On Inferring and Characterizing Internet Routing Policies

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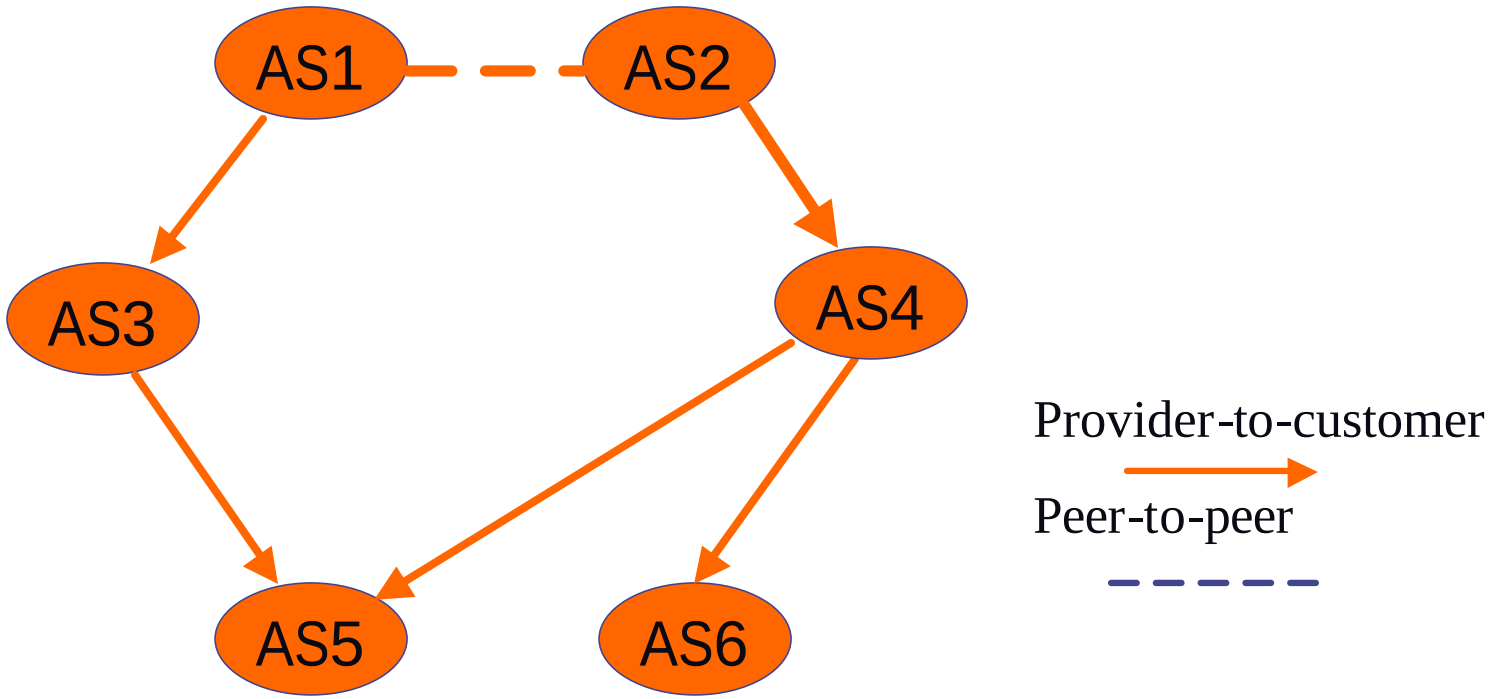
Introduction

- The Internet connects thousands of Autonomous Systems (ASs) .
- Border Gateway Protocol (BGP): an inter-domain routing protocol
- Routing policies
  - Import policy
  - Export policy

AS Relationships

- Reflecting the commercial agreement among ASs

  Provider-to-customer and Peer-to-peer



Motivation

- Reachability is determined not only by connectivity but also routing policies.
- Little is known about routing policies network operators employed.
- Global view of routing policies is useful
  - Robustness of the Internet.
  - Performing traffic engineering effectively.
- Our work:
  - Inferring and characterizing import policies.
  - Inferring and characterizing export policies.

Inferring Routing Policies

- Import policies:
  - Local preference, MED, BGP community.
- Export policies:
  - Permit or deny a route, assign MED, tag BGP community..

