E6998-02: Internet Routing

Lecture 16
Border Gateway Protocol, Part V

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Announcements

Lectures 1-16 are available.

Homework 4 is available, due 11/14.

Multihoming

- Connecting to multiple providers.
- Backup links (we’ve already examined this).
  - The backup link is idle unless the primary goes down.
  - Slow is better than dead!
  - We’ve already covered this.
- Load sharing / load balancing / redundancy.
  - To the same provider.
  - To different providers.

Redundancy Issues

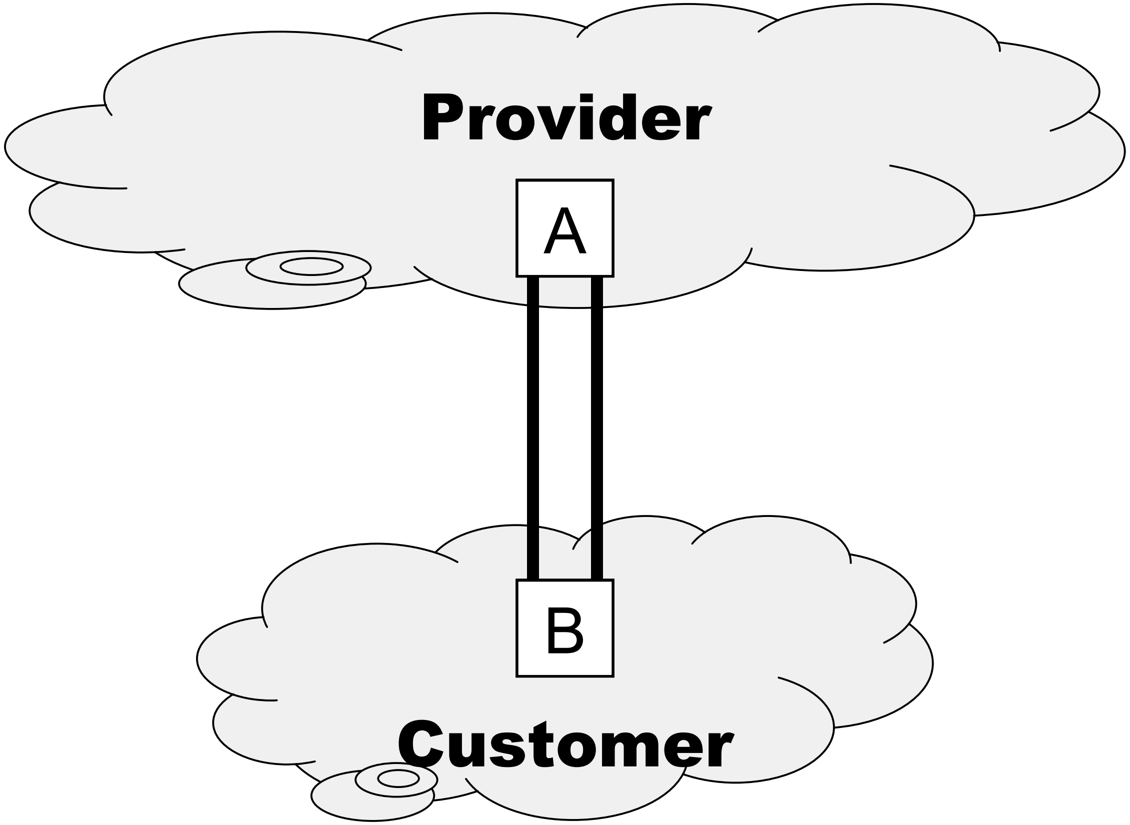
- Not just two ISPs!
- Redundant telco lines.
- Redundant power.
- Redundant exit points from the building!
- Redundant routers.
  - Make sure any additional hardware does not become a single point of failure!
- Redundant …

Multihoming Issues

- Addressing.
  - Pick addresses from upstream (main) provider.
  - Use addresses from both providers.
  - Get addresses allocated from ARIN/RIPE/APNIC.
- Routing.
  - Where/how to advertise prefixes.
    - Affects incoming traffic.
  - Where/how to set up own IGP.
    - Affects outgoing traffic.
- DNS
- Higher-layer protocols.

