BGP and RON
Internet Routing

- Internet split into *Autonomous Systems* (ASes). BGP routing between ASes.
AS Relationships

- Transit: Customer to provider, $$
- Peering: Peer to peer, no $
BGP

- 2 things: Exporting (advertising) and Importing (picking) Routes
- 1 Simple Principle:
  If I (an AS) take a packet, I better get...
AS tells everyone about its customers.
AS tells customer about everyone (it knows)
AS only tells peers about its customers.
AS doesn't tell others about peers.
BGP Route Import

Prefer routes in order:

- Customer
- Peer
- Provider

All else equal, then prefer shorter AS-path

```
AS-1
 /    \
/     /
AS-2   AS-3
       /    /
       /     /
      AS-5   "A"
```
BGP Route Import

Prefer routes in order:

- **Customer**
- **Peer**
- **Provider**

All else equal, then prefer shorter AS-path
Sample Problem (2012 Q2)

- Note arrows from provider to customer, double-arrow is peering
Sample Problem (2012 Q2)

- Path AS-1 to P?
Sample Problem (2012 Q2)

- AS Path AS-1 to P?
  AS-1 → AS-3 → AS-5
  shorter path
Sample Problem (2012 Q2)

- # Paths AS-2 learns for P? Which path used?
Sample Problem (2012 Q2)

- # Paths AS-2 learns for P? Which path used?
  3 (from AS-1, AS-3, and AS-4)
  AS-2 → AS-4 → AS-5 (prefer customer routers)
Sample Problem (2012 Q2)

- AS-2 / AS-4 link and AS-5 / AS-6 link fail. Everyone still can reach P?
Sample Problem (2012 Q2)

- AS-2 / AS-4 link and AS-5 / AS-6 link fail. Everyone still can reach P?

AS-7 can't! Won't know about AS3 b/c it's a peer
RON

Resilient Overlay Network - built over lower-level network (in this case, the Internet and BGP).
Ron 1

Ron 2

Ron 3

Ron 4

Utah

Private Peering

3 Mbps

6 ms

ArosNet

155 Mbps / 60 ms

Qwest

vBNS / Internet 2

BBN

Private Peering

45 Mbps

5 ms

UUNET

AT&T

130 Mbps

MediaOne

Cable Modem

1 Mbps, 3 ms
RON

RON 1

RON 2
Utah
Private Peering
3Mbps
6ms
ArosNet
6Mbps

RON 3
MIT
Private Peering
45Mbps
5ms

RON 4
Cable Modem

vBNS / Internet 2
155Mbps / 60ms

155

130 Mbps

AT&T
UUNET
Qwest

1Mbps, 3ms

MediaOne
RON Probing

• Need to know all other RON nodes, hence RON networks are small (up to 50 nodes)

• Active vs passive probing to obtain metrics

• Outage Detection (active):
  – Periodically send probe.
  – If times out, send quick sequence of probes.
  – If a threshold of probes in a row don't hear responses, mark link dead.
RON Link Metrics

- Stored in a performance database
- Latency, loss / packet drop rate, throughput (and application defined)
- Latency computed w/ a Exponential Weighted Moving Average: \( rtt = a \cdot rtt + (1-a) \) (sample)
- Loss: loss rate is set to loss rate of last \( k=100 \) samples.
- Throughput: estimate \( score = \frac{\sqrt{1.5 \cdot rtt \cdot \sqrt{loss/2}}}{} \)
RON Path

- Latencies add up along path
- Loss rate: Success = 1 – loss rate. Multiple success rates along path
- Throughput: Score depends on latency/loss rate of path.
RON Routing

- Packets have type (application dependent), used for classification
- Each class can have separate policy (ex: don't use Internet2 for commercial traffic)
- So each class has only routing table of allowed routes and their metrics.
- Routing algorithm computes best route, puts it in forwarding table.
- Experimentally, most routes are at most 1 intermediate RON node
RON Architecture

- More application integrated