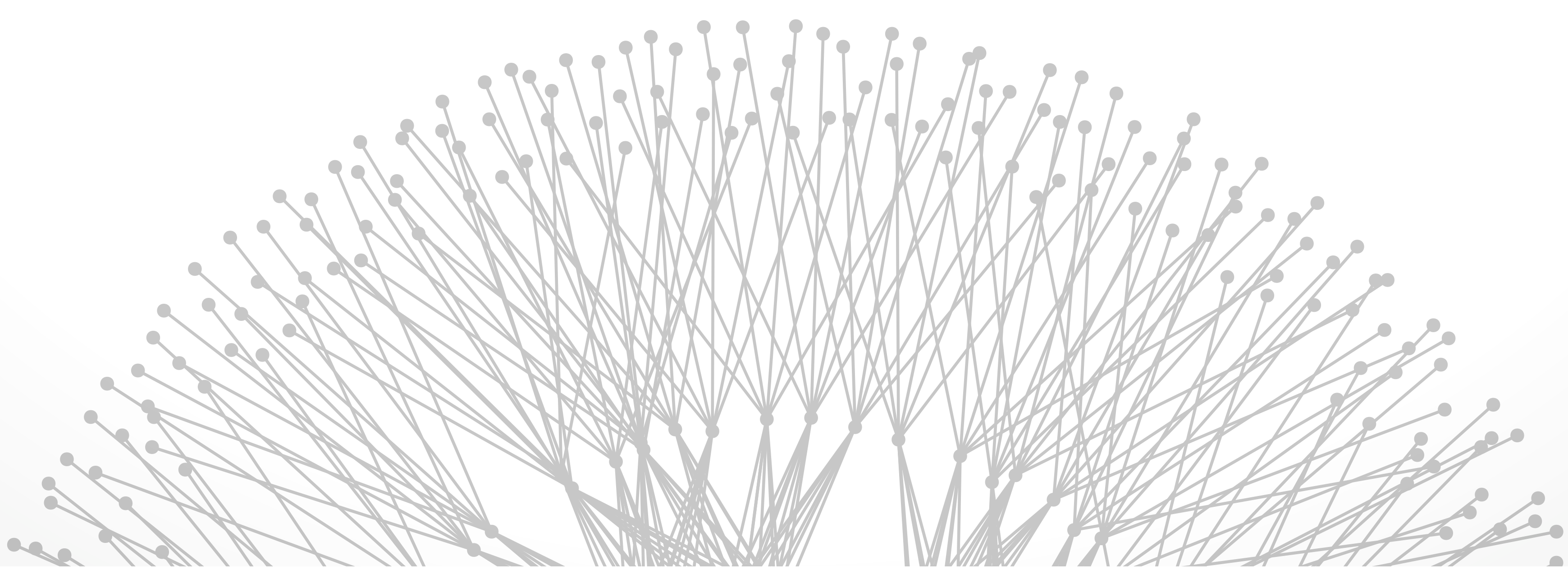
Interdomain Routing and Connectivity

Brighten Godfrey

CS 538 October 1 2013



Routing

Choosing paths along which messages will travel from source to destination.

Problems for intradomain routing

Distributed path finding

Optimize link utilization (traffic engineering)

React to dynamics

High reliability even with failures

Scale

Problems for interdomain routing

All of intradomain's problems

Bigger scale

Multiple parties

- No central control
- Conflicting interests
- Greater volume and diversity of attacks

Harder to change architecture

- Intradomain evolution: RIP, ISIS, OSPF, MPLS, OpenFlow, ...
- Interdomain: BGP.

Interdomain routing

BGP: Border Gateway Protocol

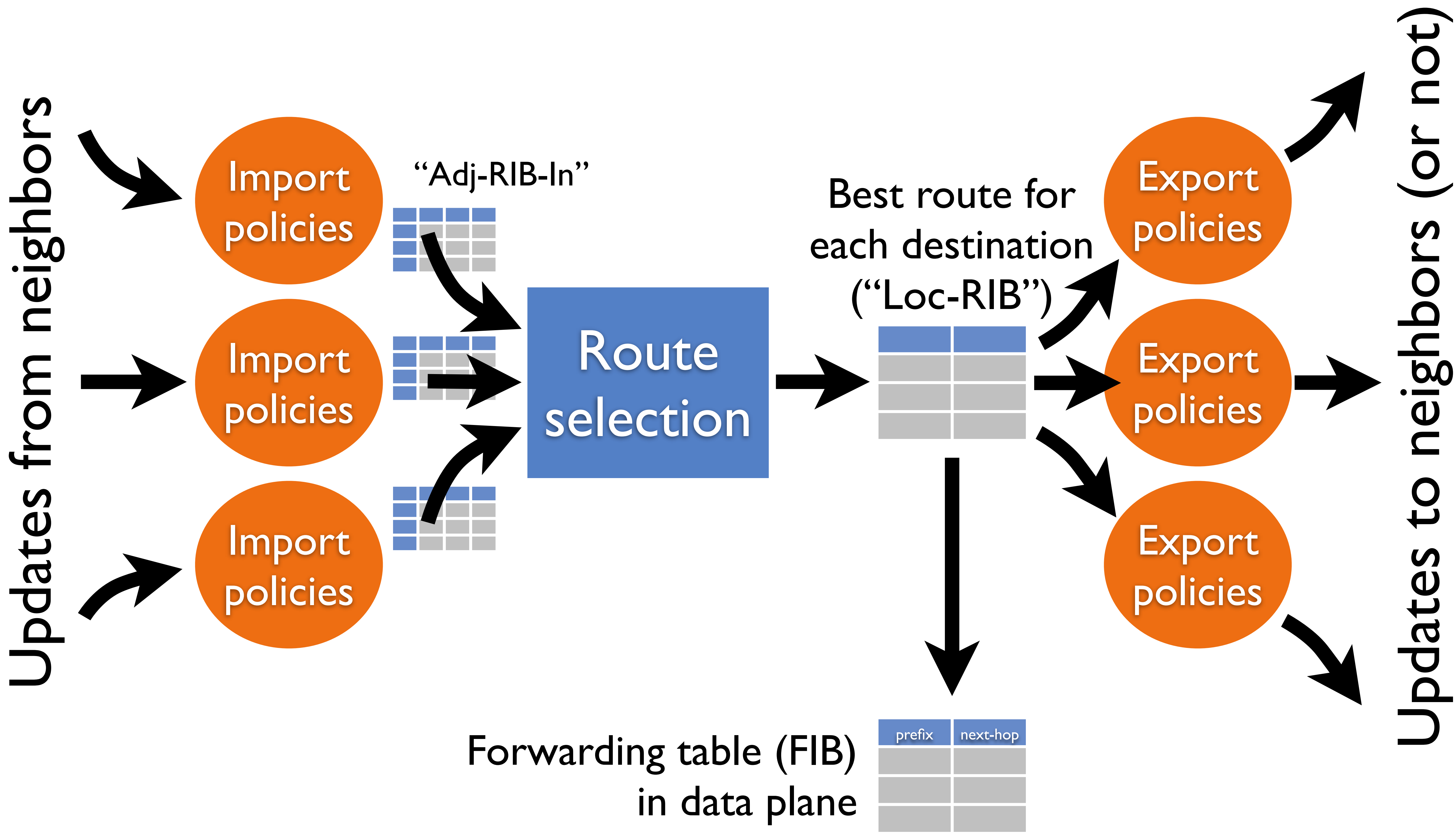
Distance vector variant

- Send incremental changes, not whole vector
- Path vector: Remember path instead of distance

Why path vector?

- Avoid DV's transient loops; but more importantly...
- Policy support: can pick any path offered by neighbors, not necessarily the shortest (Link State cannot)
- Privacy support: path choice policy is applied locally, not announced globally
  - Q: How much privacy is there?