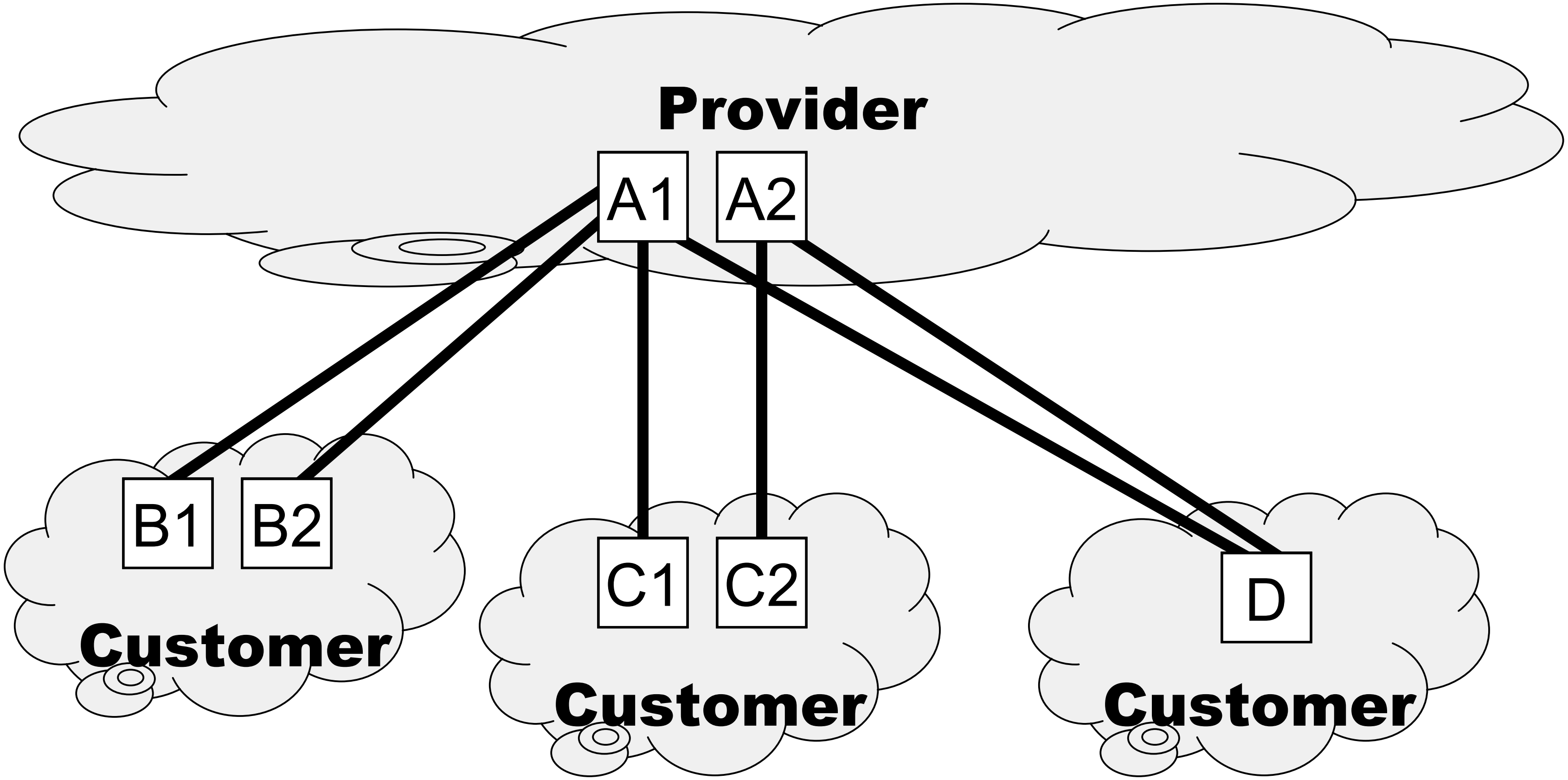
Dual Links

- Simplest cast: two distinct telco lines between the same pair of routers.
- Protects against link failure.



Dual Routers

- Different Configurations protects against router or link failure.
- A1/A2, B1/B2, C1/C2 are “near” each other.
  - IGP handles everything.
  - No BGP tricks involved.

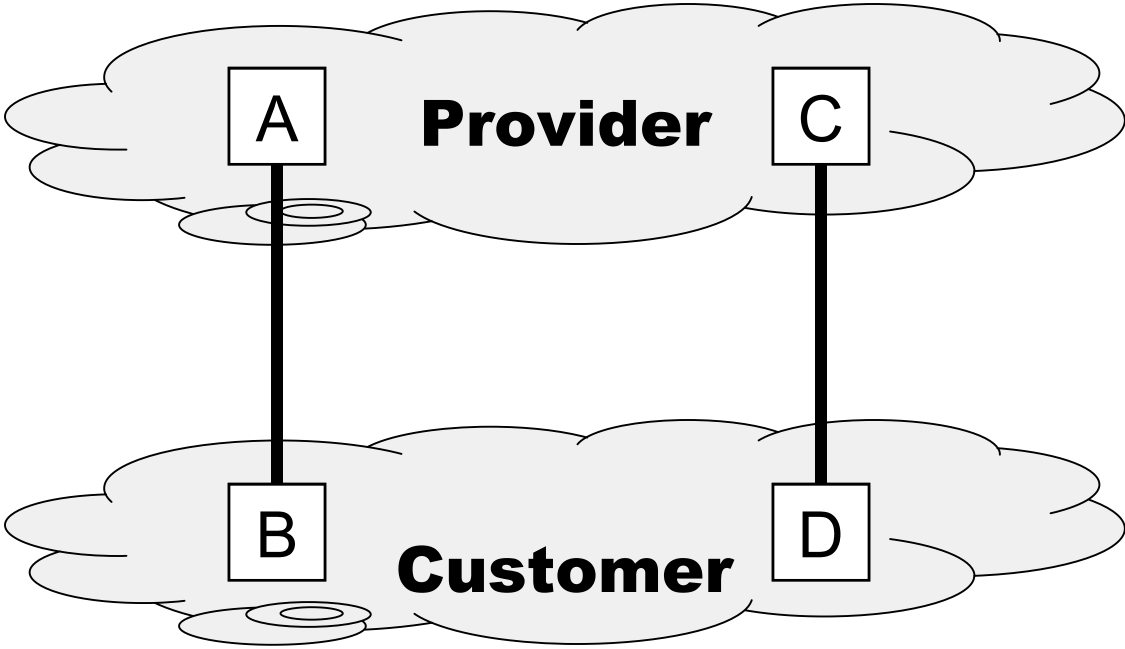


Dual {Links,Routers} cont'd

- These configurations add redundancy.
- Also enable load sharing/load balancing between the links.
- Traffic is (usually) split on a **per-flow** basis.
  - *Flow*: (protocol,src,dst,src-port,dst-port).
  - Performance reasons (can be done on the linecard).
  - Per-packet split possible at much higher CPU burden.
    - Or by using MUXes or multipoint PPP (below the network layer).
  - Packet ordering maintained.
    - At least across the redundant hop.
- OSPF can use equal-cost paths.