Data Sources

- Routing tables from Oregon RouteView on Nov. 11, 2002, and 15 ASs' Looking Glass servers (including 3 Tier-1 ASs, 2 Tier-2 ASs) on Nov. 11, 2002.
  - 42 ASs are in North America
  - 33 ASs are in Europe
  - 3 ASs are in Australia
  - 2 ASs are in Asia
- AS relationships
  - Inferred from Gao's algorithm

Inferring Import Routing Policies

- Consistency of local preference with commercial relationships
  - Typical local preference:
    - localpref(customer) > localpref(peer)
    - localpref(peer) > localpref(provider)
    - localpref(customer) > localpref(provider)
  - Atypical local preference:
    - localpref(provider) >= localpref(peer)
    - localpref(peer) >= localpref(customer)
    - localpref(provider) >= localpref(customer)
- Consistency of local preference with next hop AS

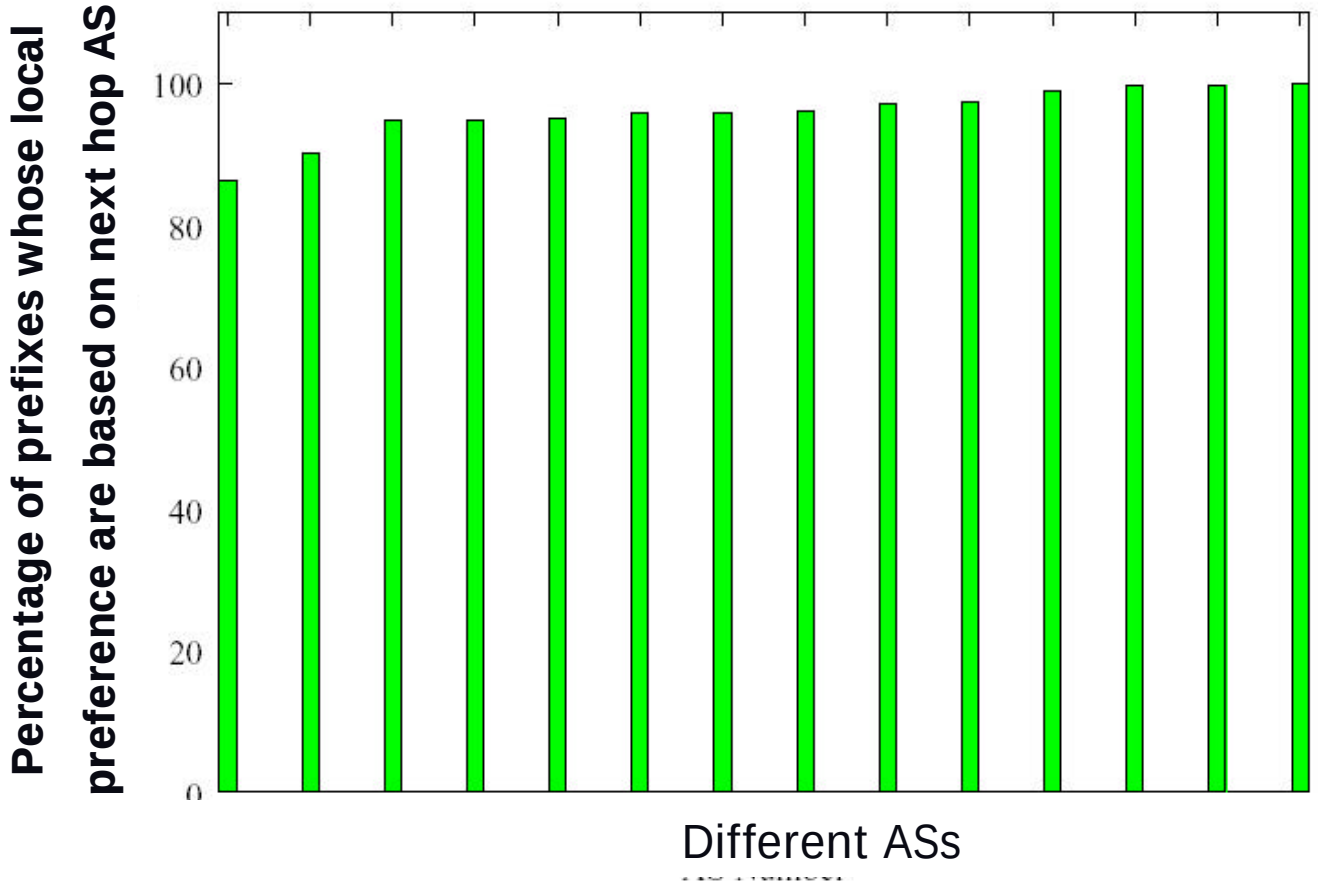
Result of Import Policies

- Most ASs employ typical local preference.