BGP: The picture at one router



Route selection process

Import policies

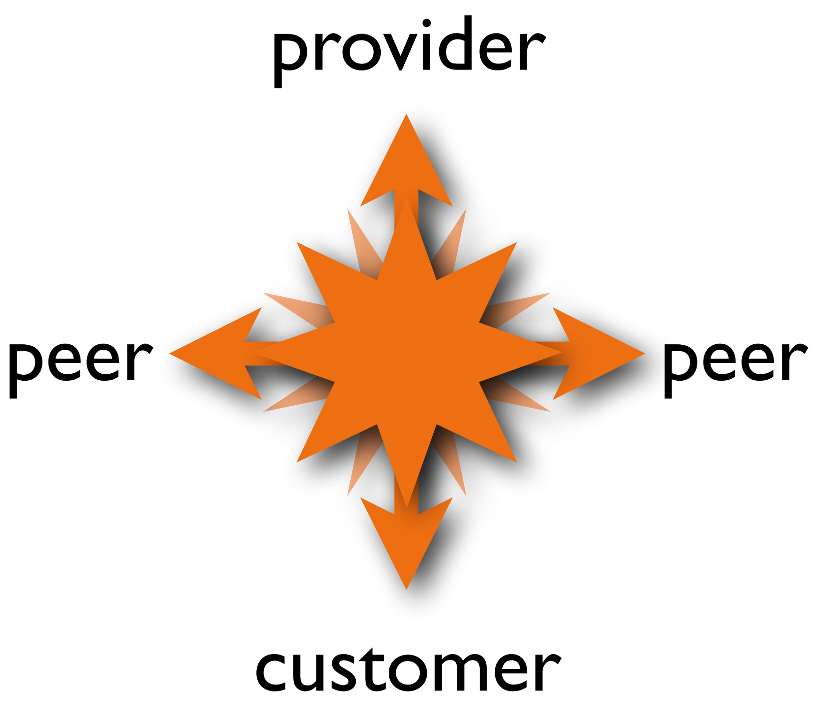
Step	Attribute	Controlled by local or neighbor AS?
1.	Highest LocalPref	local
2.	Lowest AS path length	neighbor
3.	Lowest origin type	neither
4.	Lowest MED	neighbor
5.	eBGP-learned over iBGP-learned	neither
6.	Lowest IGP cost to border router	local
7.	Lowest router ID (to break ties)	neither

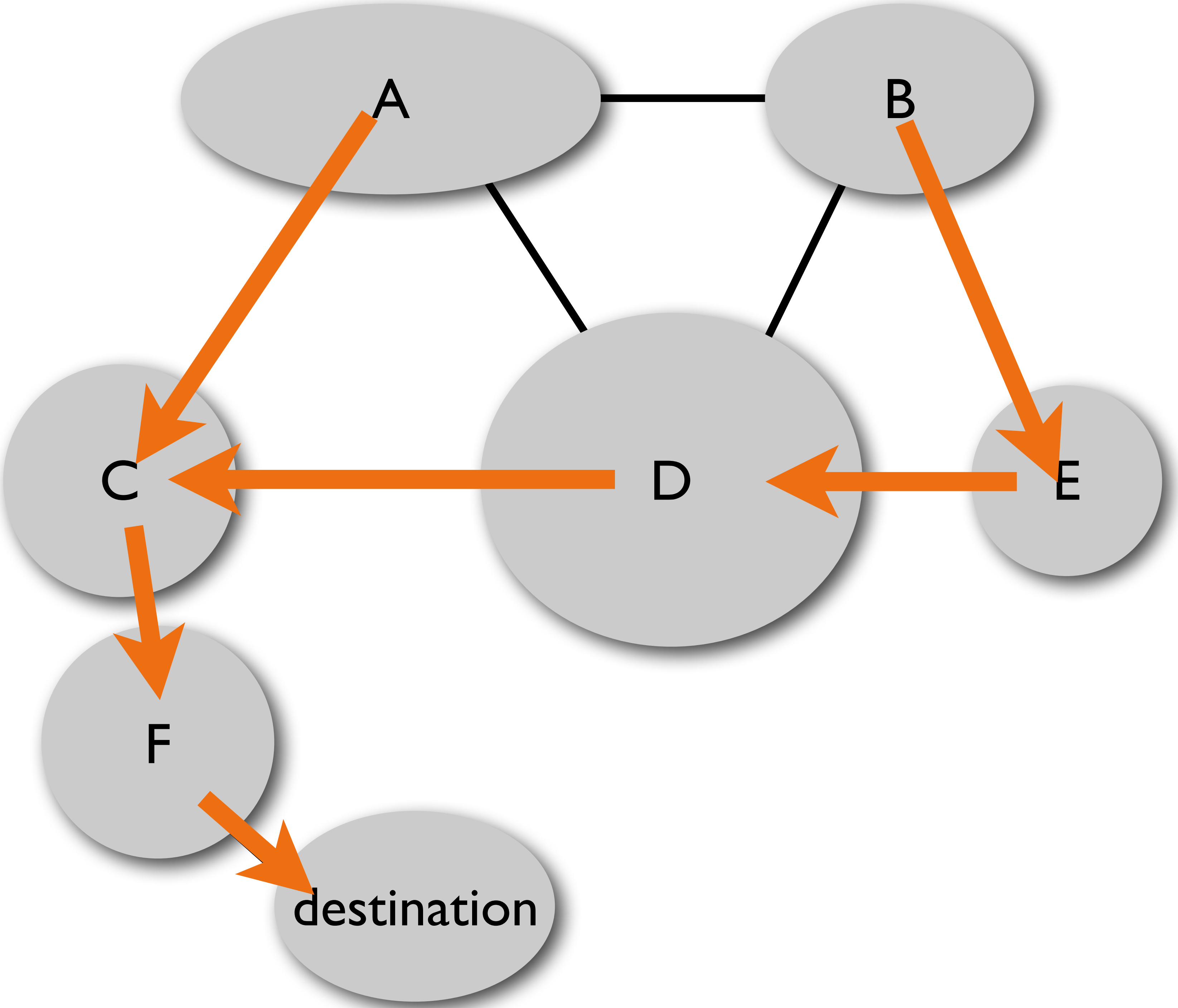
[Caesar, Rexford, IEEE Network Magazine, 2005]

This process is extended in many real implementations.

Common policies

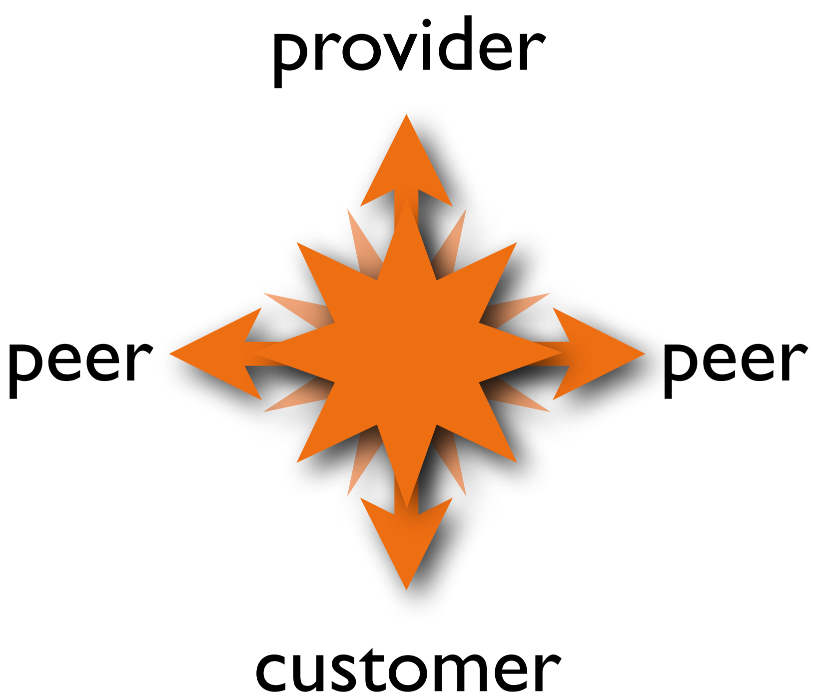
Route selection: prefer customer over peer over provider