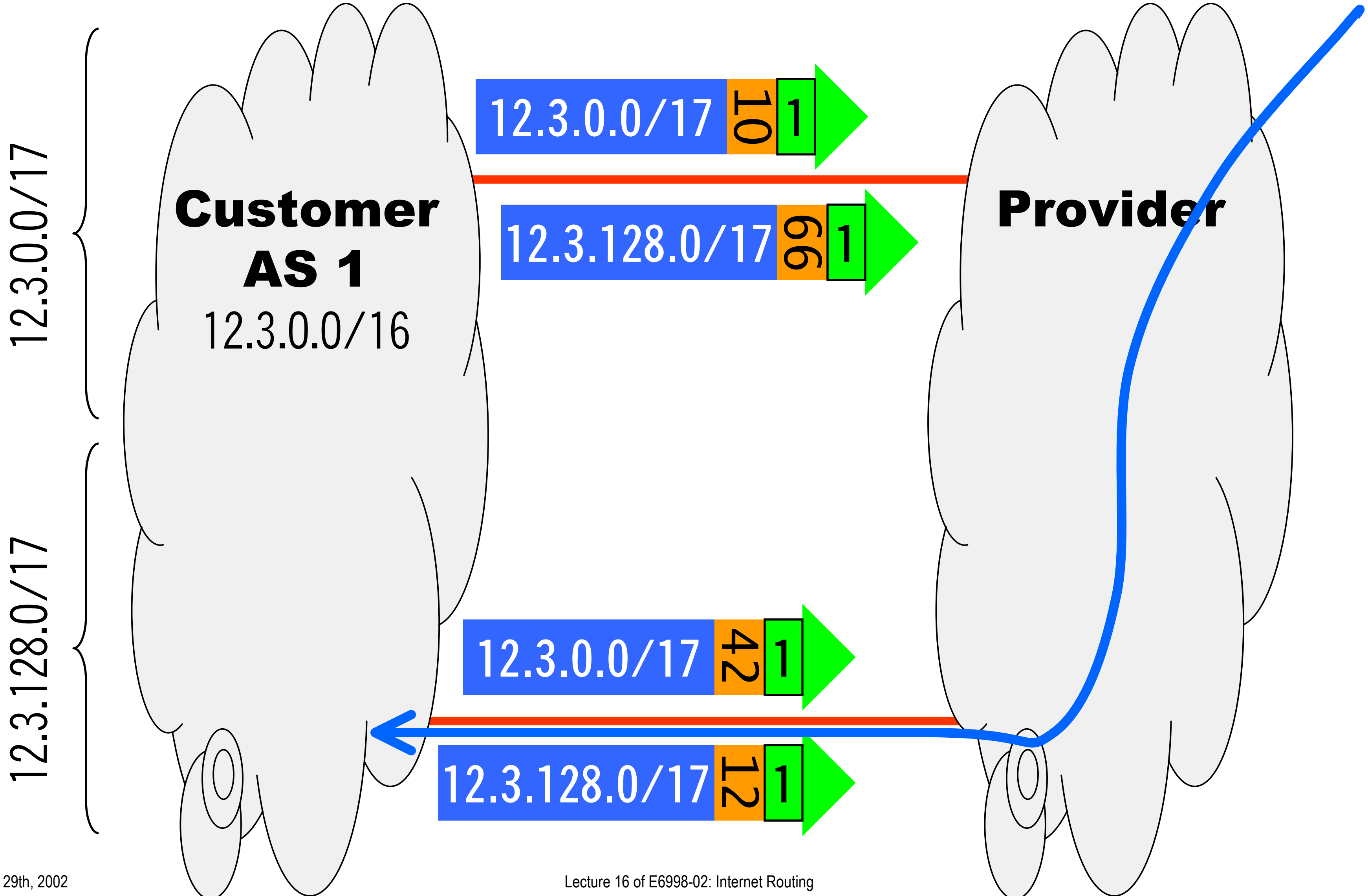
Multihoming to a Single Provider

- … when access links are “far” from each other.
- ISP advertises defaults to customer.
  - Customer’s IGP ensures packets take the closest egress router (B or D).
- Customer advertises more-specifics with MED to force cold-potato routing.

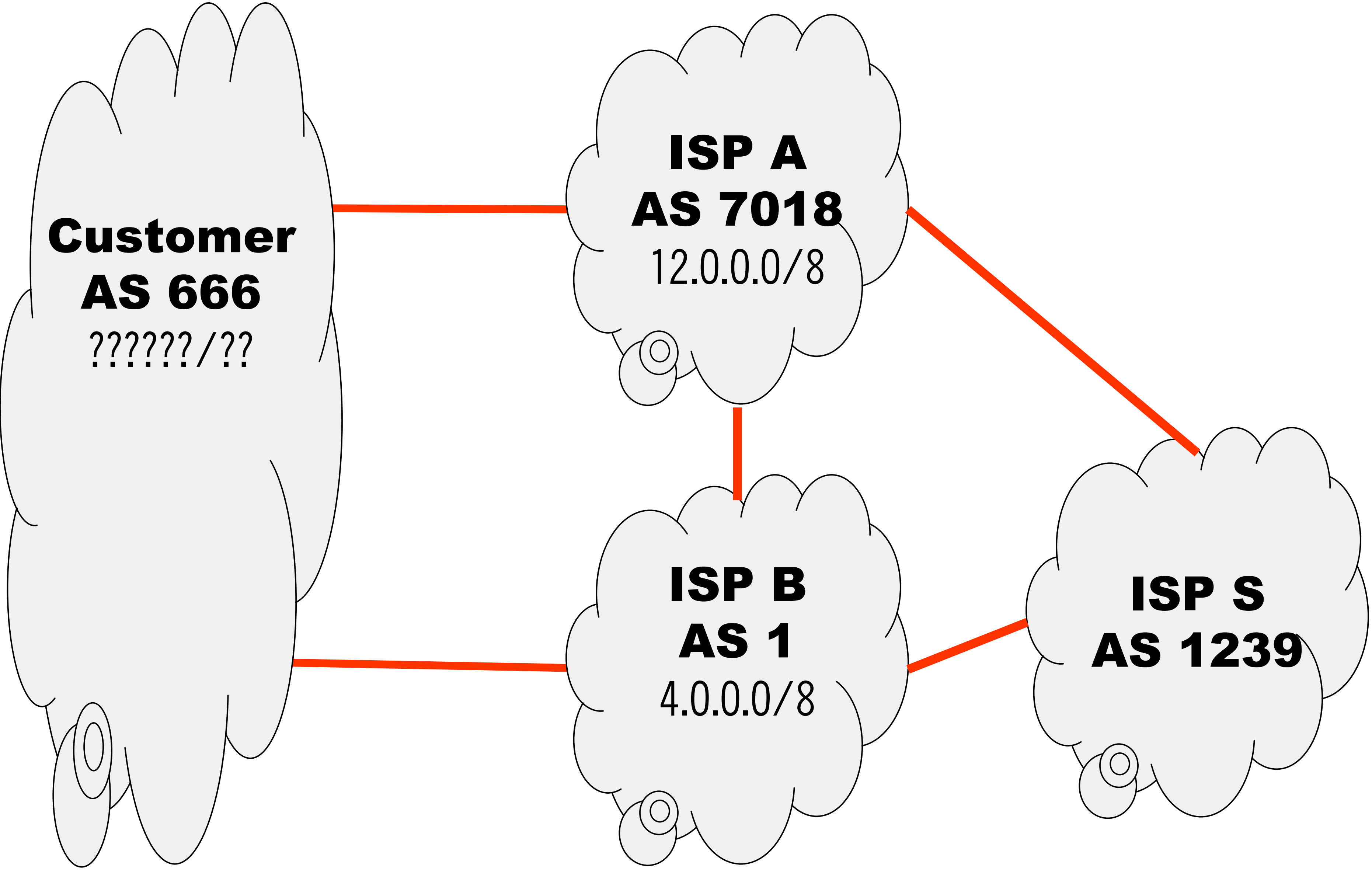


Cold-Potato with MEDs

- MED takes precedence over IGP distance.



