CS419: Computer Networks

Lecture 5, Part 5: Mar 2, 2005

Internet Routing:

AS’s, igp, and BGP

- As we said earlier, the Internet is composed of Autonomous Systems (ASs)
  - Where each AS is a set of routers, links, and hosts
  - And is controlled by a single administration (autonomous)
  - An ISP, a large enterprise (Cornell), etc.

AS’s, igp, and BGP

- Internally, each AS can run any routing protocol it wants
  - “interior gateway protocol”, or igp
  - Examples: RIP, OSPF, IS-IS
- ASs run BGP between them
  - Border Gateway Protocol
- Though many stub ASs don’t run BGP, but simply default to their ISP
  - The ISP runs BGP “on their behalf”

AS's, igp, and BGP

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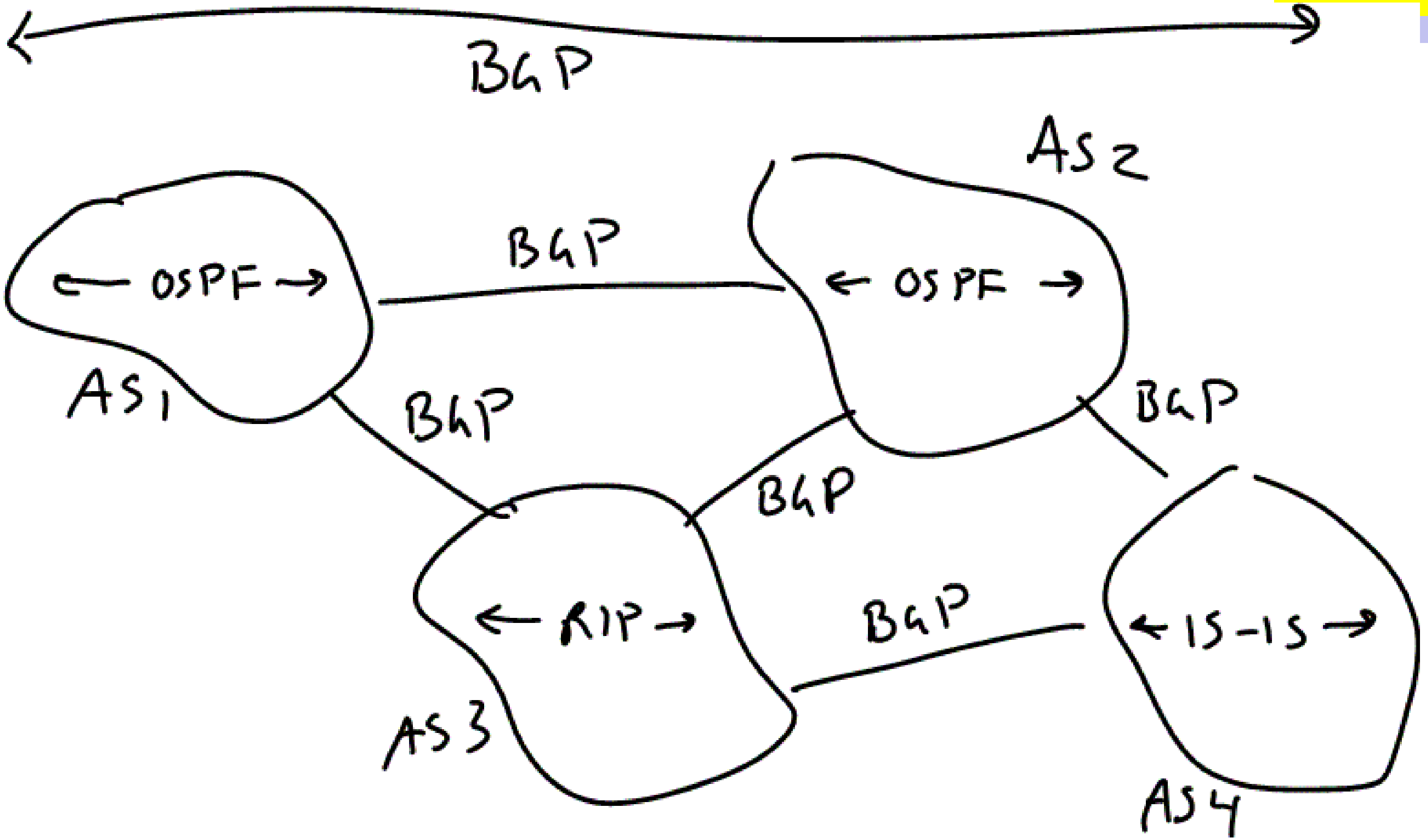

Border routers run both BGP and the igp

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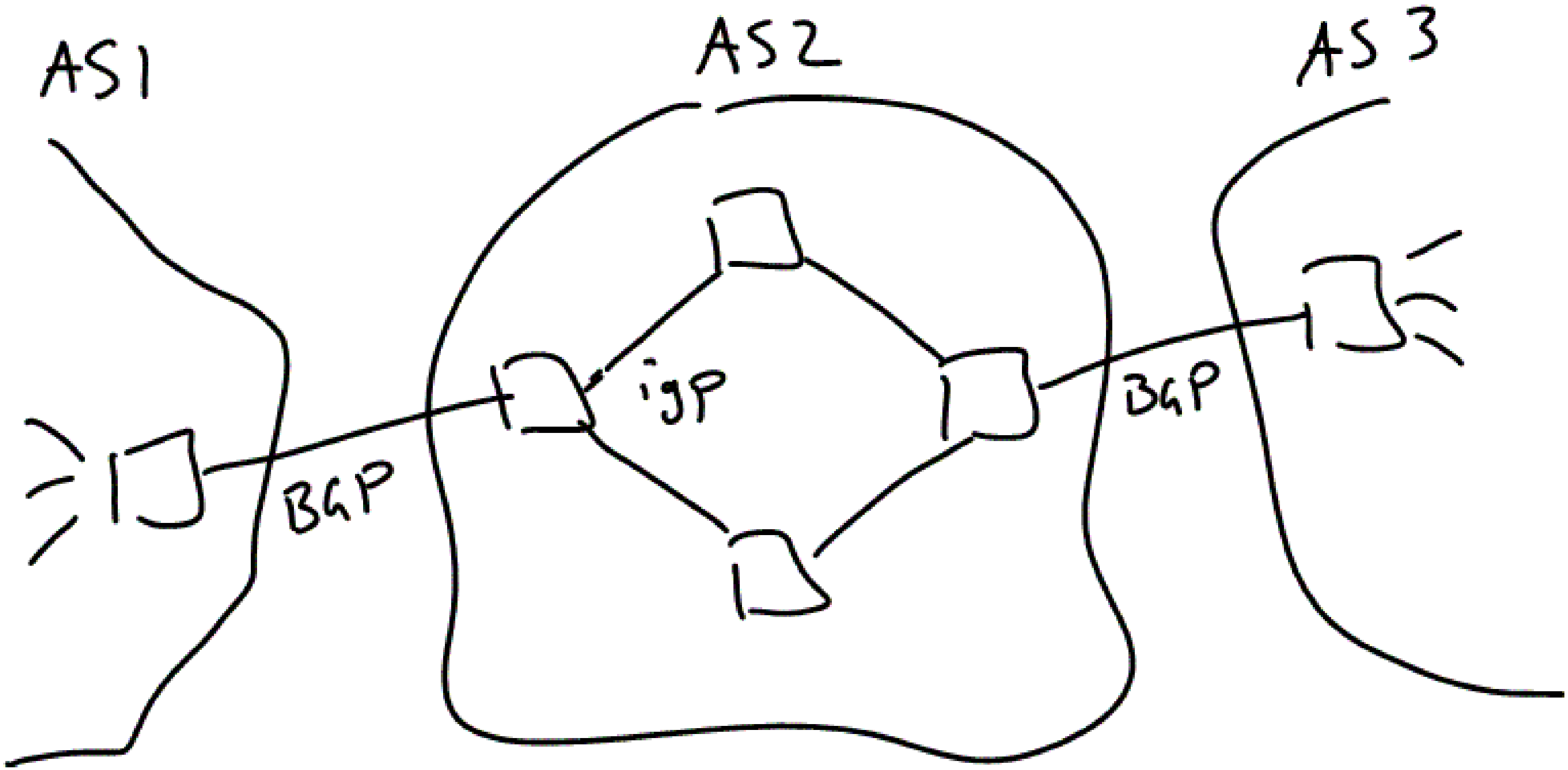

Two routing protocols, one FIB?