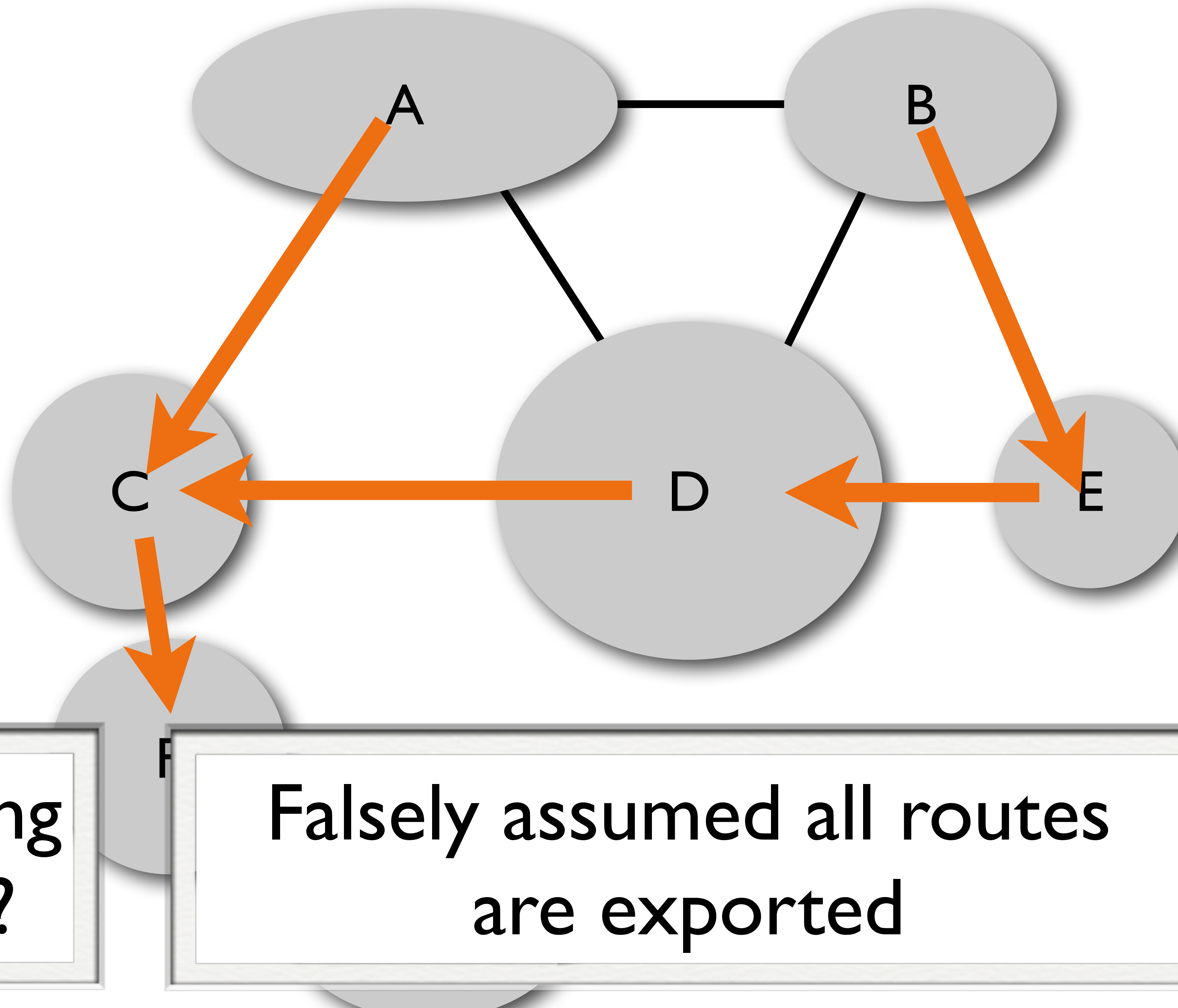




Common policies

Route selection: prefer customer over peer over provider



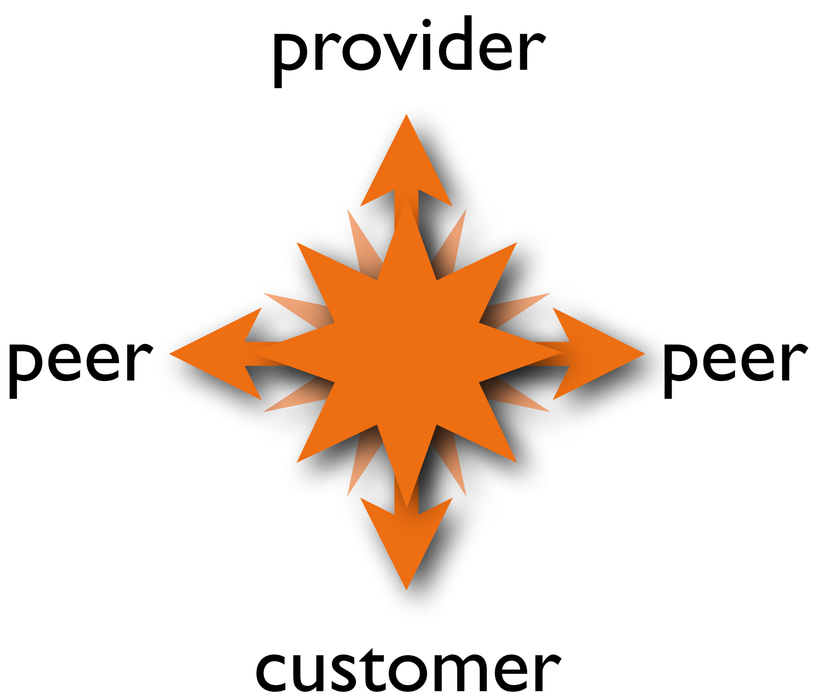


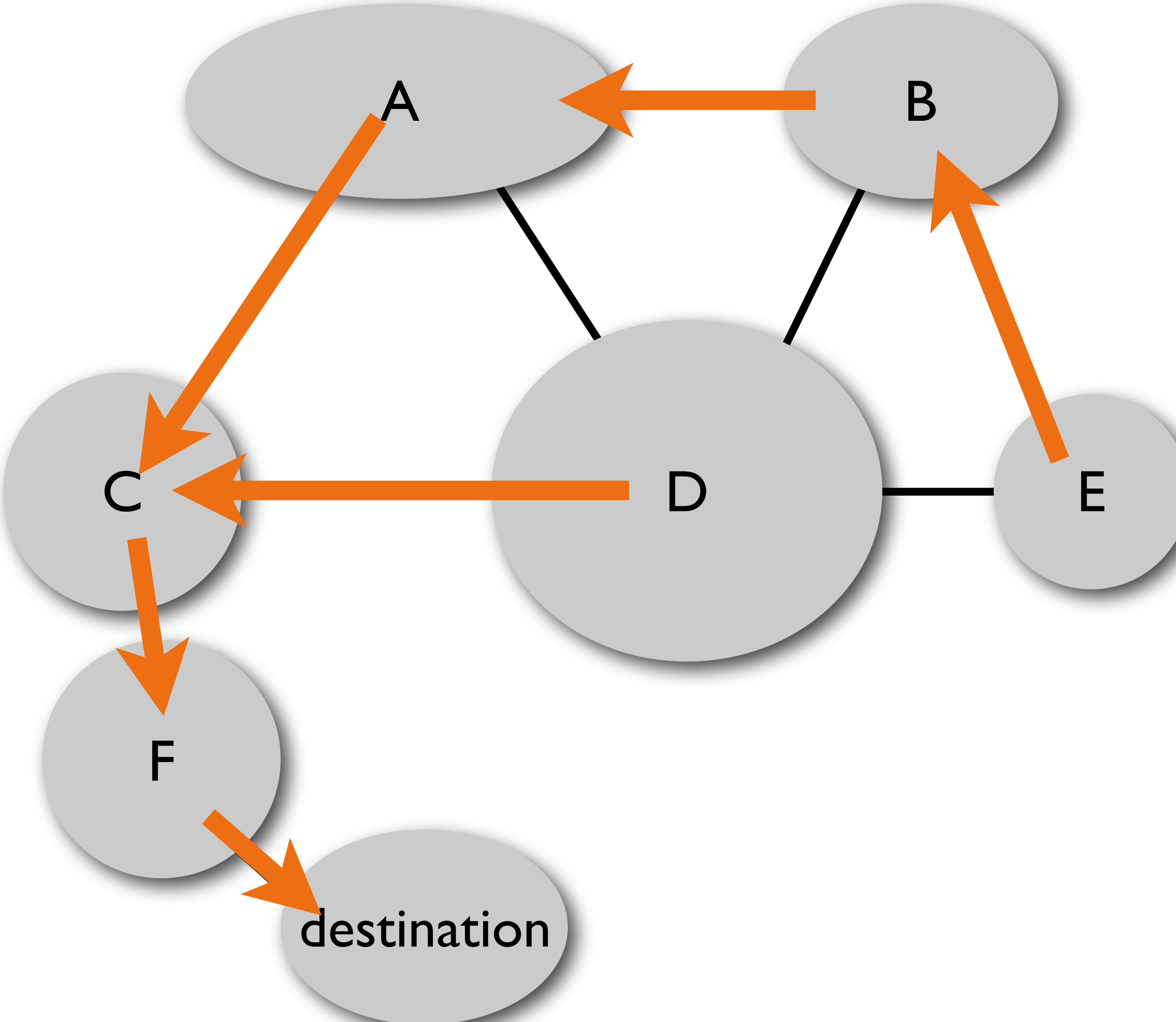
But ... What's wrong with this picture?