Multihoming to Multiple Providers



Own Address Space

- Great if you can get it!
  - And if you’re big enough.
- If the prefix is too long (> /24), it may not get through filters.
  - Lose connectivity from parts of the Internet.
- It does get redundancy.
- Does it get us good load-sharing?
  - Depends on the relative sizes of ISP A and ISP B.
- If equally “important”
  - roughly half the traffic will be coming from each
  - roughly half the announcements will be “better” from one of the two
    - resulting in outbound load sharing.
- Otherwise, may use AS_PATH padding to shed some traffic.

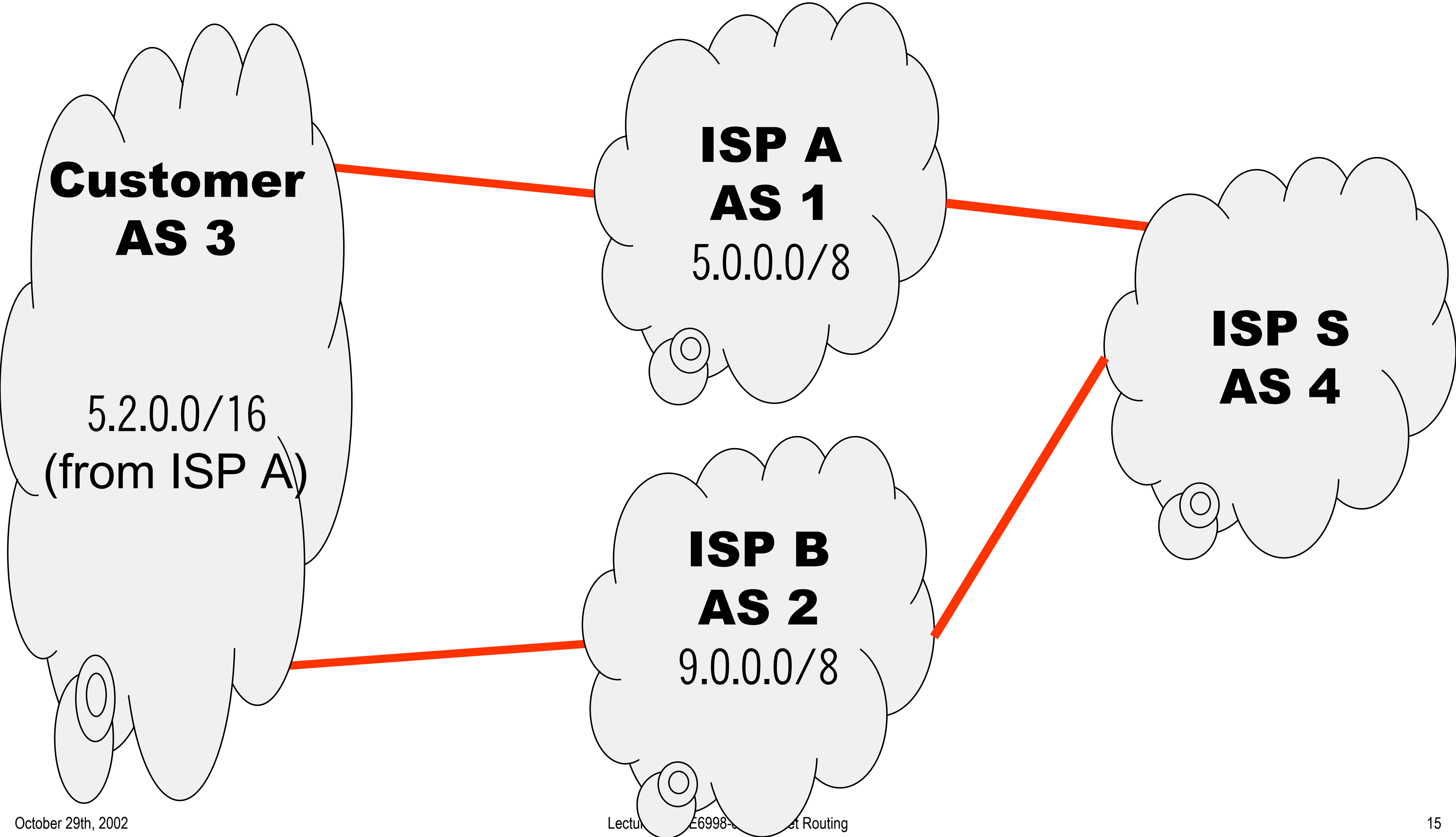
Address Space from Both ISPs

- With the service agreement comes address space.
  - 12.96.16.0/20 from ISP A.
  - 4.99.32.0/21 from ISP B.
- Announce the 12… space to A, and the 4… space to B.
  - (or not announce at all).
- Load sharing depends on source/destination of bulk of traffic.
- No redundancy.
  - If one link goes down, half of Customer’s address space is unreachable.
  - And unusable (no return routes).

- Use DNS round-robin to respond with addresses from both spaces.
  - Incoming connections will chose an address at random.
  - Not optimal in half the cases.
- How to pick address for outgoing connection?
  - Allocate address by region.
  - Random.
- Problems if ISPs do ingress filtering.
- Use of NAT has been suggested (arrrggggghhhh!)

Address Space from one ISP

- Outgoing traffic **from** Customer is not affected.