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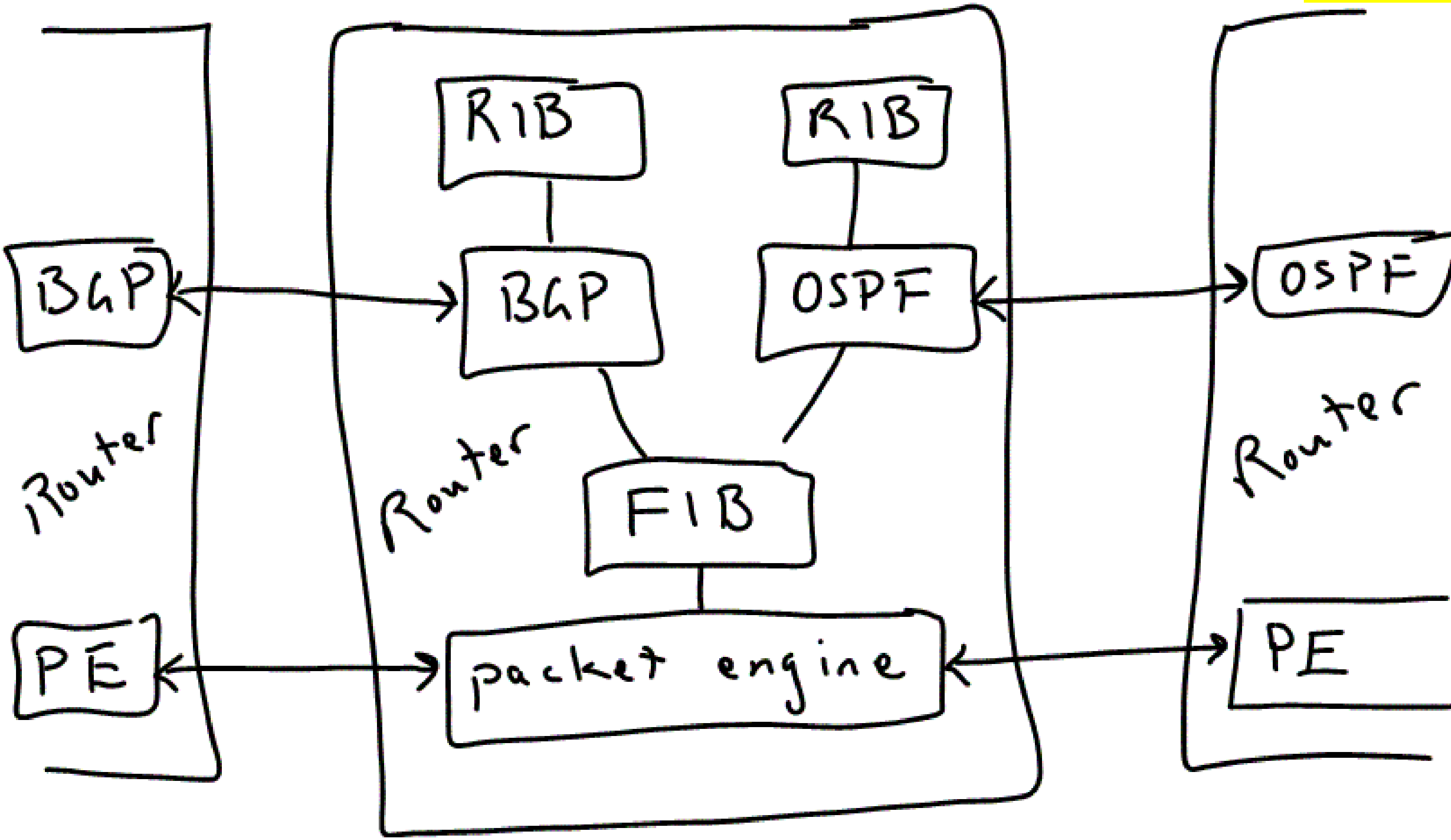

Importing and exporting routes

- Routing algorithms have to "originate" routes
  - Which means that the routing algorithm has to "import" the route in some way other than getting it from a neighbor router
- Two ways:
  - From configuration (iface1 has prefix P . . .)
  - From another routing algorithm!
- Likewise, routing algorithms can "export" routes

Importing and exporting routes

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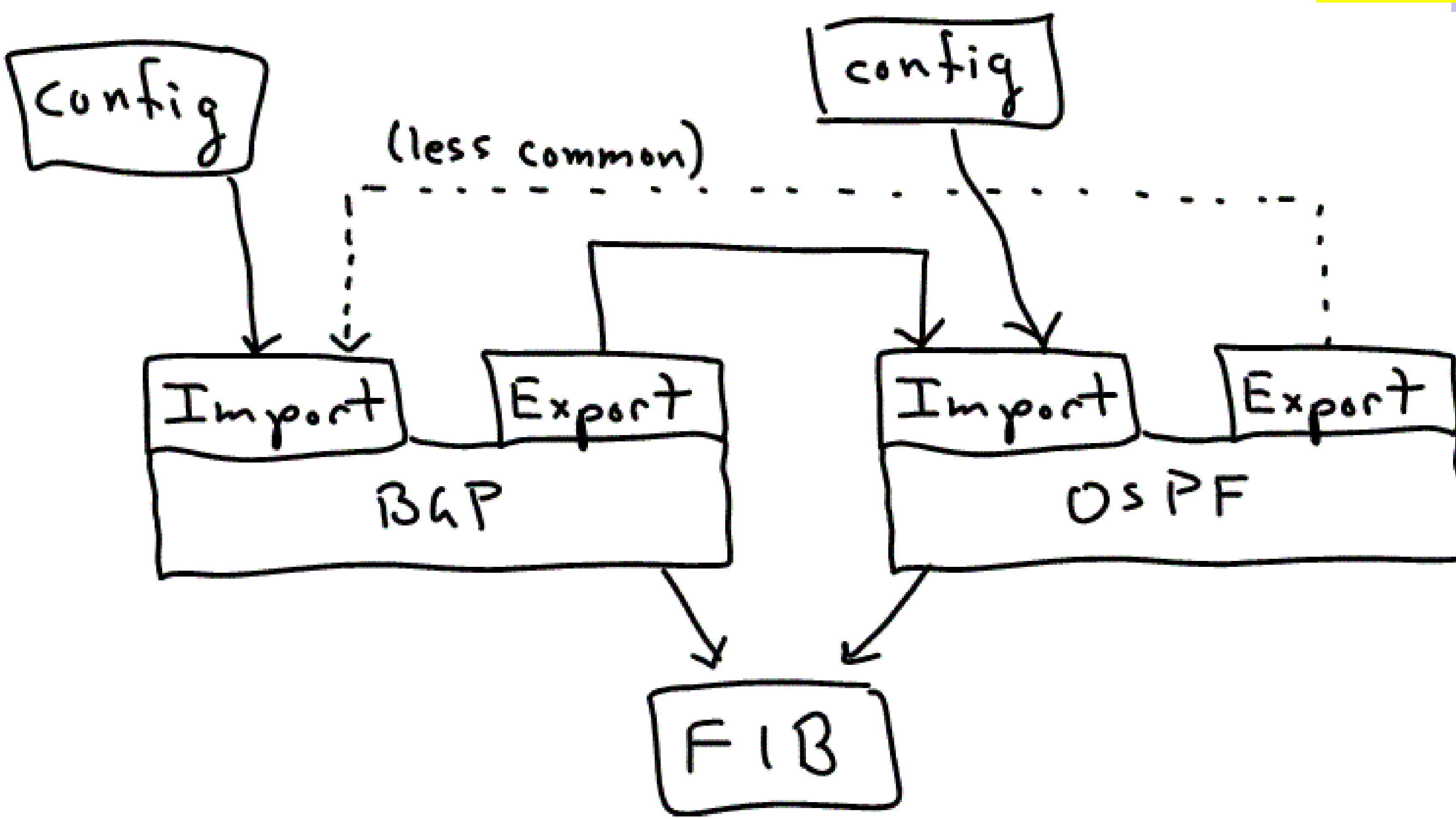