Falsely assumed all routes are exported

Common policies

Route export (most common): to/from customer only ("valley-free")





Paper discussion

How does BGP inbound traffic engineering fit with TeXCP? Are they solving the same problem?

How can ISPs perform interdomain outbound TE?

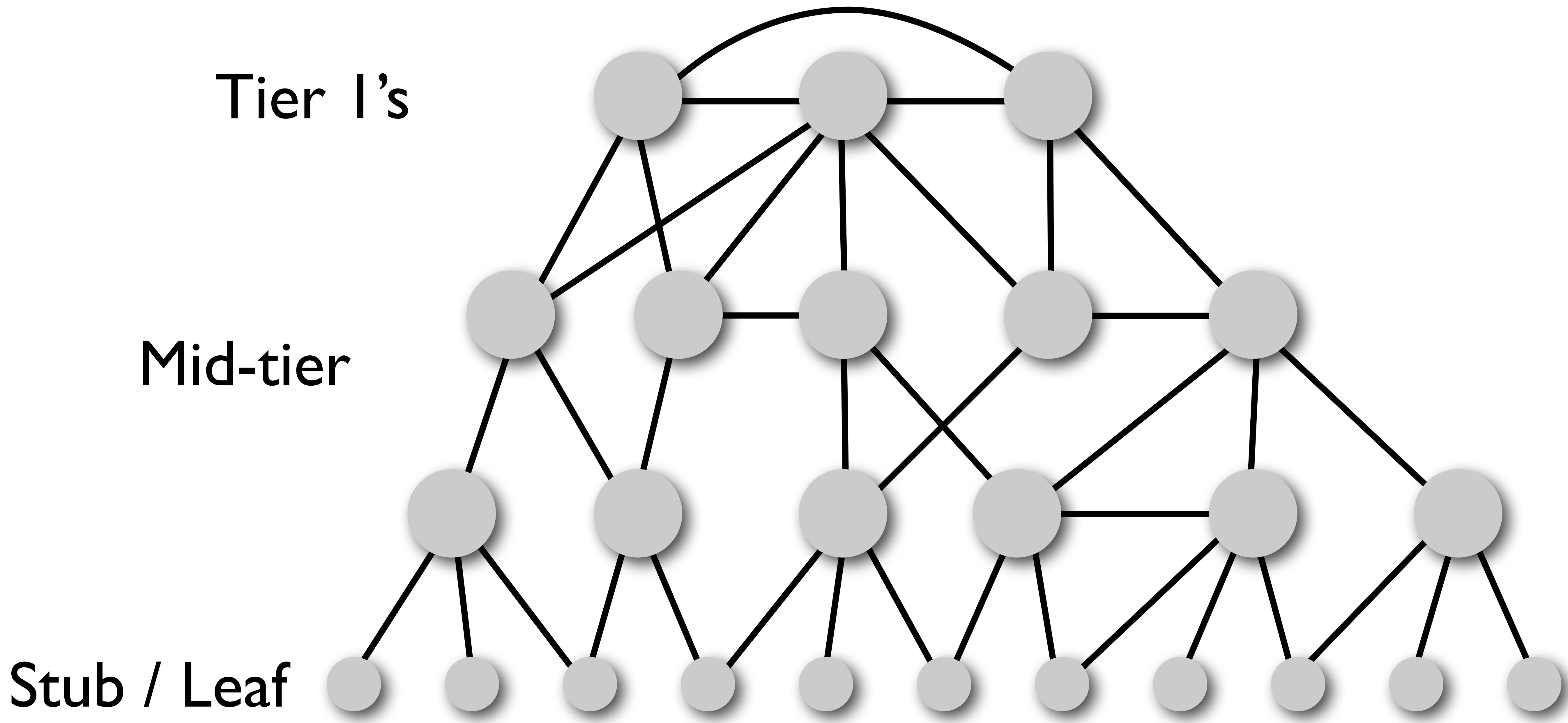
CS 538 Fall 2013/9/16
Assignment 1

Peng Zhang
netid : pzhang29

2#1. The sequence of ISPs (AS numbers and/or business names) from the last step.

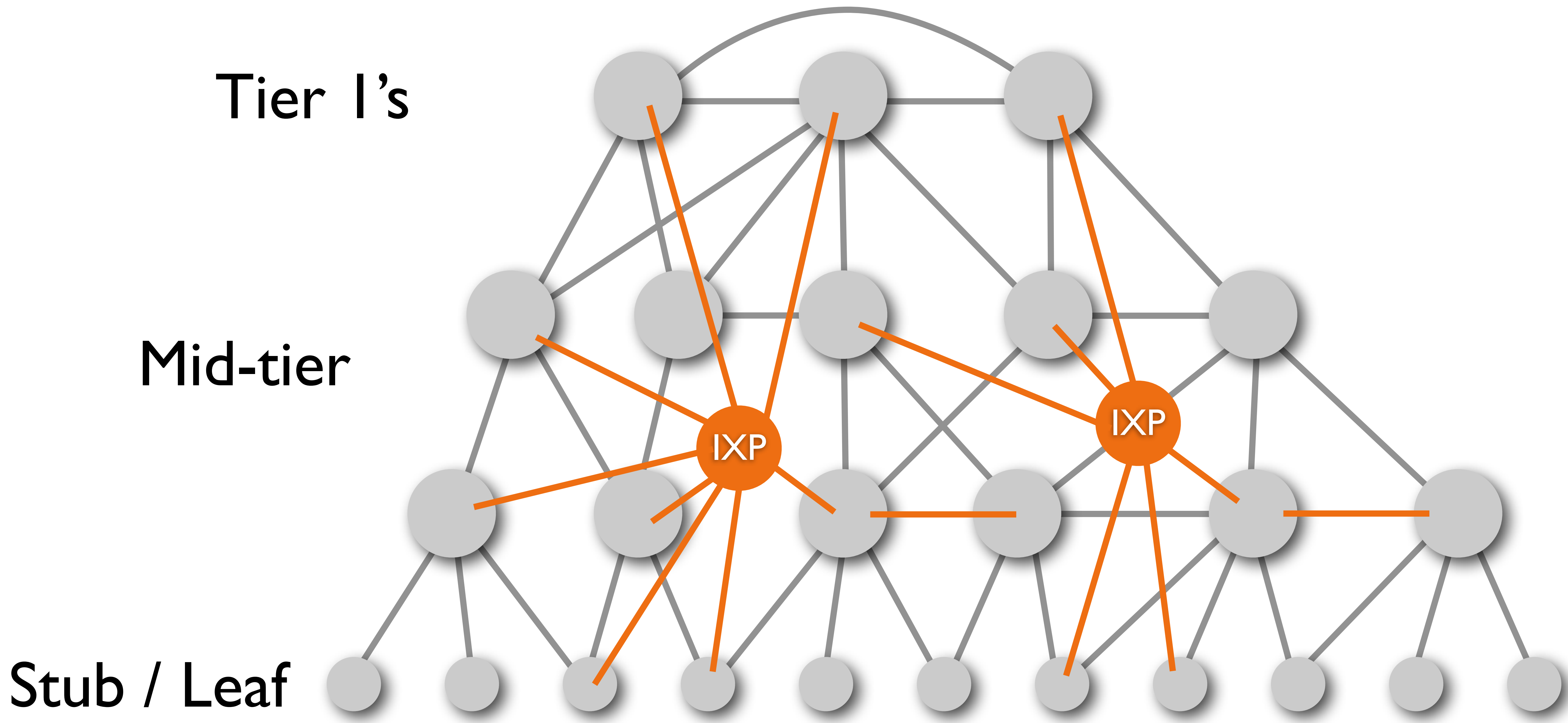
13030 11537 40387 38
31500 174 40387 38
8928 7132 40387 40387 40387 40387 38
1299 174 40387 38
5413 1299 174 40387 38
6067 174 40387 38
8426 3549 11537 40387 38
19151 11537 40387 38
6939 11537 40387 38