Customer
AS 3

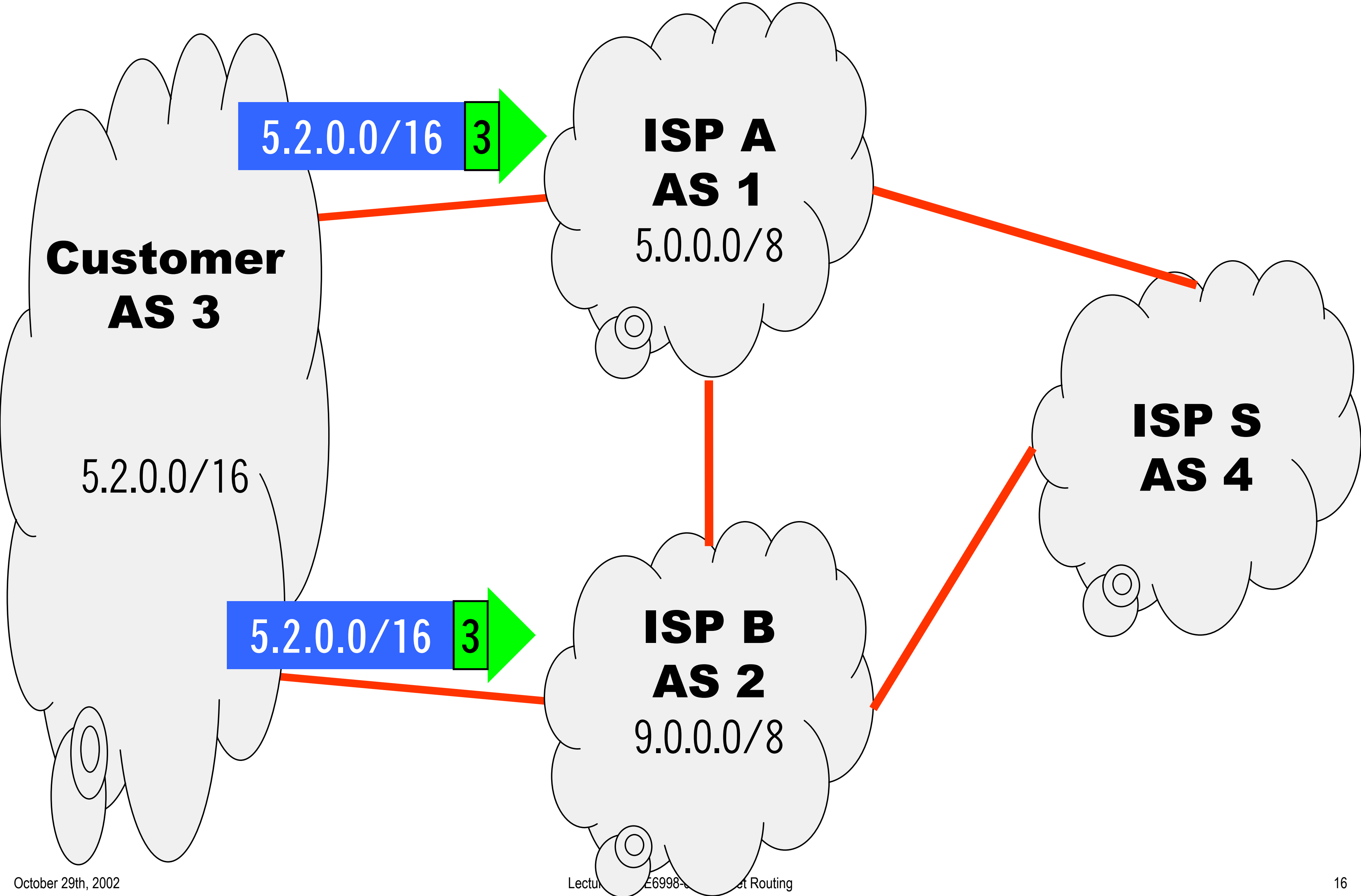
5.2.0.0/16
(from ISP A)

ISP A
AS 1
5.0.0.0/8

ISP B
AS 2
9.0.0.0/8

ISP S
AS 4

What does AS3 Advertise?

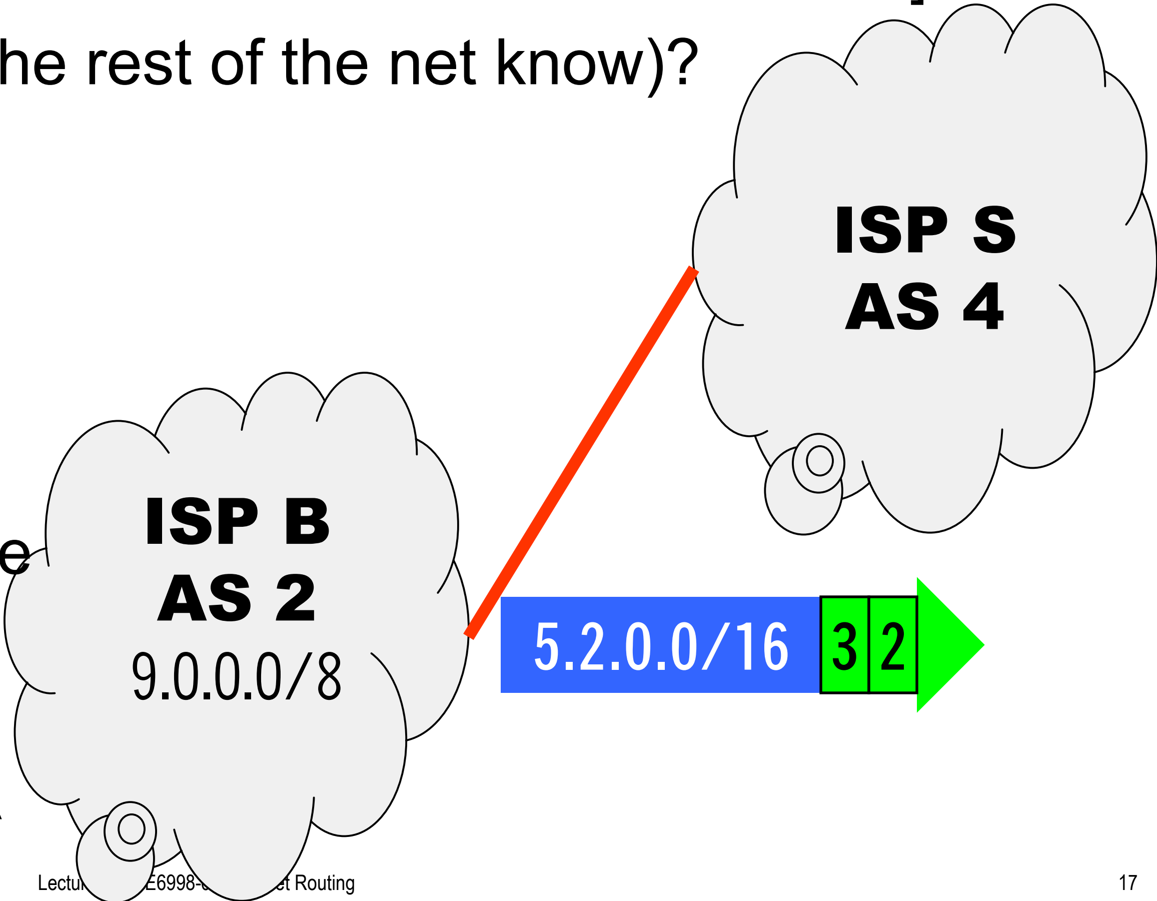


- Customer advertises its prefix to both its ISPs.
- ISP A (and its customers) now knows how to reach 5.2.0.0/16.
- ISB B (and its customers) also knows how to reach 5.2.0.0/16.
  - – Although it gets 5.0.0.0/8 from ISP A.
    - Longest-prefix match.