ASN	Percentage of typical local preference	ASN	Percentage of typical local preference
AS577	94.3	AS2578	99.982
AS5511	96.5	AS513	100
AS3549	99.7	AS6762	100
AS6667	99.94	AS559	100
AS7474	99.955	AS12859	100
AS12359	99.98	AS8262	100
AS7018	99.99	AS6539	100
AS1	99.994		

Consistency of Local Preference with Next Hop ASs

- Most ASs set local preference values based on next hop ASs

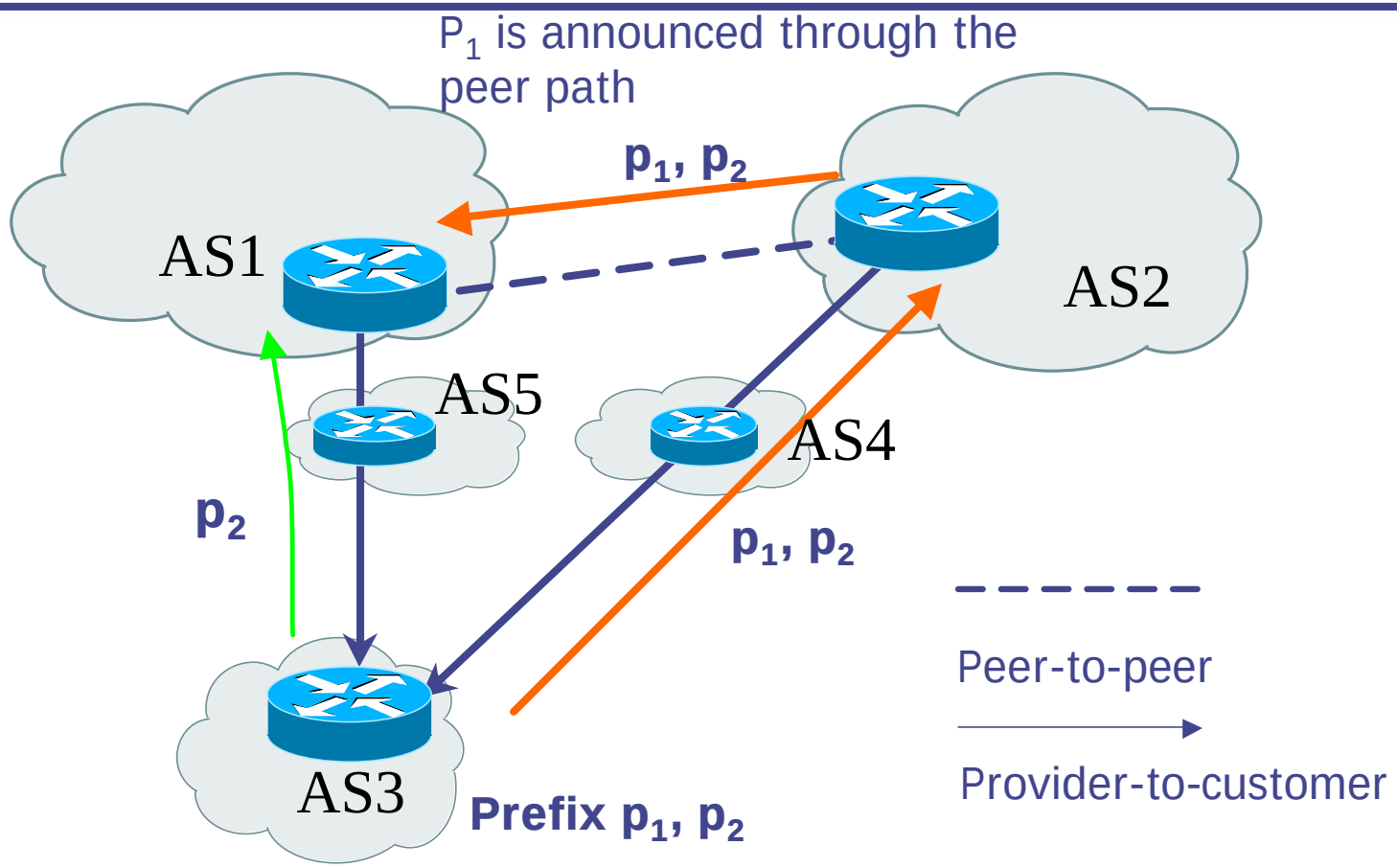


Potential Error Introduced by Inferred AS Relationships

- Using BGP community, we verified 9 ASs' relationships derived by Gao's algorithm.
- The potential error introduced by inferred AS relationships is small.