Limits to importing and exporting

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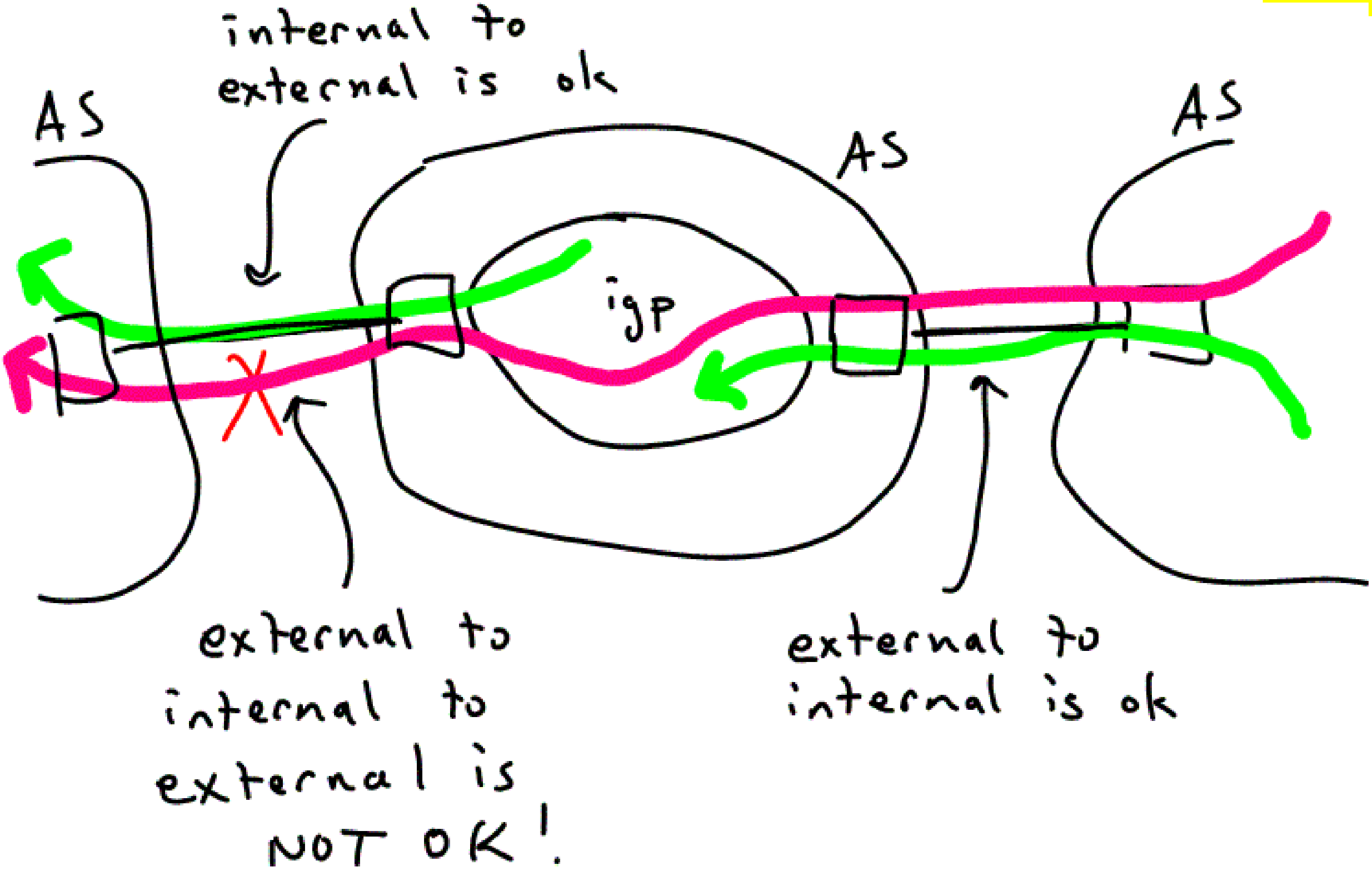

Why this limitation?

- Semantic mismatch between BGP and igp
  - BGP is path-vector, and requires the AS-path to the destination prefix
  - igp's don't require this AS-path, and can't be expected or forced to carry it
  - Want to maintain independence between igp and BGP
- Also, igp convergence may be slow…

iBGP and eBGP (interior and exterior)

- BGP avoids dependence on igp by running both between ASs (exterior, eBGP) and within ASs (interior, iBGP)
- iBGP runs over TCP

iBGP and eBGP (interior and exterior)

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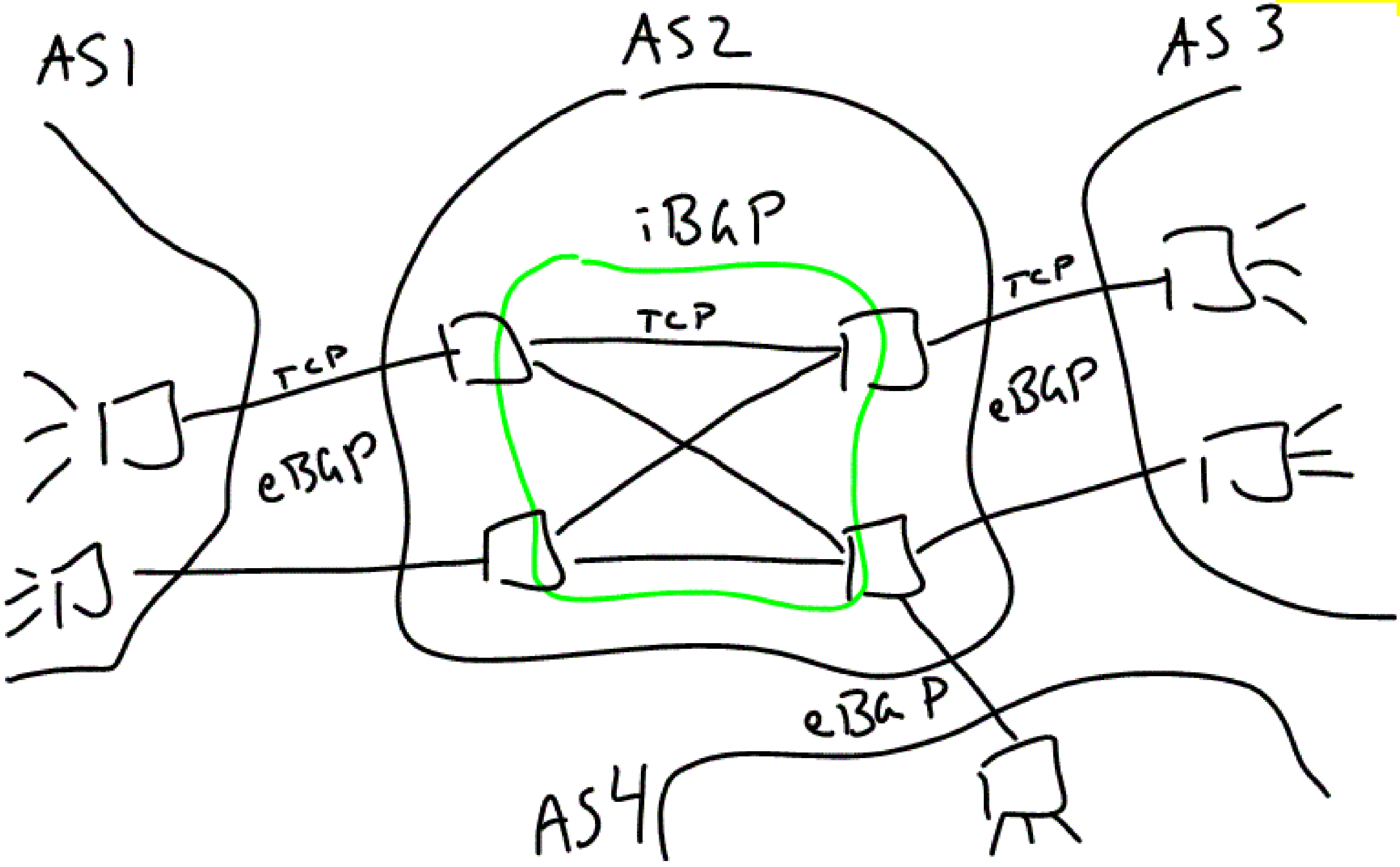

iBGP and eBGP (interior and exterior)