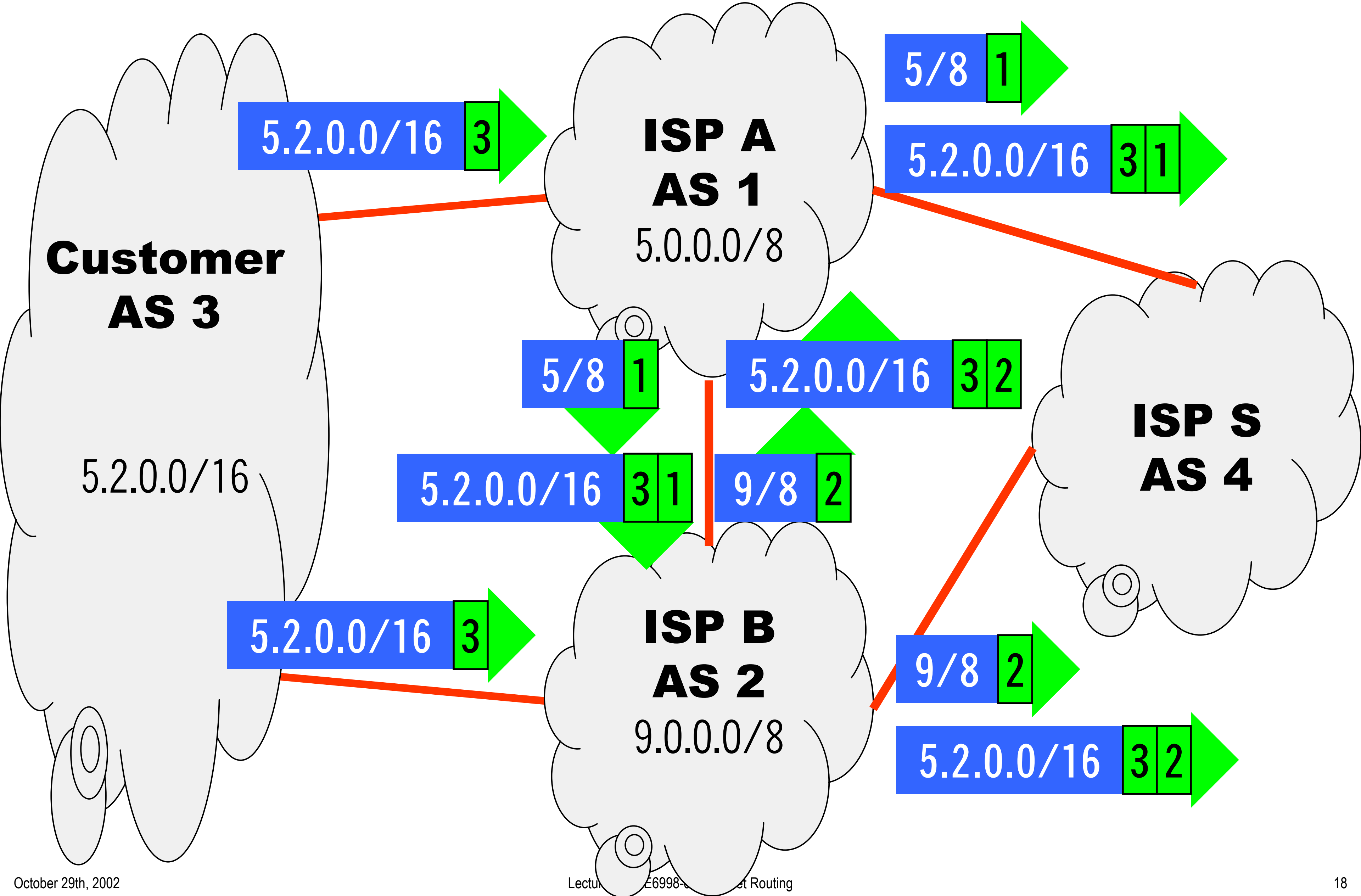
[ISP B could in some situations filter 5.2.0.0]

- What does ISP S (and the rest of the net know)?

- ISP B advertises the longer prefix to S.
- S now sends all traffic for 5.2.0.0/16 via B!
- This can lead to massive asymmetry!
  - Depends on relative amts of traffic from A vs. B+S



What is being advertised?



- ISP A had to “**punch a hole**” in its aggregation policy.
- What is carried in ISP A’s I-BGP?
  - ISP-A knows that Customer is a proper subset.
  - If the access router does not readvertise inside I-BGP the more-specific, traffic for Customer would go out via ISP B!
    - Access router has to be configured accordingly.
- Customer and ISP A **must** run BGP.
  - I.e., A’s access router can’t just inject a static route.

- ISP S has the more-specific for Customer from both ISP A and ISP B.
  - Will route traffic for Customer properly.