Interconnection: Traditional view



Hierarchical, limited peering at lower tiers

Interconnection: Modern view



Significant and increasing peering at lower tiers

Data from Ager et al, SIGCOMM'12

Significant peering

- Estimated 200,000 peerings just in Europe
- More than 2x as many as non-peering links!

These peerings missed in past measurements

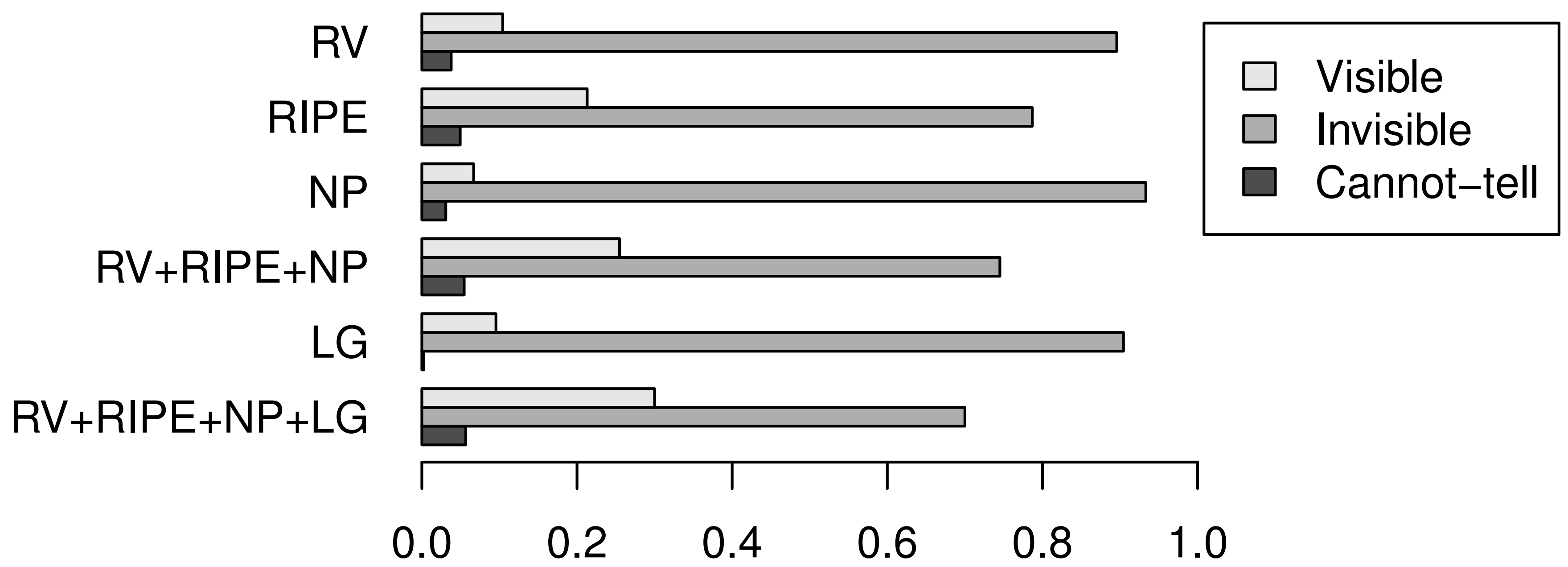
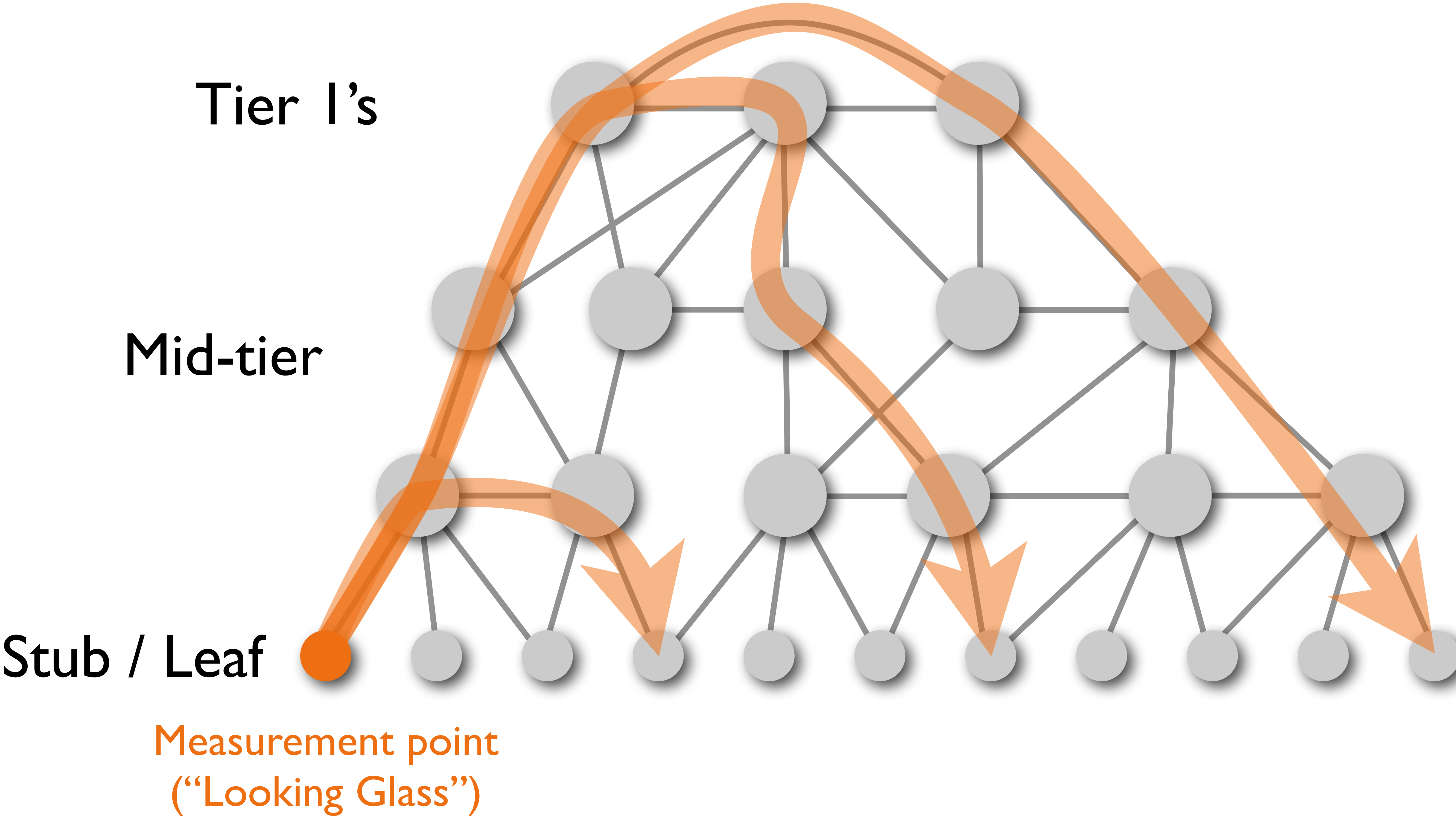


Figure 2: Peering links and visibility in control/data plane (normalized by number of detected P-P links).

