A Scalable Routing System Design for the Future Internet

Dan Massey (Colorado State University)
Lan Wang (University of Memphis)
Beichuan Zhang (University of Arizona)
Lixia Zhang (UCLA)
Where We Are

- In the original Internet, all routers were in the same domain.
- The current global routing has two levels: intra- and inter-domain.
  - to accommodate administrative needs
  - to scale to a large number of routers
- Why only two levels?
  - Two levels are (scalable) enough.
  - Where to draw the line for the third or more levels?
- But, will these hold true in the future?
Scalability Challenges

- The Internet routing architecture is facing serious scalability challenges.
- Growth
  - IP address: IPv4 to IPv6
  - AS number: 16-bit to 32-bit
  - Denser connectivity
- Failure of aggregation
  - Site multi-homing
  - Traffic engineering
- Churns
Customers vs. Providers

- Customer networks are consumers of the global transit service; Provider networks are the producer of the global transit service.
  - whether appear in the middle of an AS path

- They are different in many ways:
  - Types of business
  - Operational goals
  - Network characteristics
  - Growth trends
Our Proposal

- Separate customer networks from provider networks in the global routing.
  - Distinct address spaces
    - Globally routable addresses (GRA)
    - Globally deliverable addresses (GDA)
  - Distinct routing spaces
    - DFZ routing table is limited to provider prefixes only.
  - Distinct forwarding spaces
    - Tunneling through provider networks.
  - Need a mapping service between GRA and GDA
Global Transit Network

Global Routable Address Space

P1 P2 Src Dst

P1 P2 Src Dst

A

P1

C1

Src Dst

Global Deliverable Address Space

Customer S

Dst

C2

X

P2

Global Deliverable Address Space

Customer D

Src

P1 P2 Src Dst
Estimating Provider Prefixes

- Need # of provider prefixes vs. customer prefixes to estimate the table size reduction.
- Take one-month RouteViews data, find customer networks and provider networks based on AS paths.
- However, prefixes originated from provider networks could belong to customers.
- Compare WHOIS records of the origin (provider) AS and the prefix
  - If match, then the prefix belongs to the provider.
## Provider Prefixes

<table>
<thead>
<tr>
<th>AS Number (ISP name)</th>
<th>Total Prefix</th>
<th>Transit Net. Pref (manual)</th>
<th>Transit Net. Pref (automated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7018 (ATT)</td>
<td>1501</td>
<td>39</td>
<td>35</td>
</tr>
<tr>
<td>174 (Cogent)</td>
<td>930</td>
<td>21</td>
<td>19</td>
</tr>
<tr>
<td>1668 (AOL)</td>
<td>202</td>
<td>115</td>
<td>100</td>
</tr>
<tr>
<td>1239 (Sprint)</td>
<td>852</td>
<td>133</td>
<td>131</td>
</tr>
<tr>
<td>701 (Verizon)</td>
<td>4989</td>
<td>537</td>
<td>570</td>
</tr>
<tr>
<td>3549 (GBLX)</td>
<td>342</td>
<td>133</td>
<td>81</td>
</tr>
<tr>
<td>3561 (Savvis)</td>
<td>521</td>
<td>231</td>
<td>263</td>
</tr>
<tr>
<td>3356 (Level3)</td>
<td>514</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>209 (Qwest)</td>
<td>691</td>
<td>59</td>
<td>63</td>
</tr>
</tbody>
</table>
Routing Scalability and Stability

- If we separate customers from providers on today’s Internet, both the table size and the routing churns will be reduced significantly.
  - Overall 11% of all prefixes belong to provider networks
  - Of all the routing updates, 15% belong to provider prefixes
Site Multi-homing and TE

- Site multi-homing won’t cause table size growth.
- Customers can change providers without renumbering.
- The indirection introduced by mapping service can be used to express TE requirements explicitly.
Security Benefits

- Raise the barrier for attackers to target routing infrastructure.
  - Most attacks come from customer networks
- May be able to trace back to the source provider.
- Still need to secure the provider space.
The Mapping Service

- The key component to glue customers and providers together.
  - Scalable
  - Flexible
  - Resilient
  - Secure

- Design choices
  - Push data to local routers (e.g., flooding the mapping information in provider space)
  - Pull data from a DNS-like service
  - Overlay, DHT, ...
Border Link Failures

- The link connecting a customer network and a provider network.
- When the link flaps, how to ensure that data will be re-routed to alternative links?
  - The flaps will not be propagated into the provider’s routing system.
  - Too frequent/short-term for mapping service.
Network Diagnosis

- The provider space will become a black box to customer networks.
  - may frustrate some network diagnosis tools.
- Can still do end-to-end probing and diagnosis
- Expose some network information to the customers via well-defined interfaces?
Summary

- The Internet has grown to the stage that we need another level of separation: customer networks vs. provider networks.
  - not a brand-new idea: ENCAPS, LISP, HLP, CRIO, ...

- Benefits
  - Smaller routing table, less routing churns, easier multi-homing and TE, higher security barrier.

- Challenges
  - How to implement the mapping service, handle border link failures, and facilitate network diagnosis
Thanks!