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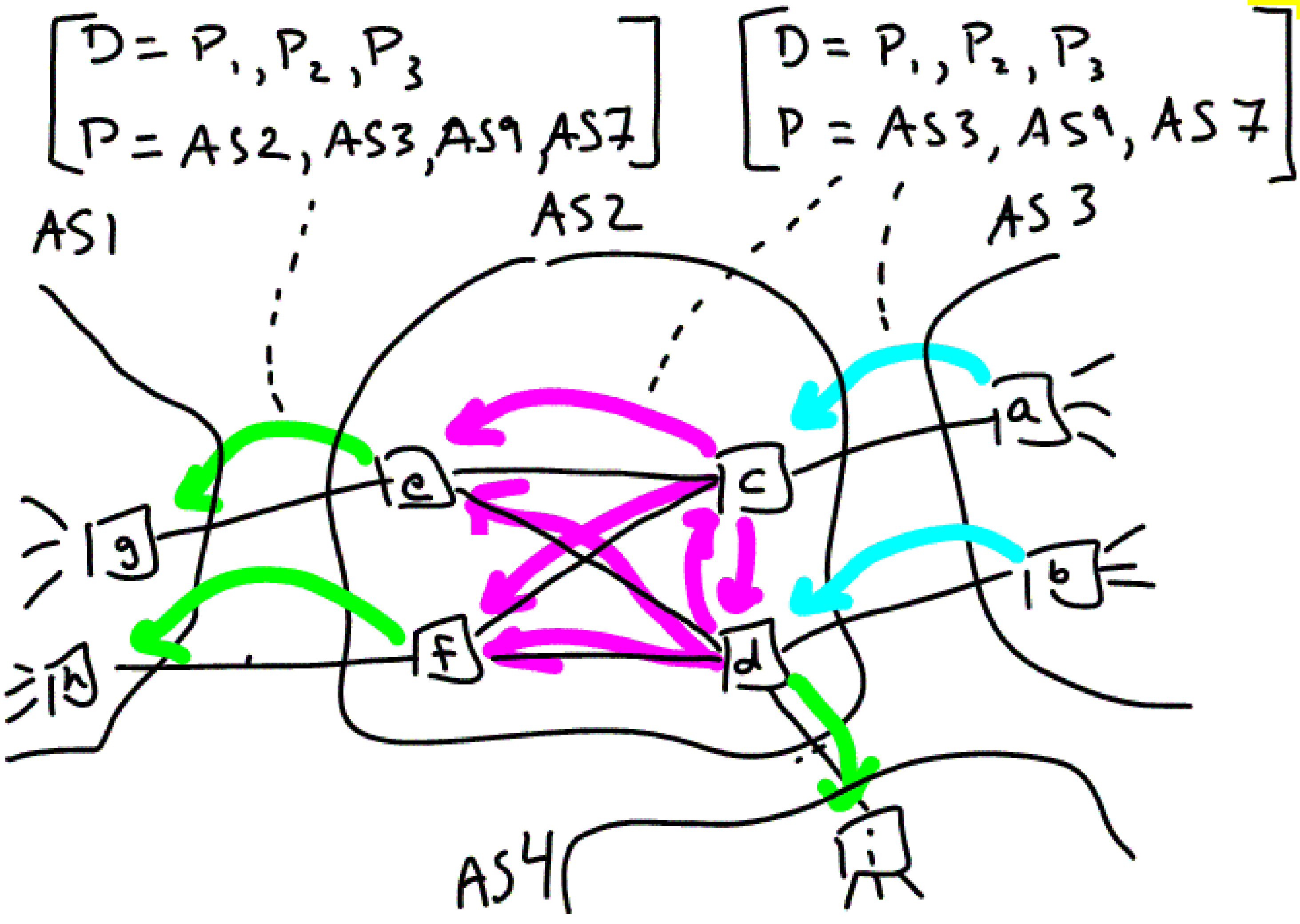

Next hops are weird in iBGP

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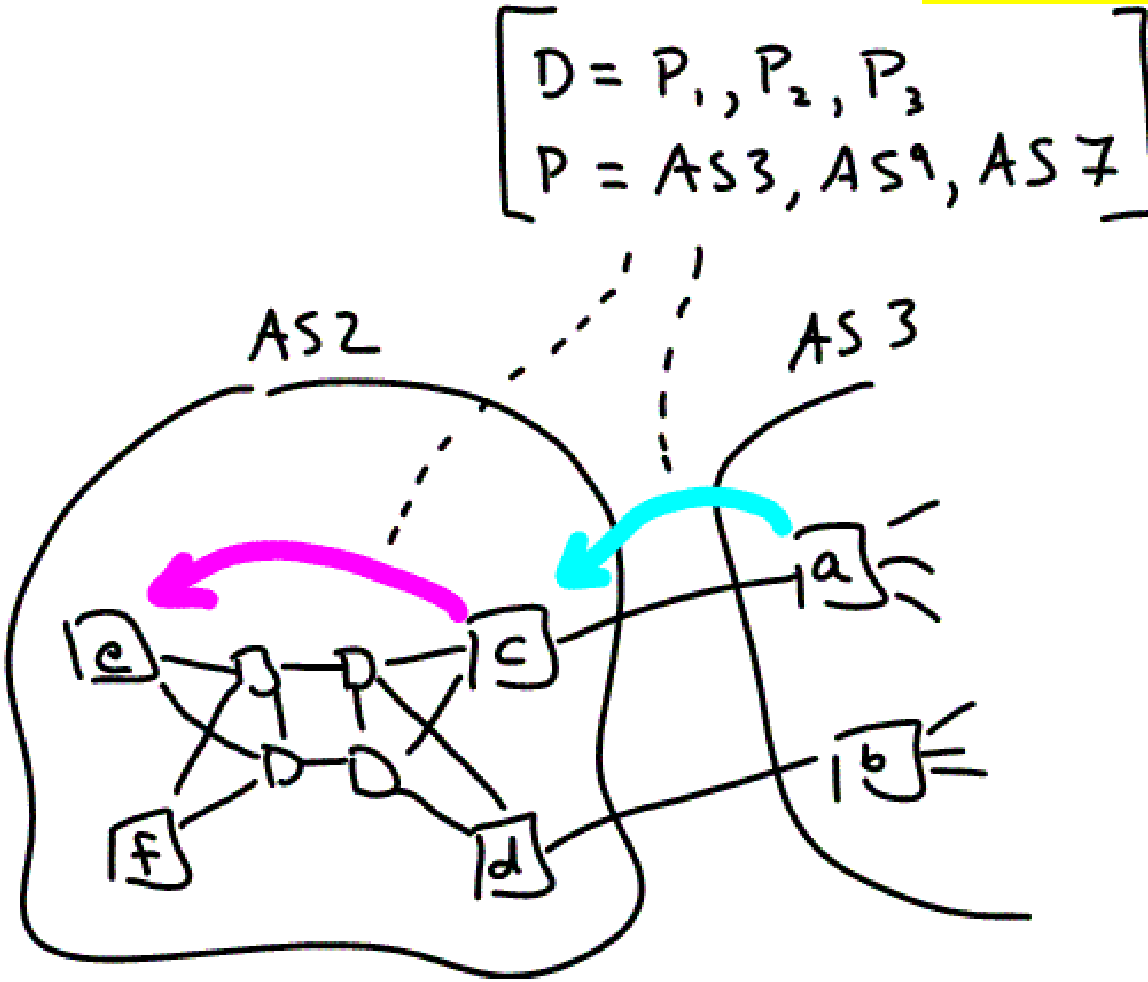
What does it mean for e to have c as its next hop to P1, when there are multiple routers between e and c???



One option: tunnel across AS

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- iBGP speakers form IP tunnels across the AS
  - IP over IP
    - (perhaps with GRE between them, but lets not get into this now)
  - This creates a “link” between the two iBGP speakers
  - Remember, IP doesn’t care what subnet technology it runs over, even if that subnet is IP!!!