Why measurements miss so much



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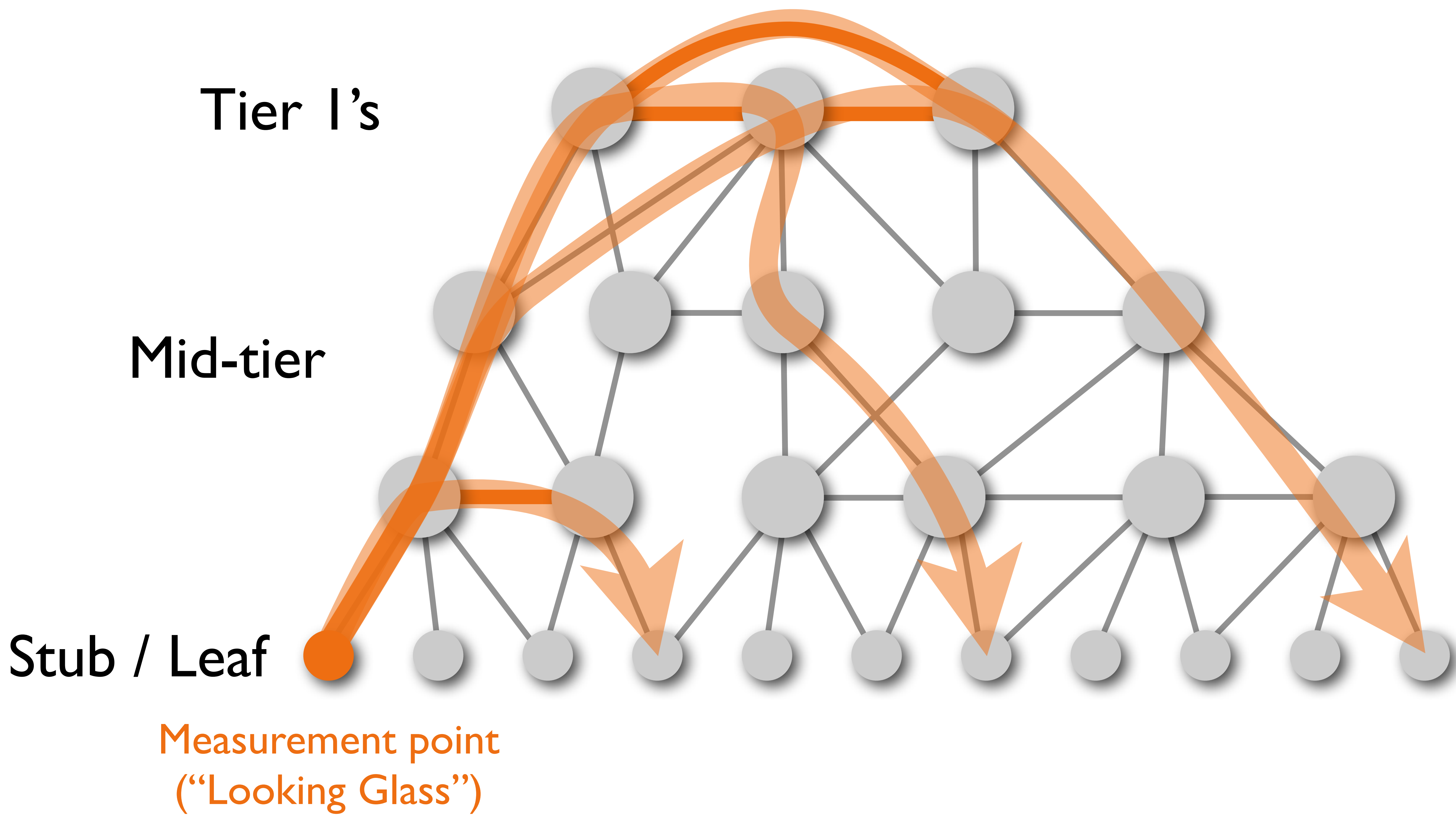

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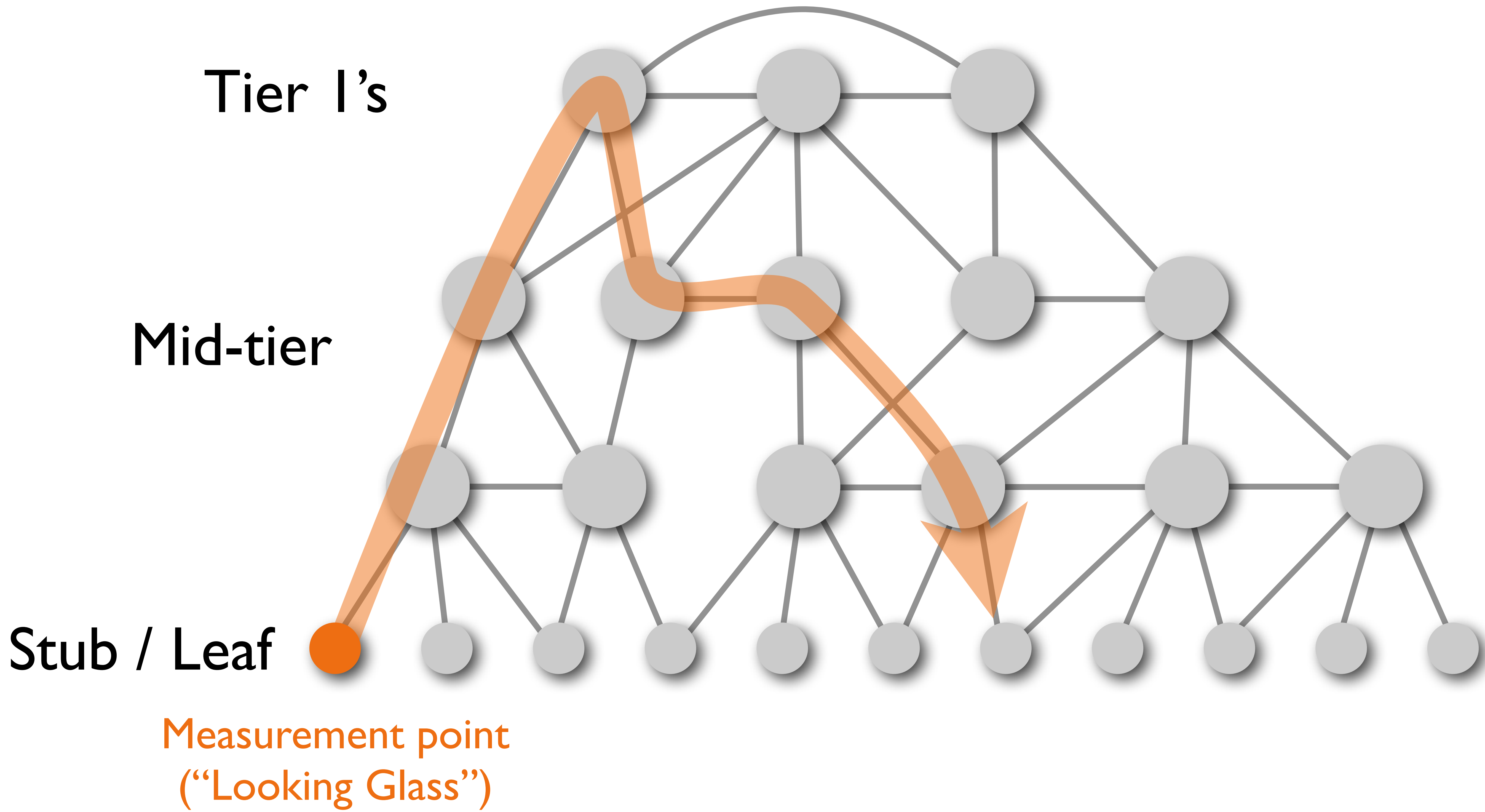