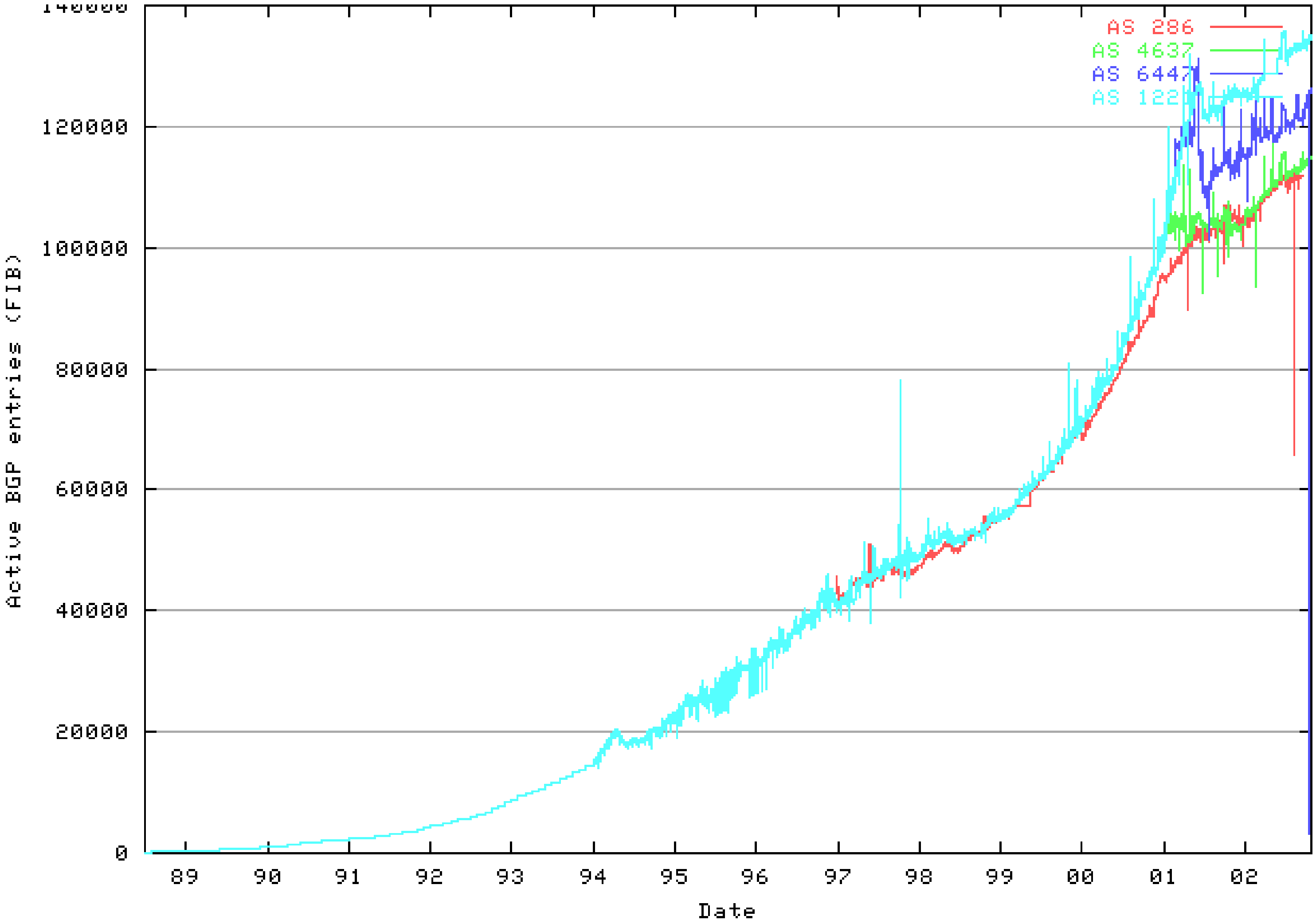
Aggregation

- Address aggregation: announcing one less-specific prefix in lieu of many more-specific prefixes.
- Example:
  - Provider has a /12.
  - Customers are allocated /16s through /24s from that space.
  - Provider **filters** the more-specifics and only announces the /12 to its peers.
- More-specifics may still need to be carried inside I-BGP.
  - Finer-level aggregation on access routers.
  - (e.g.) Sixteen /24 customers are on an access router.
  - Access router advertises a /20 into the I-BGP mesh.
- More-specifics may still be announced (e.g., with NO_EXPORT) to some peers.

Aggregation and Filtering

- External aggregation: provider only announces aggregates to its peers, not individual customer more-specifics.
- Internal aggregation: longer prefixes allocated to access routers, so that fewer routes are carried in I-BGP.
- Many times providers have to de-aggregate.
  - For multi-homed customers.
- Some providers do not allow in (filter) prefixes longer than /19 or /20 from aggregatable address space (post-CIDR allocations).
  - Contentious issue.
- Deaggregation leading cause of BGP table size.
  - “Grazing the commons”

Routing Table Size



- Source: http://bgp.potaroo.net/
- Active (used for the FIB) table.

BGP Scaling Issues

- Previous graph shows **active** routes (in the “Loc-RIB”).
- Many more routes floating around.
- Can’t just “add more memory”.
  - FIB memory is expensive, on linecards.
  - CPU/link capacity still an issue.
- Both the number of routes and the rate of UPDATEs (and their first derivatives) are scaling issues.
- Moore’s law only means we have to keep buying new routers!
- For a good time, go to `telnet://route-views.oregon-ix.net/`
- Chief problem: (at least) one route per advertised prefix.
  - De-aggregation due to multihoming a main source of the problem.
  - Switching to IPv6 doesn’t fix this!
  - Need a better routing architecture?

AS Numbers

- About 14K already.
- Increasing faster than linearly.
  - Current derivative: 2K/year.
- Source of new AS numbers:
  - New ISPs.
  - New multihomed customers.
- At this rate, we run out around 2007-2010.
  - IPv6 doesn’t fix this either!
- Suggestions:
  - 4-byte AS numbers (draft-ietf-idr-as4bytes-05.txt).
  - ASE (AS Number Substitution on Egress (AitFotL)).
    - Another cause of MOAS conflicts.

Route Flapping

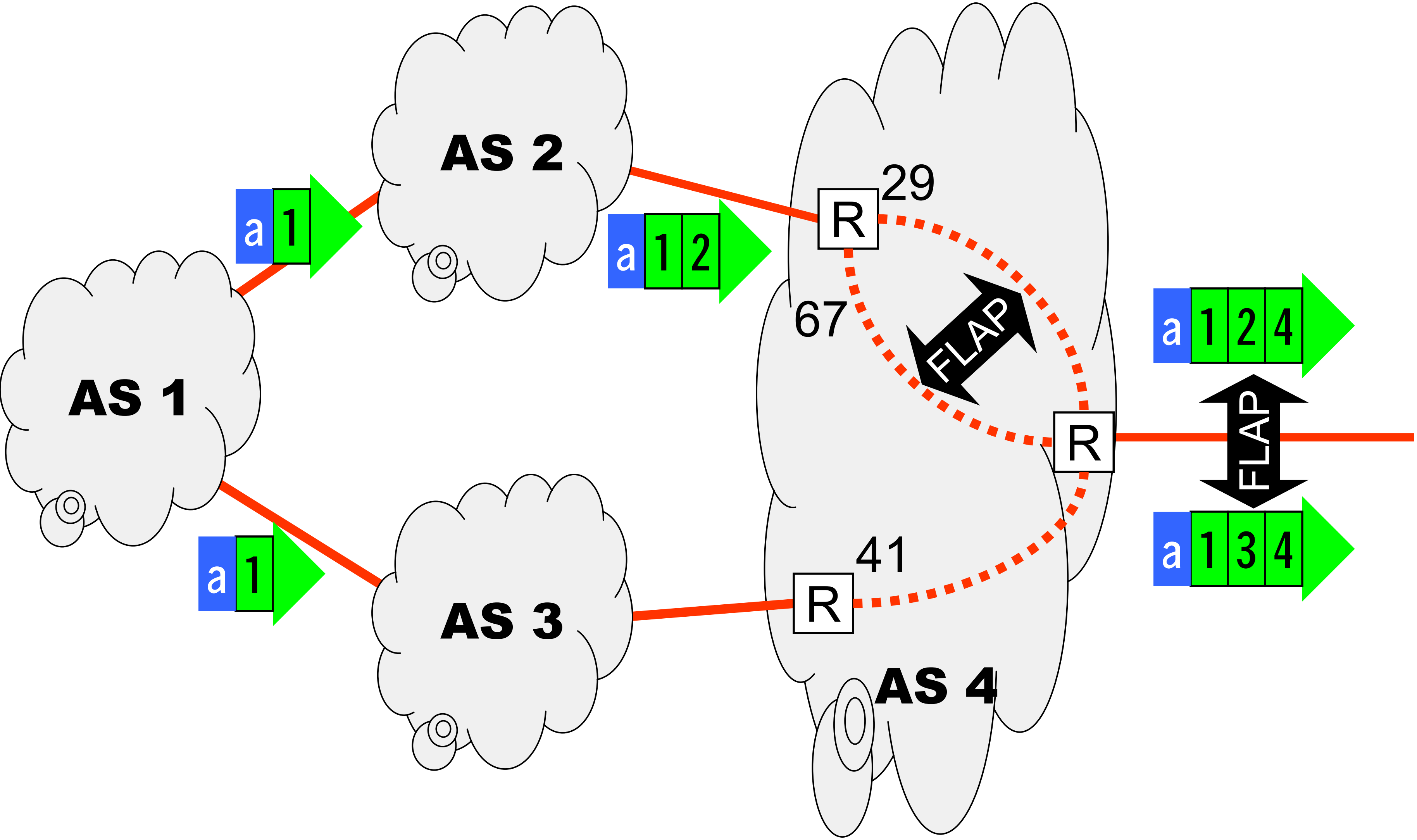
- Routing instability.
- Route disappears, appears again, disappears again…
  - Withdrawal, announcement, withdrawal, announcement…
- Visible to the entire Internet.
  - Wastes resources, triggers more instability.
- Some causes of *Route Flapping*:
  - Flaky inter-AS links.
  - Flaky or insufficient hardware.
  - Link congestion.
  - IGP instability.
  - Operator error.

