A Scalable Routing System Design for the Future Internet

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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 <u>two</u> 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

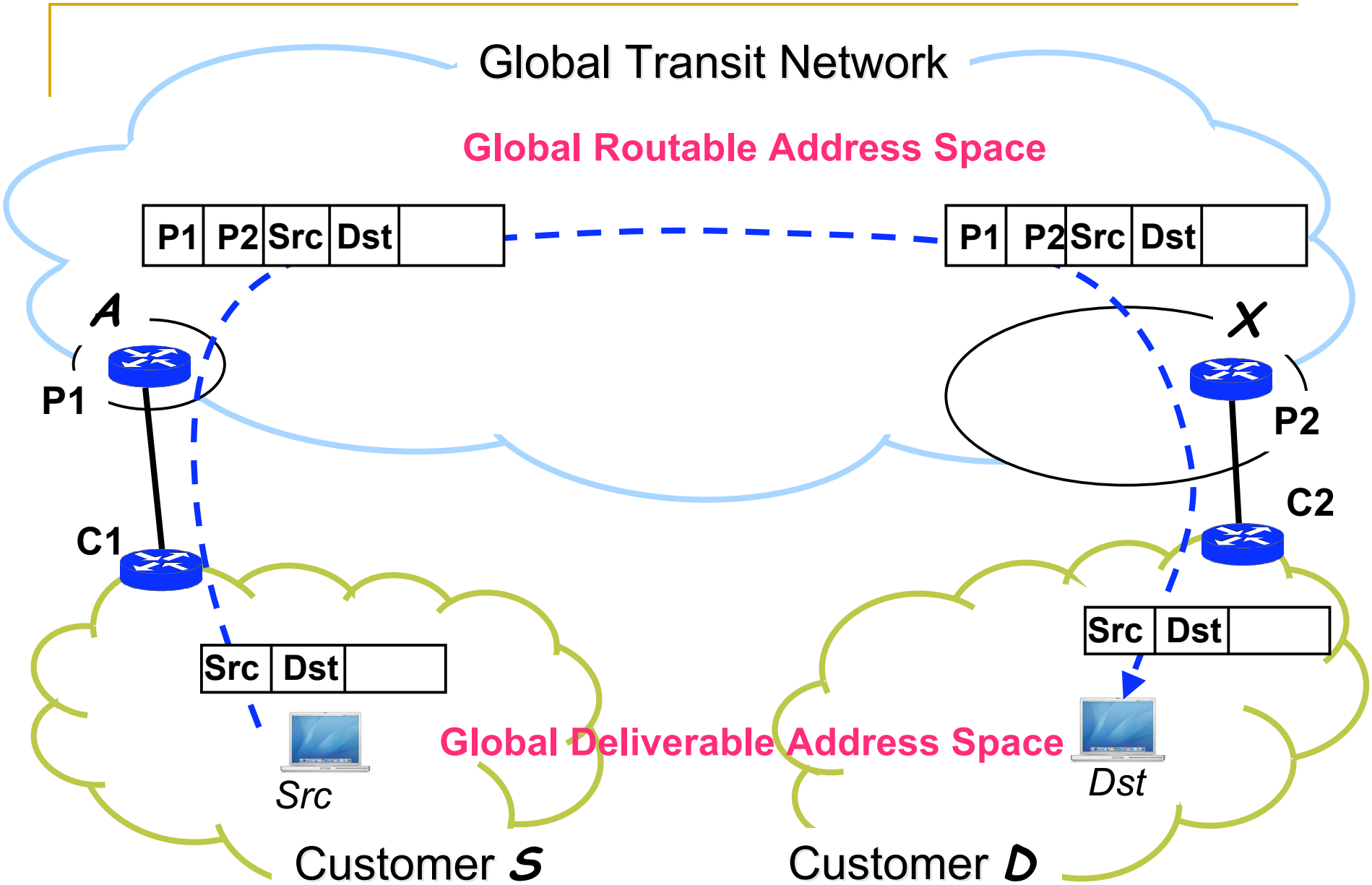
Customers vs. Providers

- 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
X
P2
C2
C1
Src
Dst
Src
Dst
Dst
Global Deliverable Address Space
Customer S
Customer D

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

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

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!