iBGP next hop using IP-in-IP tunneling

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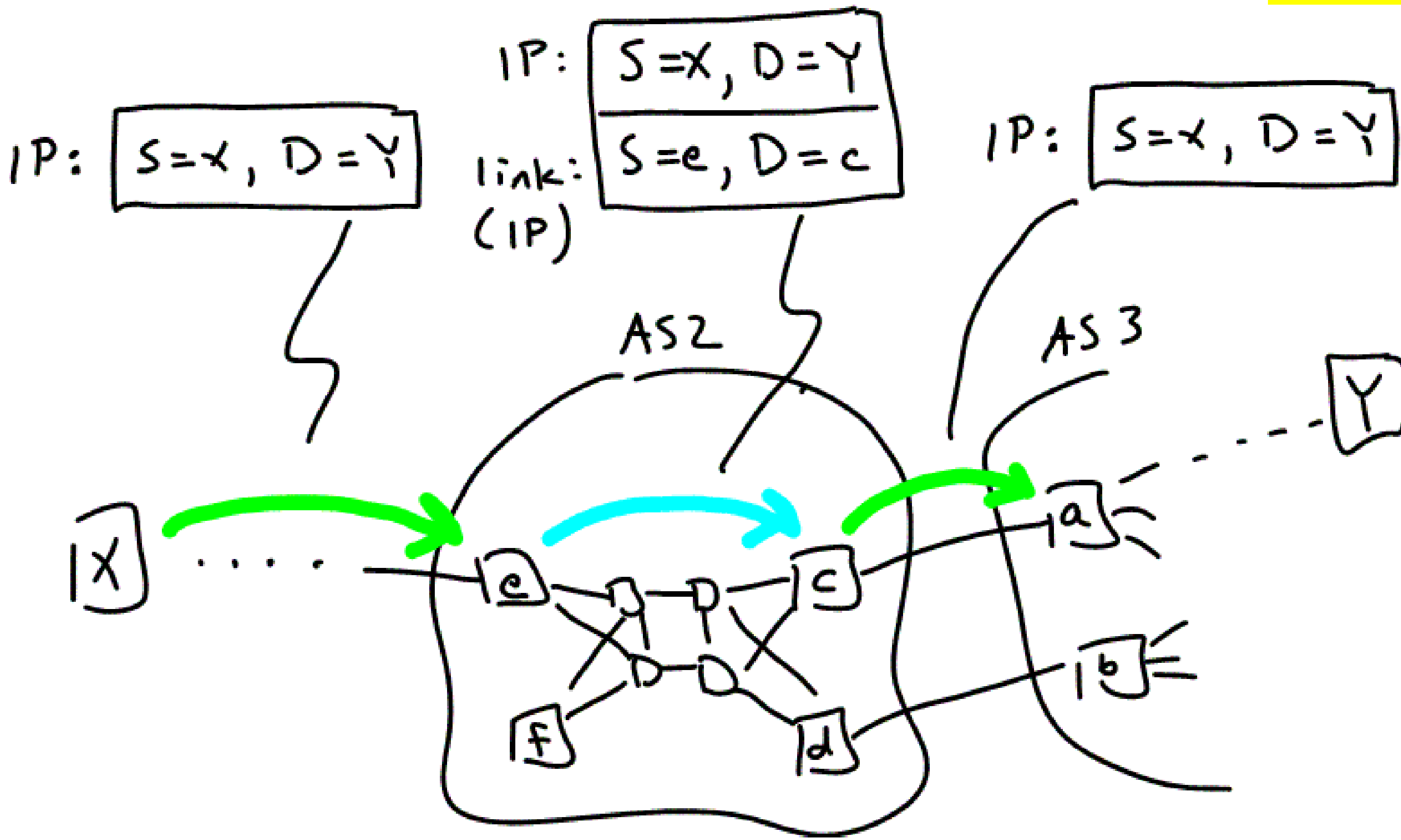

Another option, use both BGP and igp RIBs

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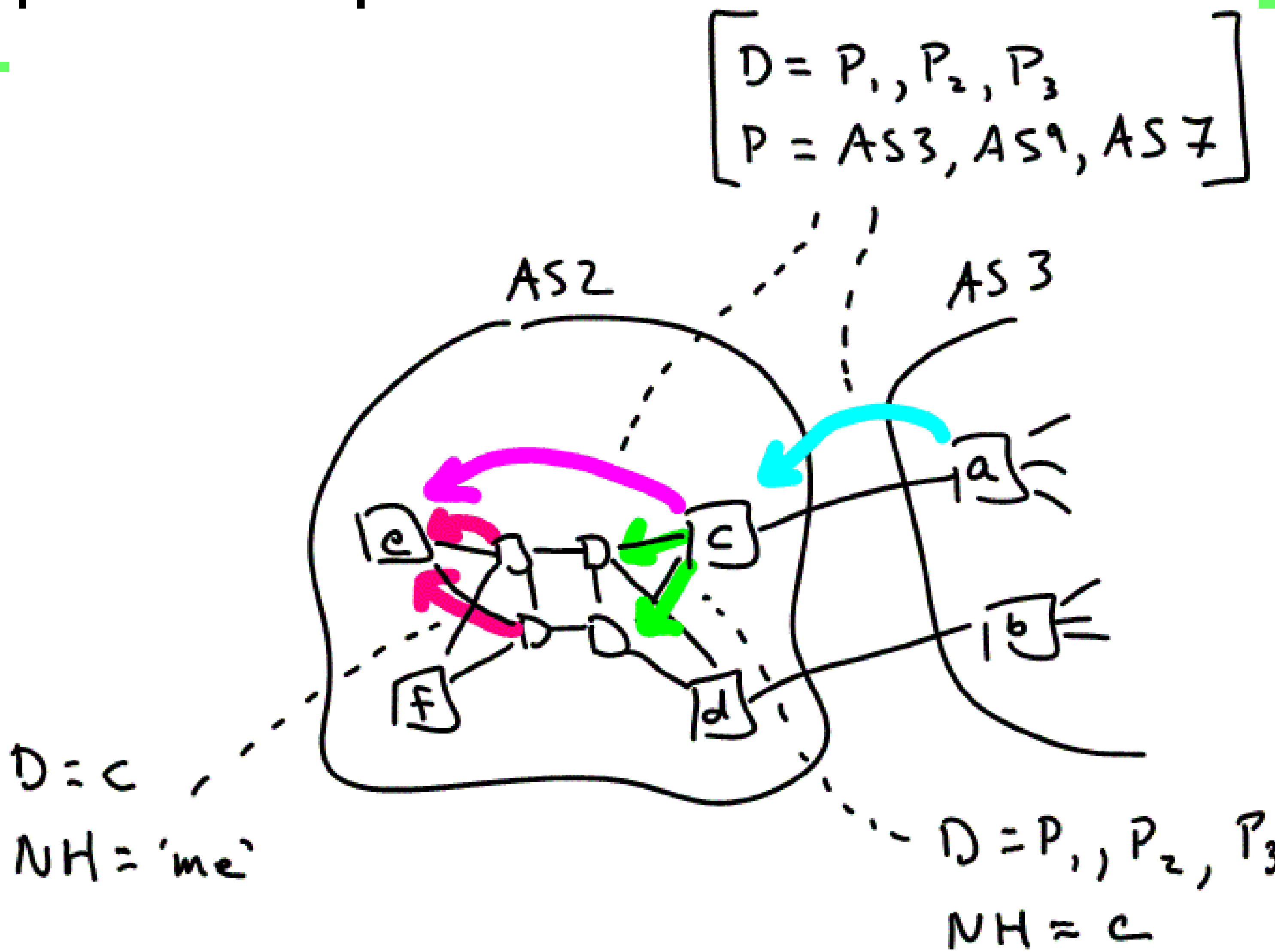
- iBGP “resolves” the iBGP next hop to its igp next hop
  - iBGP computes its next hop
  - iBGP looks into igp RIB to determine igp next hop to iBGP next hop
  - This becomes the actual next hop
- iBGP must advertise external prefixes into the igp

iBGP using igp RIB to resolve next hop



BGP security model

- Authentication is hop-by-hop, like OSPF
- But threat is much worse, because no single organization controls all of BGP
- So, BGP uses policy to help prevent bogus routes
  - BGP routers have an expectation of what they should hear from where

BGP policies

- Who to peer with (which ASs)
- What routes to originate
- What routes to import (prevent bogus advertisements)
- What routes to export (and how to aggregate them)
- What paths to prefer
  - Shorter AS paths
  - Some ASs preferred over others
    - The big ASs (UUnet, AT&T, etc.)
    - Primary versus backup transit AS

BGP policy limitation (hop by hop policy decisions)

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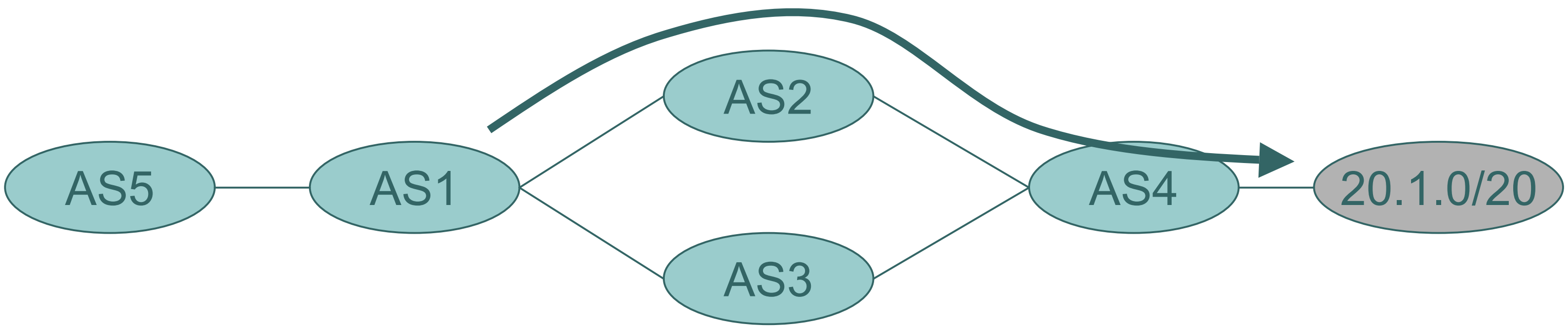