AS number	# of neighbors	Percentage of AS relationships between AS and its neighbors verified
AS1	599	95.65%
AS577	89	98.9%
AS3549	558	96.28%
AS5511	168	99.4%
AS6539	157	96.45%
AS6667	26	97.46%
AS7018	1330	99.55%
AS12359	31	94.1%
AS12859	109	98.2%

Inferring Exporting Policies to Provider



- From the view point of AS 1, prefix p_1 is a **SA prefix** (selective announced prefix).

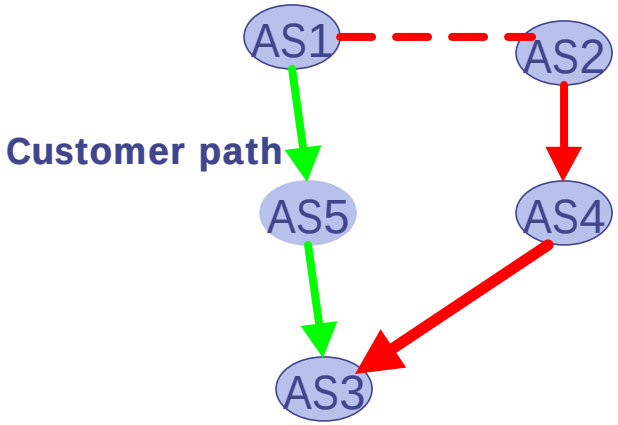
SA Prefixes

- Tier-1 ASs, have a significant number of SA prefixes.

ASN	Tier	% of SA prefixes		ASN	Tier	% of SA prefixes
AS1	1	32		AS7018	1	22
AS3549	1	23		AS701	1	27.8
AS6453	1	48.6		AS6461	1	4
AS1239	1	29.4		AS3561	1	5.2
AS2914	1	14		AS209	1	38
AS5511	2	18		AS577	2	17
AS6538	2	11		AS6667	2	13
AS12359	3	0		AS12859	3	0

Validation of SA Prefixes

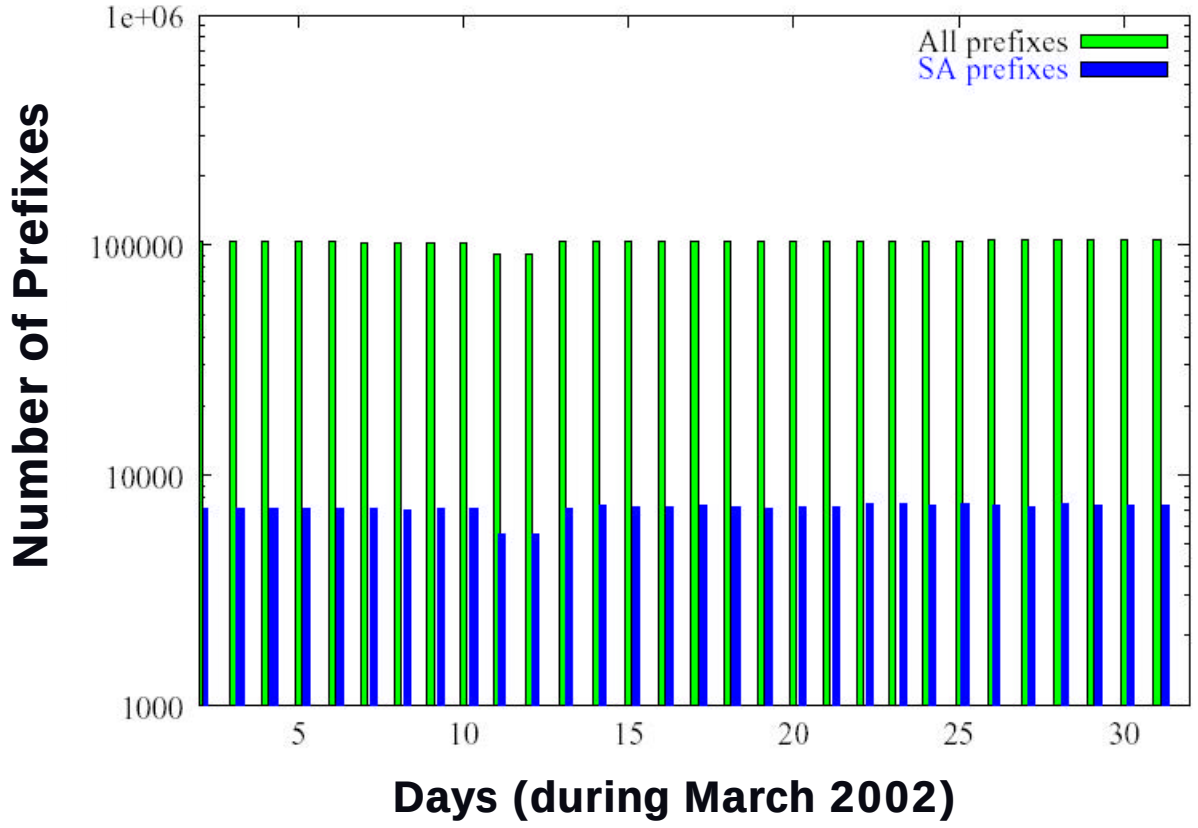
- Validation by email?
- Validation by paths used by other prefixes



