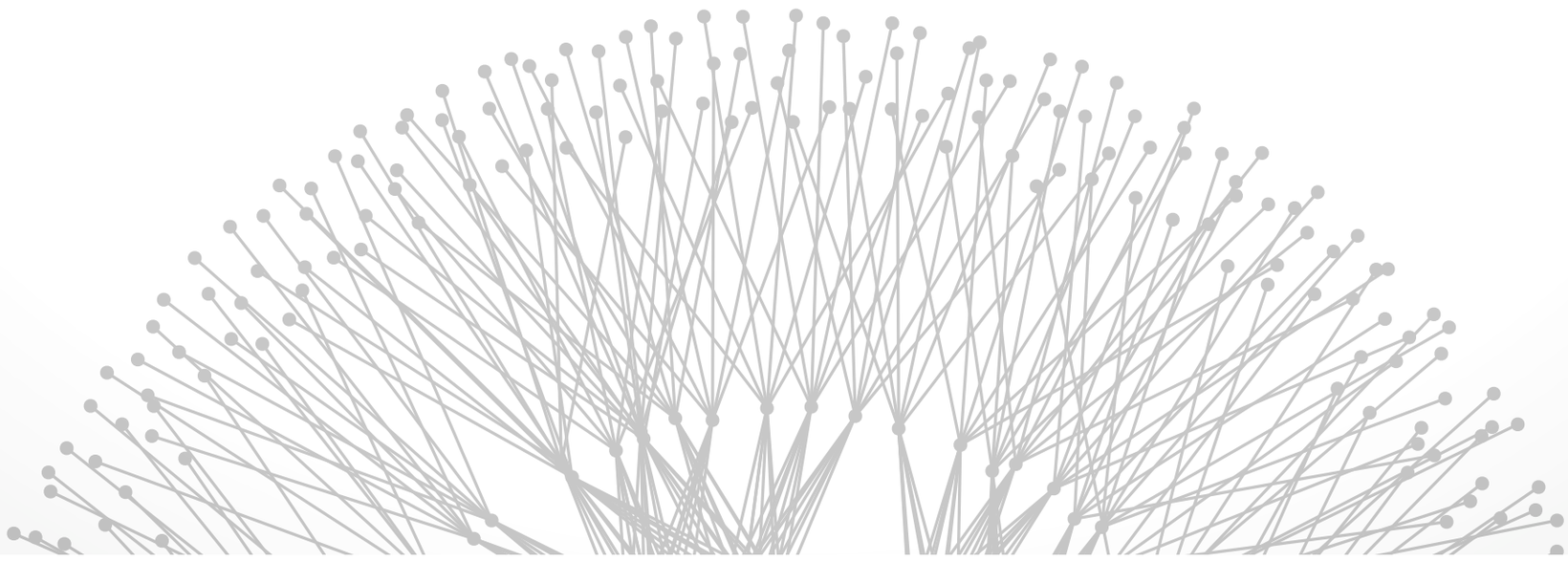
Future Internet Architectures

Brighten Godfrey

CS 538 November 29 2012



Internet Architecture challenges

Security / accountability

Privacy

Mobility

Scalability

Content-awareness

Evolvability of the architecture itself

“Tussle” between stakeholders

"Tussle in Cyberspace"

[Clark, Wroclawski, Sollens, Braden, ToN'05]

Tussle: process of "contention among parties with conflicting interests"

What tussles have we studied this semester?

"Tussle in Cyberspace"

What tussles have we studied this semester?

- Congestion: selfish user behavior; ISPs block apps; etc.
- Content access: countries & ISPs censor & block for security; users circumvent with Tor
- Routing policy: conflicting preferences cause divergence
- ...

Key point: Design of protocols shapes how tussles play out in the running system

Example 1:
Naming & Addressing

Naming & addressing

Originally "just" technical problems...

- Address: indicates location, convenient for routing
- Name: location-independent, convenient for human

...all wrapped up in tussle

- Names tied to trademarks
- Addresses difficult to change (and now scarce for IPv4!)

How would you fix this?

Modularize to protect the system

Principle: Modularize along tussle boundaries

- Separate task of location independent identification of endpoints (hosts/services) from tussle spaces

Possible implementation: flat names

- Endpoint identifier (EID): Just a bag of bits
- Human-readable name maps to location-indep. EID
- Location-independent EID maps to address

Or, can we route directly on flat names?