Link Instability

- The first three are examples of link instability.
  - Link itself fails.
  - Router/router interface fails.
  - Messages can’t get through.
- When a link goes down, routers withdraw routes associated with this link.
  - Customer-ISP.
  - ISP-ISP.
- Announcements travel throughout the default-free zone.
- Aggregation may mask downstream flapping.
  - Does not work for multihoming

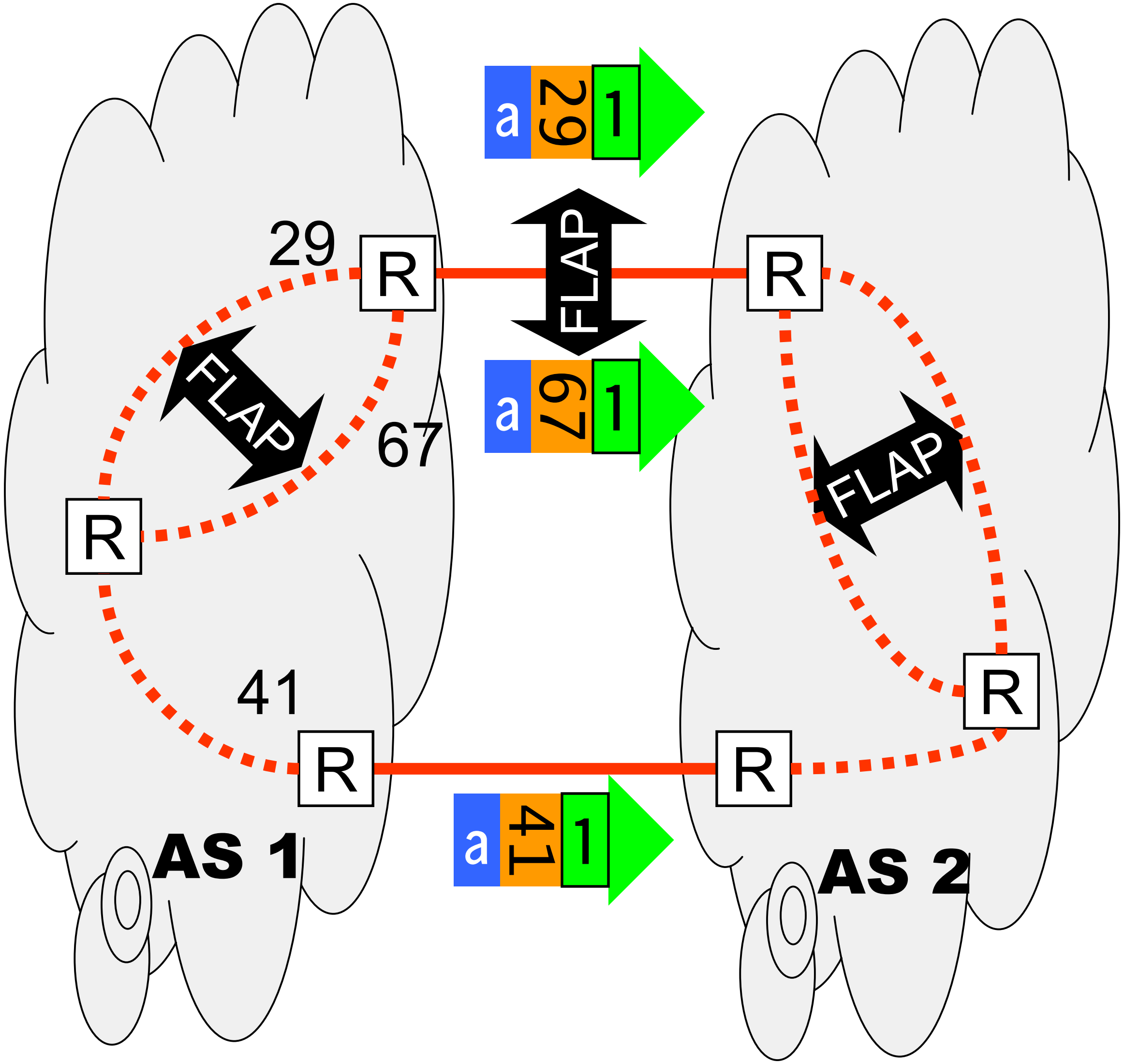
IGP Instability

- IGP route-preference rule exports instability.



IGP Instability

- MEDs can export internal instability.



Route Flap Dampening

- Router detects route flapping.
- *Penalty*:
  - Increased each time a route flaps.
  - Decreased over time.
- If penalty threshold exceeded (*suppress limit*), route is suppressed.
- Until penalty drops below a certain level (*reuse limit*).