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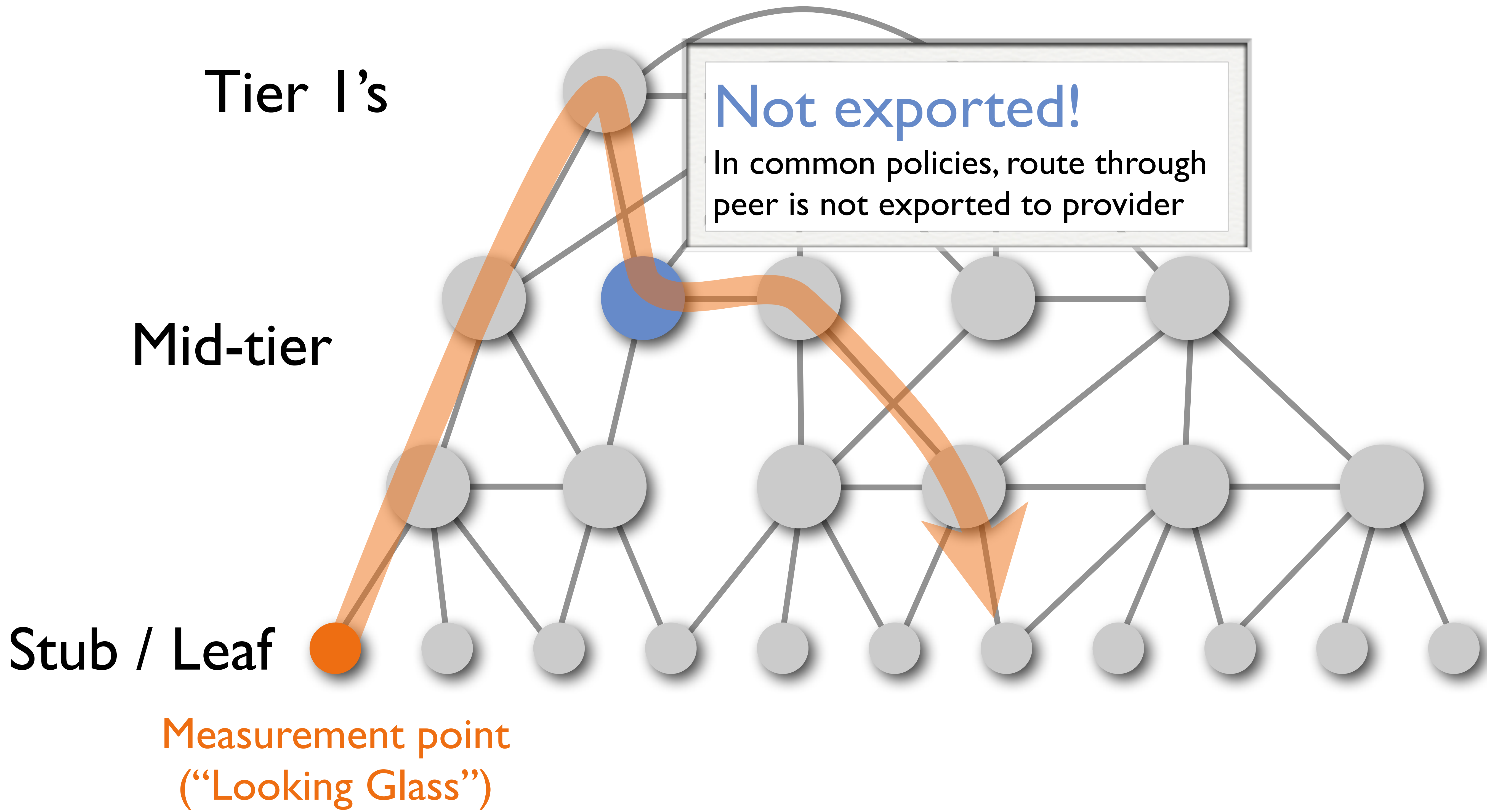

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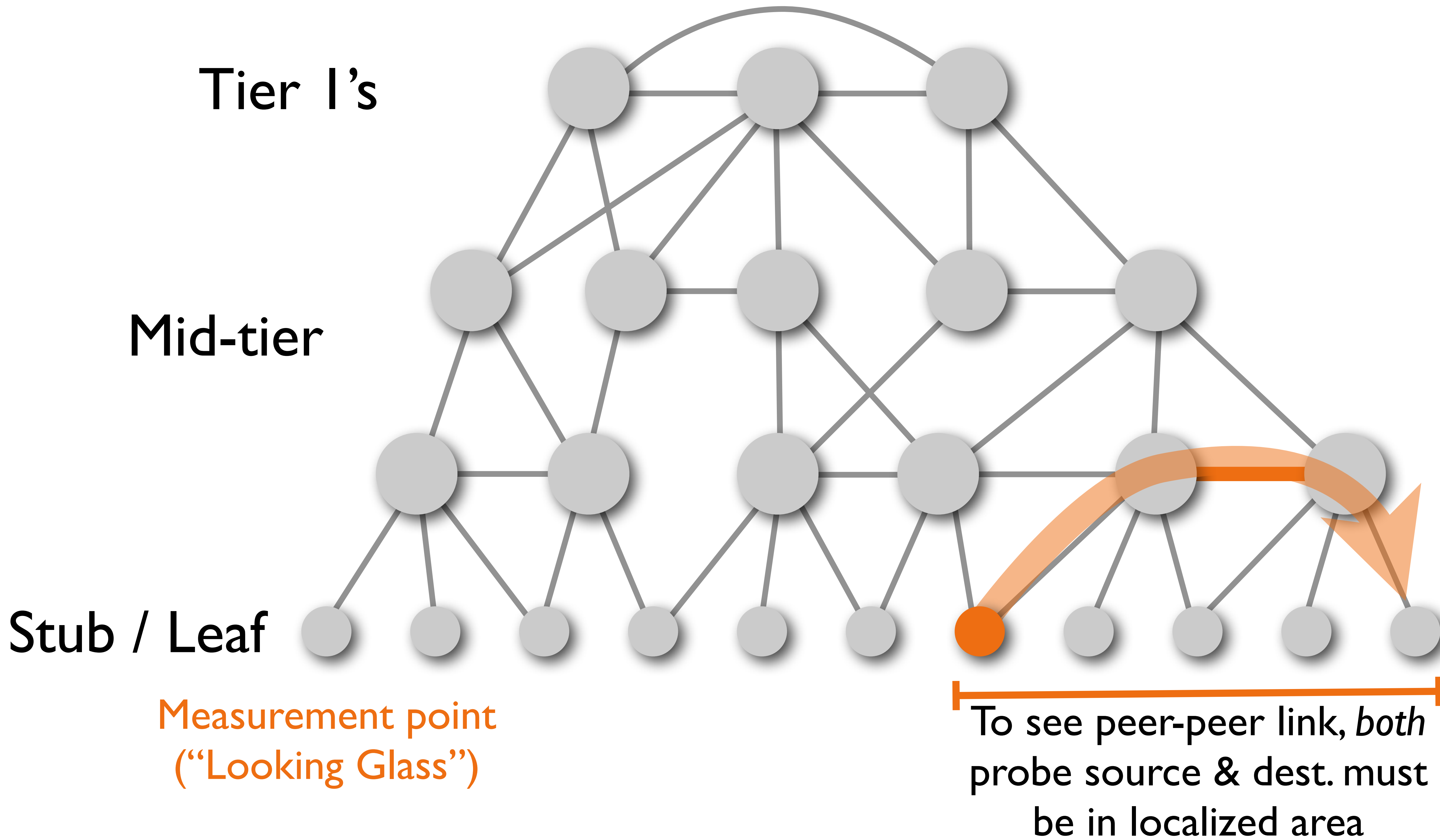
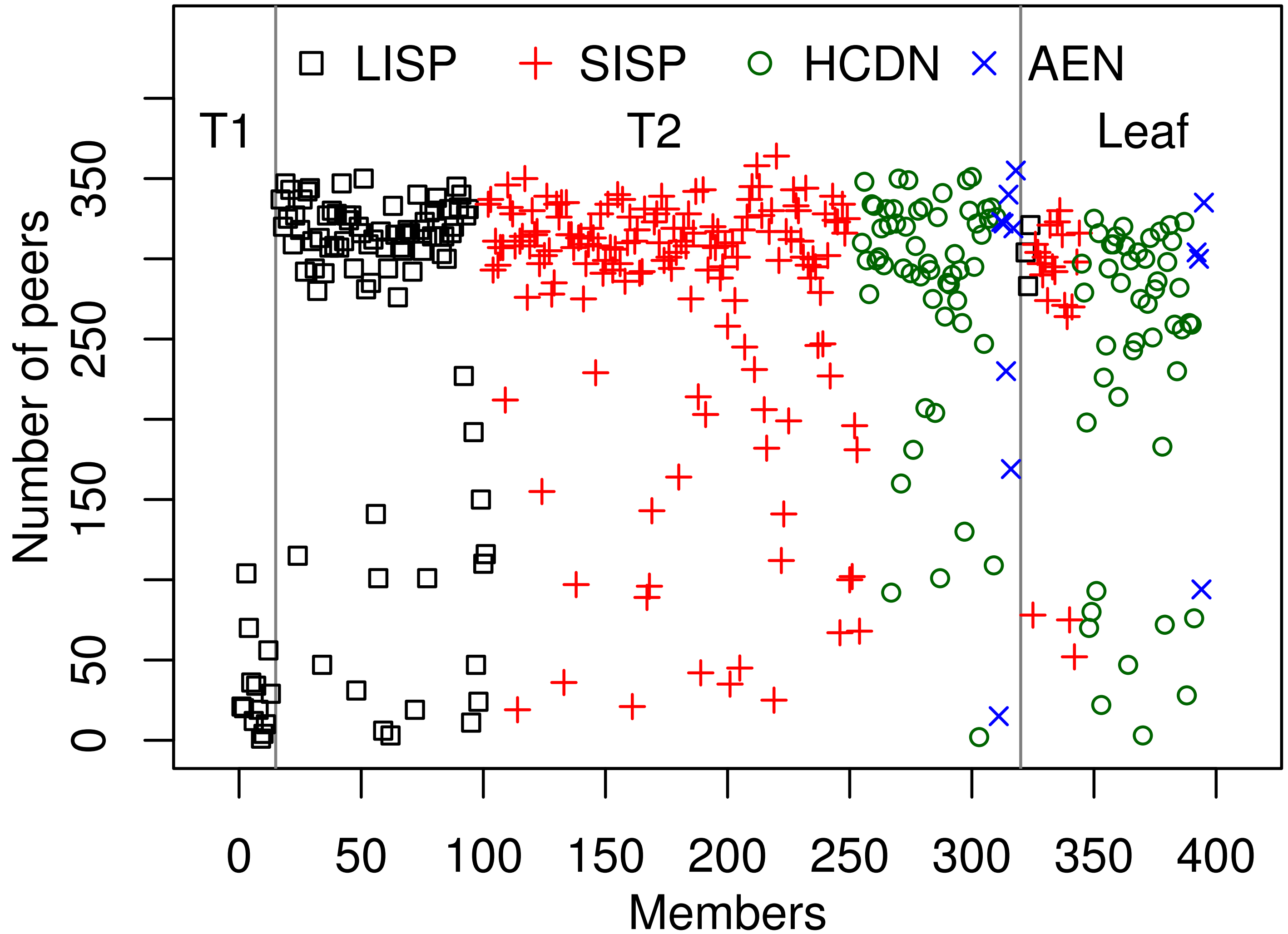