AS1 chooses AS2 as the path to 20.1.0/20.
AS5 is forced to accept the choice of AS1
(If AS5 <u>really</u> doesn't like it, it should find a new peer)

BGP policy conflict

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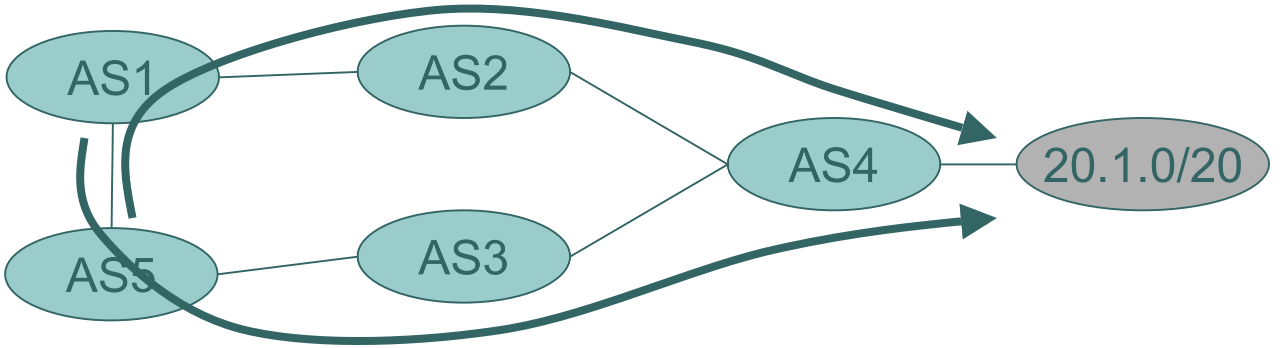

AS5 policy is to prefer route to AS4 via AS2
AS1 policy is to prefer route to AS4 via AS3
<u>Both policies cannot be satisfied</u>

Hot potato routing

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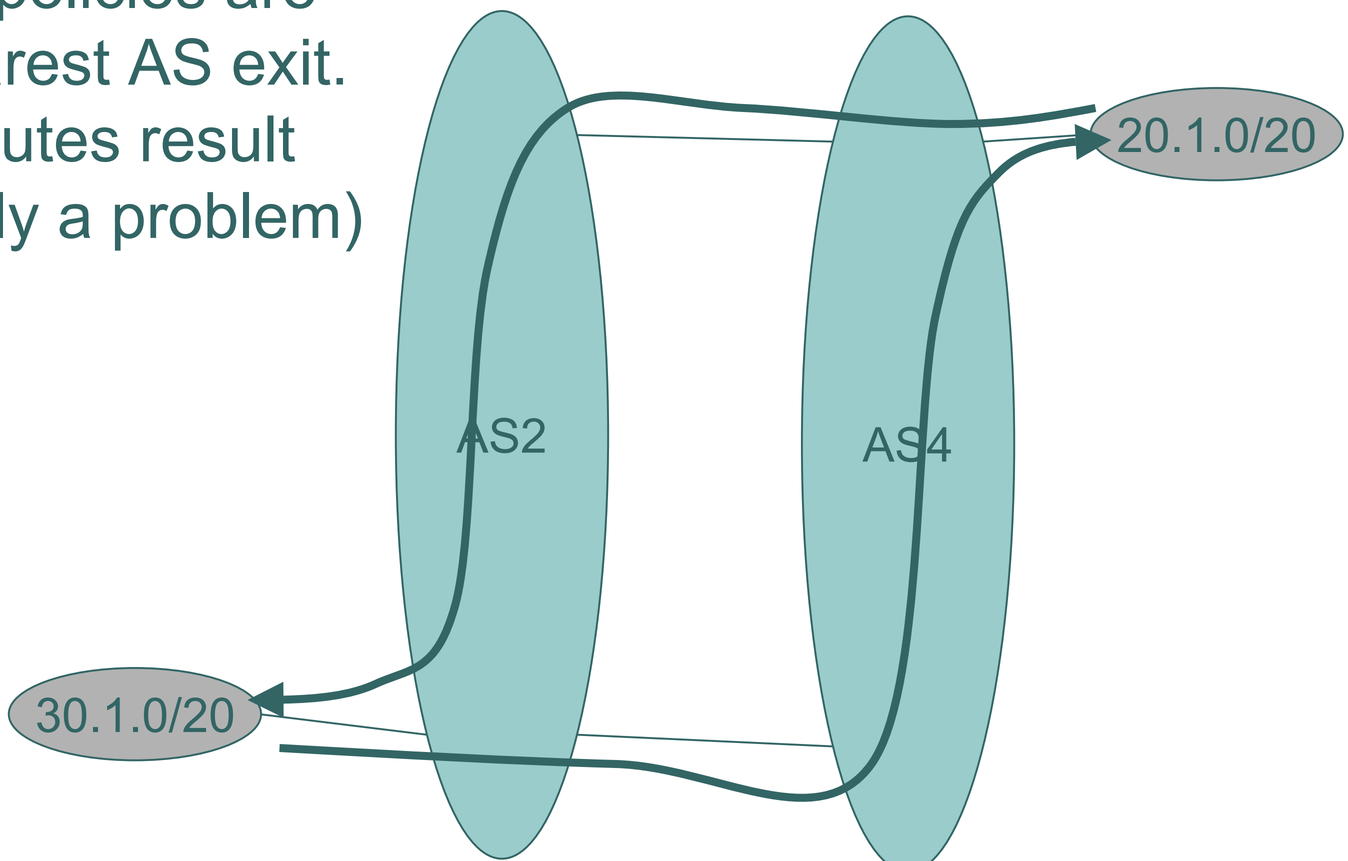
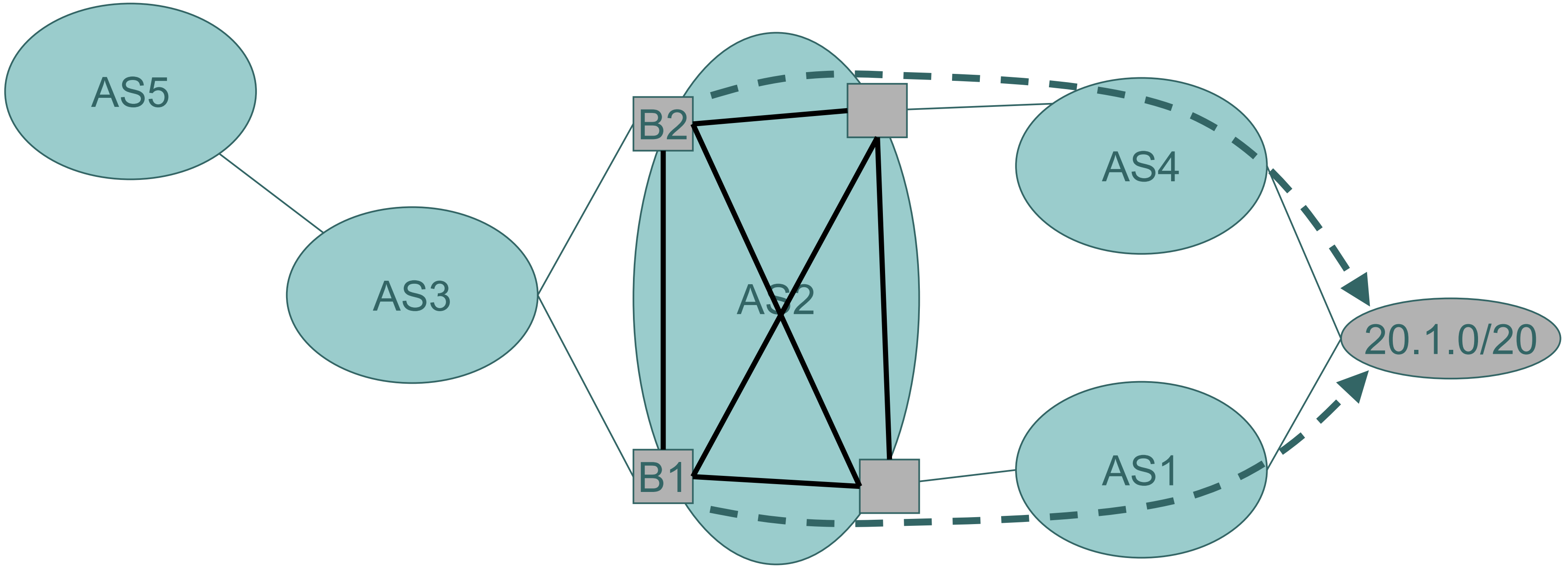
AS2 and AS4 policies are to route to nearest AS exit. Asymmetric routes result (not necessarily a problem)