Provider	# of *SA* prefixes	% of *SA* prefixes verified
AS1	9120	97.6%
AS3549	3431	95%
AS7018	4374	97%

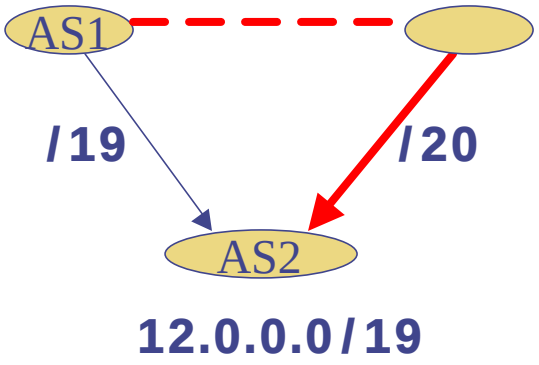
Persistence of SA Prefixes

- For AS1's, each bar represents a snapshot of BGP routing table.

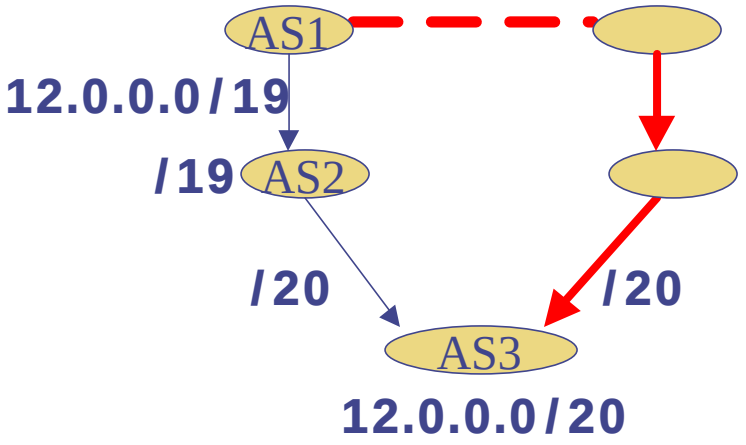


Possible Causes of SA prefixes

1) Prefix splitting



2) Prefix aggregating



Results of Possible Causes

- Prefix splitting and prefix aggregating are not the major causes of selective announcement.

Provider	# of *SA* prefixes	# of prefix splitting	# of prefix aggregating
AS1	9120	127	218
AS3549	3431	63	104
AS7018	4374	71	179

Conclusions

- Import policy typically obeys preference as follows:
  - Customer > peer and provider
  - Peer > provider
  - Based on next hop ASs
- A number of customers selectively announce their prefixes to a subset of upstream providers.
  - Giving insight on traffic engineering and implication on robustness of the Internet.
- Result of exporting policies to peers.

Questions?