- VRR, ROFL [Caesar et al, SIGCOMM'06]
- Disco [Singla et al, CoNEXT'10]

Example 2:
Control of routes

Choice in routing

Current Internet: routes fixed within the network

- Each router makes part of the route choice
- Picks one route per destination & advertises that one

Technical problems

- Single offered path may be broken, congested, insecure
- Decision-makers (in the network) may not have useful information (at end-hosts)

Tussle problems

- Parties disagree on what is a "good" path
- Lack of choice discourages competition

Choice in routing

Architecture exacerbates tussle: no way to enable choice even if involved parties want it

- In IP, typically just get to specify destination
- No infrastructure for exposing extant choices

One solution: separate routing from the network by letting sender specify a route in packet

- Switch quickly in response to end-to-end failures
- Use multiple routes simultaneously
- Better load balance, more efficient use of capacity
- Competition among providers

Pathlet routing

[Godfrey, Ganichev, Shenker Stoica, SIGCOMM '09]

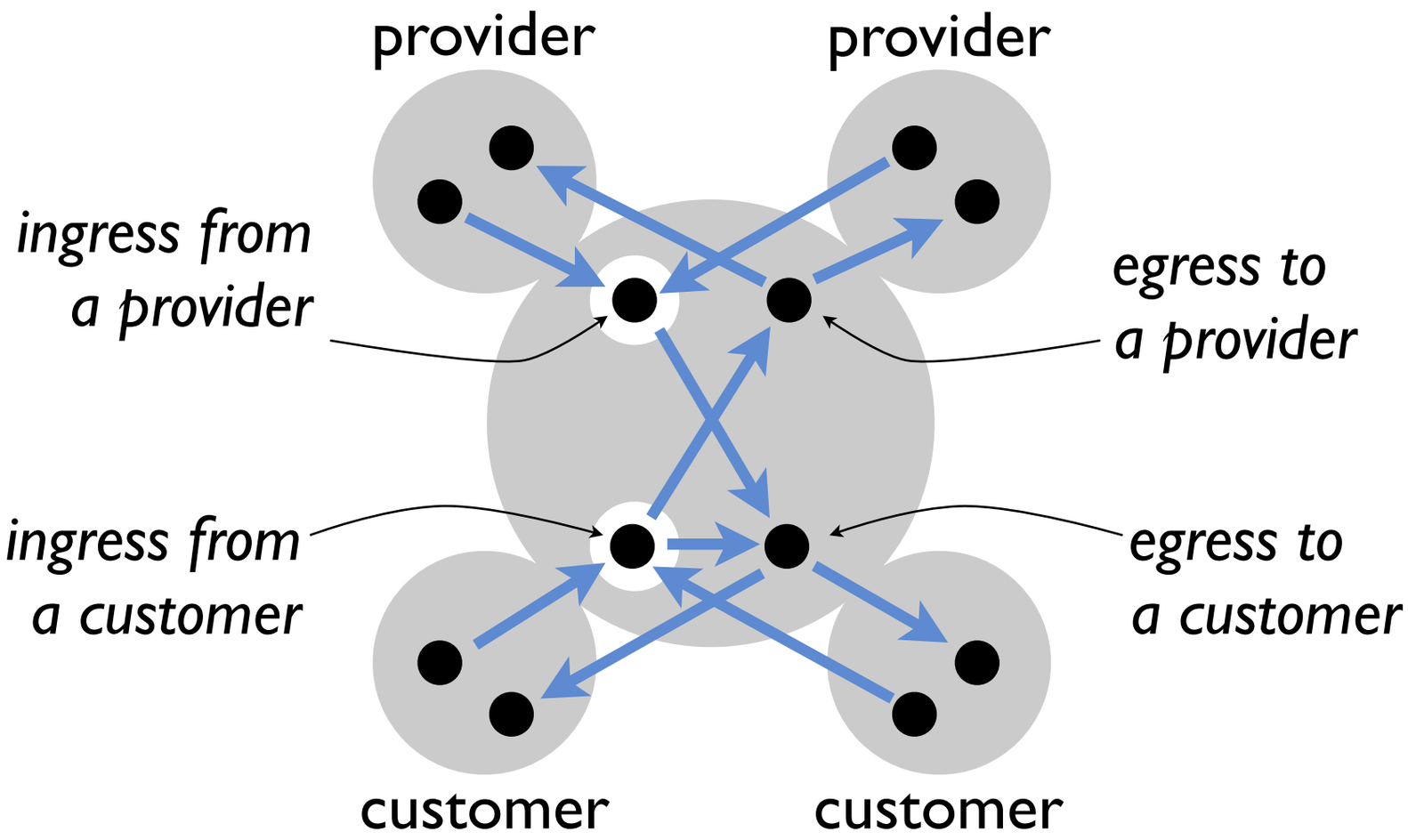
Idea: separate route computation from the network

Refined idea: route in a virtual topology which can flexibly represent policy constraints