Misconfigured policies may lead to oscillation



B2 configured to prefer AS4
B1 configured to prefer AS1

Misconfigured policies may lead to oscillation

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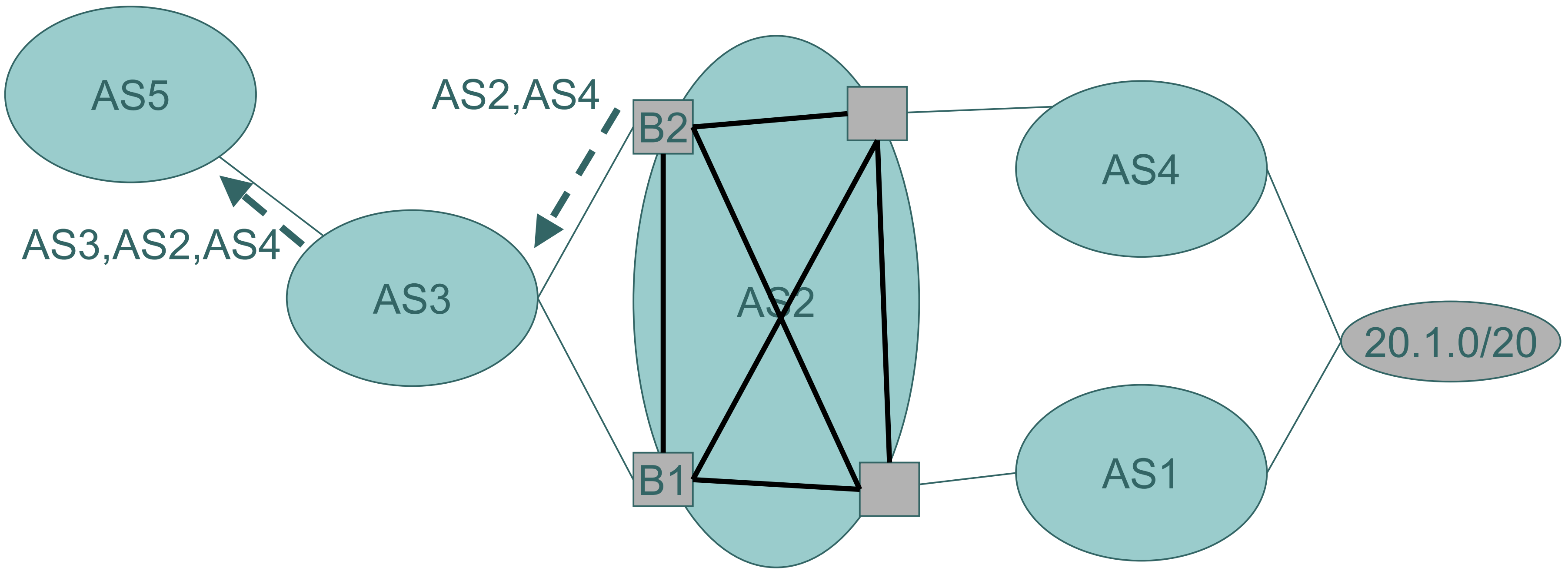

B2 (periodically) updates AS3 with path AS2,AS4

Misconfigured policies may lead to oscillation

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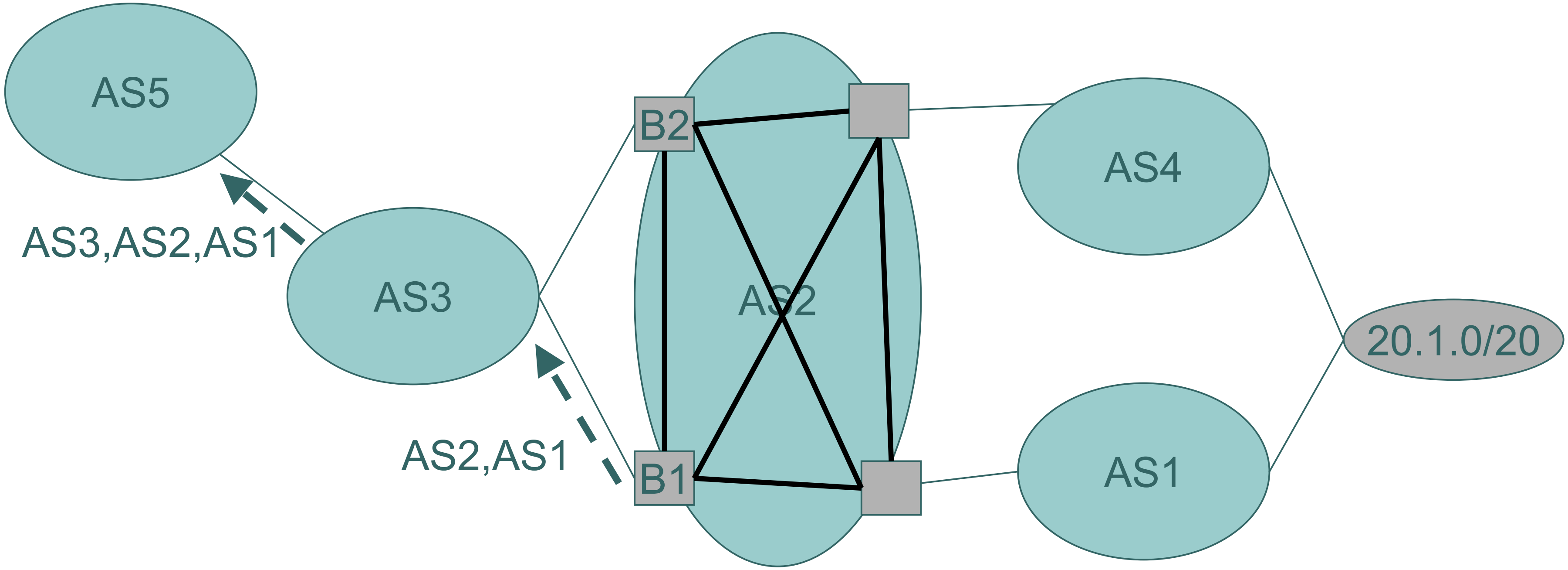

B1 (periodically) updates AS3 with path AS2,AS1
With each period AS3 advertises a different route

Other route flapping

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- A link continuously goes up and down
  - The update for this is propagated throughout the internet
- Mid-90's these kinds of problems were severe
  - 1996: 45,000 prefixes, 1,500 unique AS paths, 1,300 ASs, 3-6 million BGP update messages/day
    - 6 updates per prefix per hour!
    - (Labovitz et. al.)