Paper discussion

What's the purpose of an IXP?

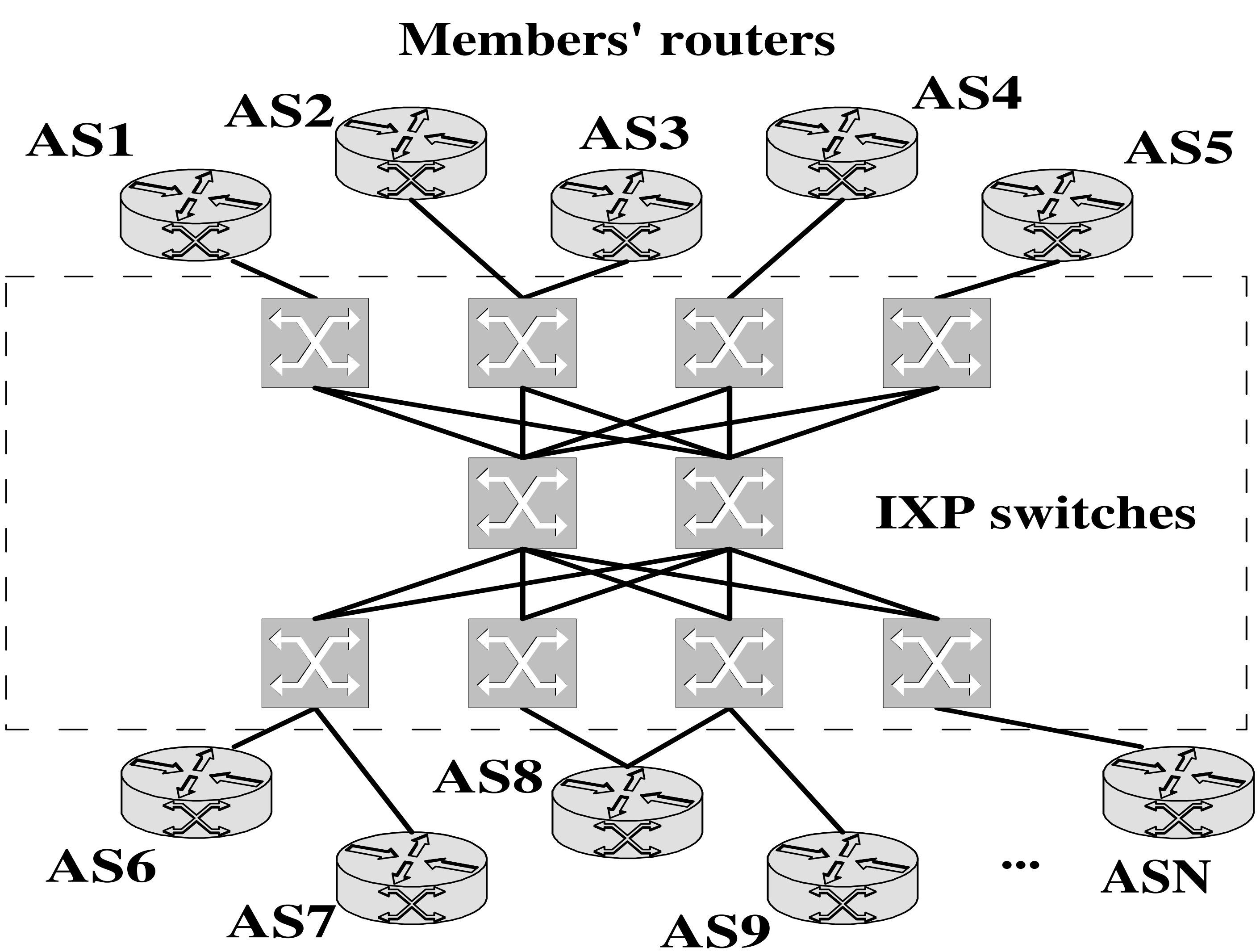
- "Metcalf's law": value of net is O(n^2) when *n* participants

Why don't top-tier ISPs peer much at the IXP?



Paper discussion

How might router-level interconnection differ from AS-level peering? Would this paper's conclusions be the same for router-level?



[Ager, Chatzis, Feldmann, Sarrar, Uhlig, Willinger, SIGCOMM 2012]

physical links = 27

potential peerings = 45

Paper discussion

Similarly ... suppose we treat the IXP as an AS “in the middle” of each member AS-to-AS connection

Now how many links are there?

- 396 total members of this IXP, so 396 links
- vs. 50,000 reported in the paper!
- O(n^2) inflation factor for n member ASes

This suggests interesting measurement projects:

- If you care about only the router level, what fraction of the links are observable?
- If you treat the IXP as an AS “in the middle”, what fraction of the links are observable?

What's to come

Project proposals

- Comments back by Thursday

Next: Part Two of the course: Grand Challenges

- scalability
- complexity: SDN
- reliability
- selfishness
- security & privacy