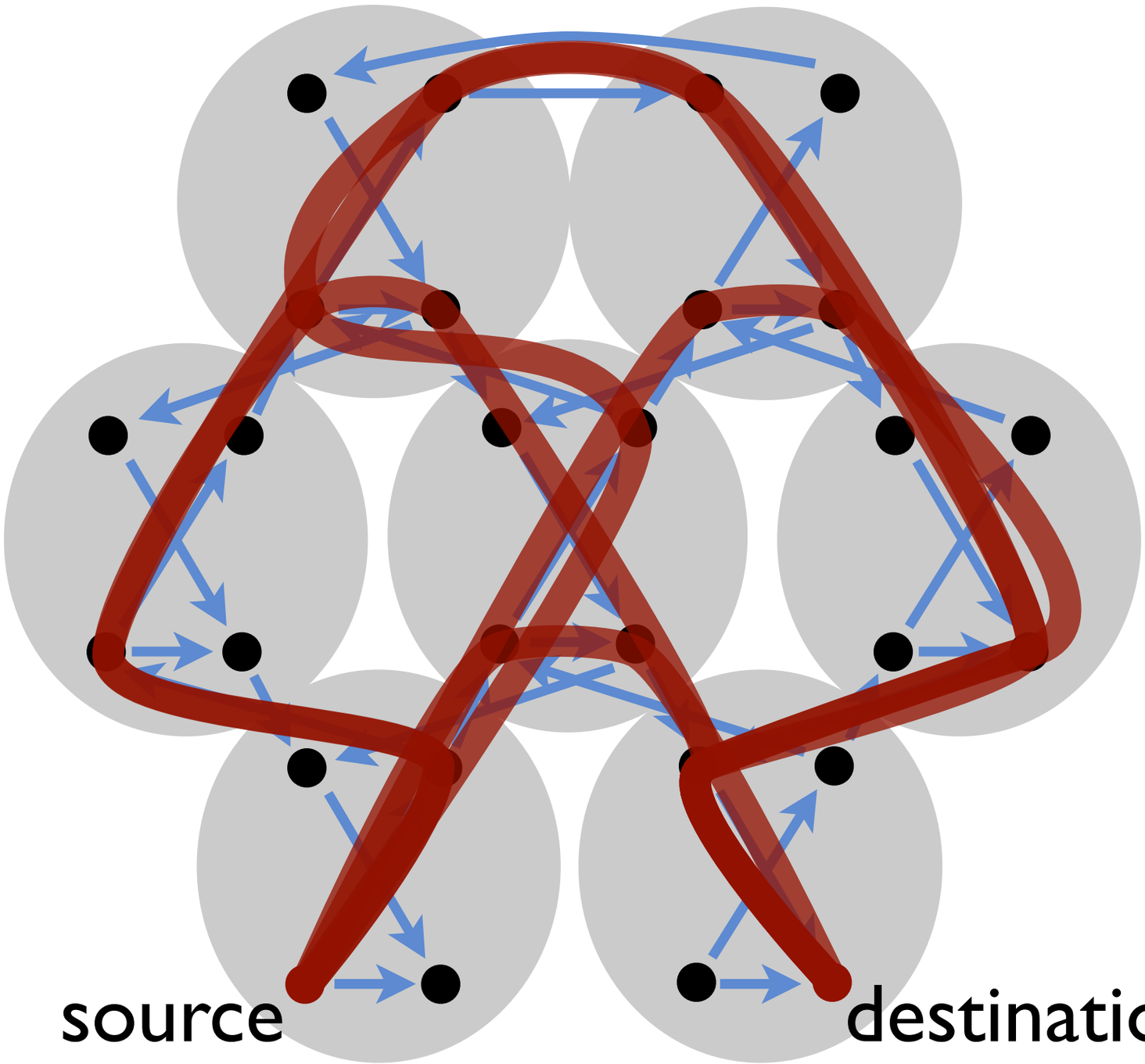
- For network owners: flexibility to define how the network can be used, via what virtual links (pathlets) are advertised
- For users: flexibility to choose paths or services defined by any concatenated sequence of advertised pathlets

Pathlet routing example

e.g., all valley free routes
("customers can go anywhere;
anyone can route to customer")



Pathlet routing example



Design for variation

> *Design for variation in outcome*, *so that the outcome can be different in different places, and the tussle takes place within the design, not by distorting or violating it.*

— Clark, Wroclawski, Sollins & Braden

Tor as IP

[Liu, Han, Krishnamurthy, Anderson, HotNets 2011]

Discussion

What leads to high latency in this design?

- Traffic passes through mailboxes in core
- Zig-zagging on way to mailboxes
- Receivers poll for incoming traffic

How would you improve the design's latency while preserving privacy & anonymity as much as possible?

Announcements

Brighten out of town next Tuesday

- Guest lecture: Prof. Indranil Gupta
- Office hour next week moved to Thu after class