Today much improved

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- Better policy tools
- Better software
- Lots of damping
- But still, advances in BGP lead to new policy bugs
  - Route reflectors published in 2000 (RFC2796)
  - Inconsistent route reflectors problem published in 2002 (RFC3345)

Policy Tools

- Routing Policy Specification Language (RPSL) (RFC 2280)
  - Earlier policy languages exist
- Language to define BGP policies
  - Peers, import, export, route preference, aggregation
- Posted at Routing Registries (RIPE, RADB, etc.)
- Tools created to look for policy inconsistencies (within AS and across ASs)
- Tools created to match measured reality (BGP tables, traceroute) with policy expectations
  - RAToolSet, USC/ISI

Lots of Damping

- Stop advertising certain prefixes if they go up and down a lot
  - Improve stability
  - Lower overhead
- RIPE guidelines:
  - Don't dampen until after 4th flap in a row (in 50 minutes)
  - /24: dampen 60 minutes
  - /22,/23, dampen 30-45 minutes
  - </22, dampen 10-30 minutes

Lots of Damping

- Helps the internet, but means that you can go away for a long time
  - Because of some problem in the middle!
- Most damping is done on routes that you don’t care about
  - Poorly managed small ISPs
- Routes through major ISPs tend to be very stable
  - Your favorite web sites

Effect of BGP policies on path quality

- Ramesh Govindan study (USC)
- Methodology:
  - Learn real physical topology with traceroutes, deduce actual AS connectivity
    - Imperfect, but not bad
  - Examine used “policy topology” from BGP tables, RADB (routing registry) database
  - Compare the two

Effect of BGP policies on path quality

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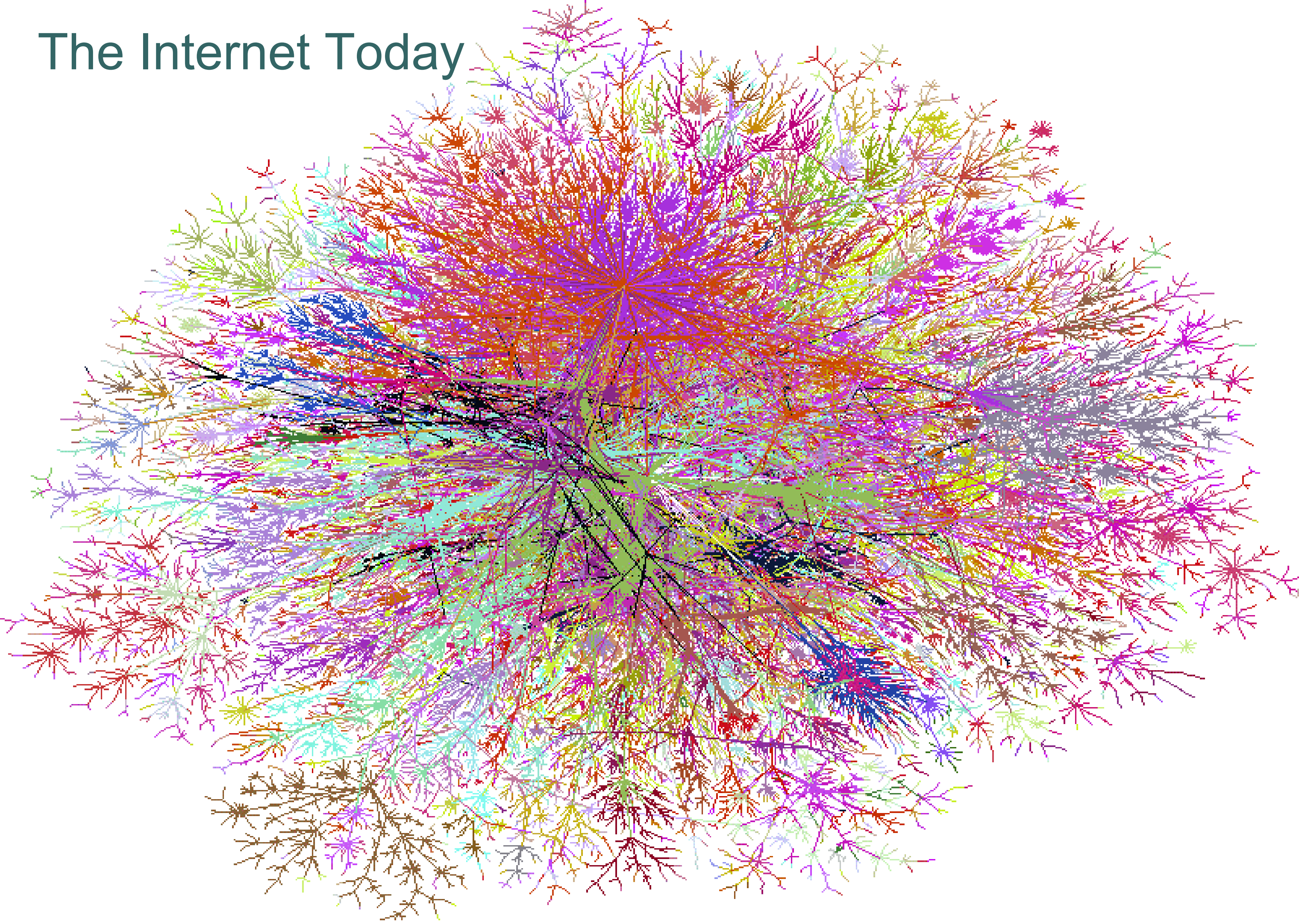
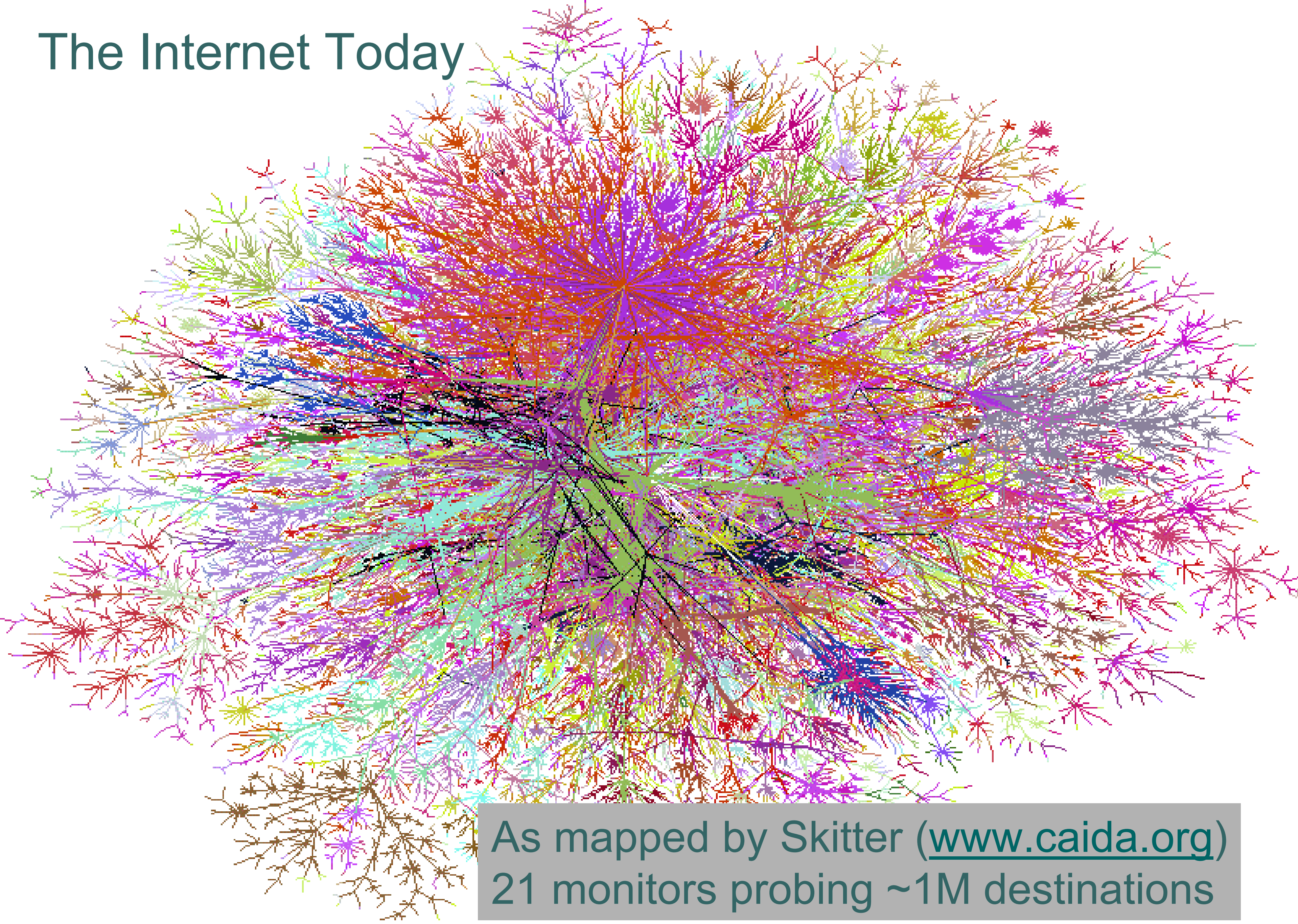
- Results:
  - About ½ of the paths a longer than shortest path
  - 20% of policy paths are 50% or more longer
  - 20% of policy paths are 5 hops or more longer
  - Policy tends to push paths through major backbones rather than possibly shorter routes
    - (But shorter routes may not be better routes!)

The Internet Today



The Internet Today



As mapped by Skitter (www.caida.org)
21 monitors probing ~1M destinations

BGP Routing Table Growth

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