



The Missing AS Links and Their Impact On the Internet Topology Model



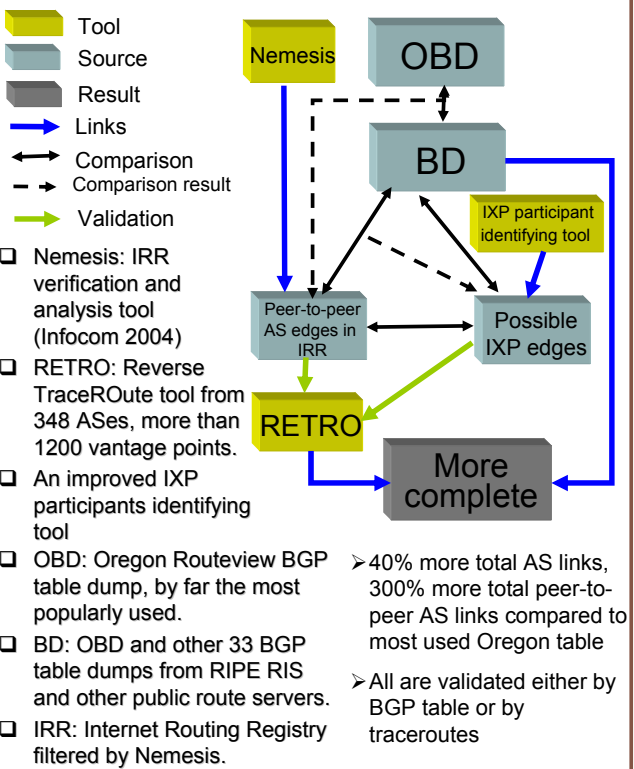
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Introduction

Motivation

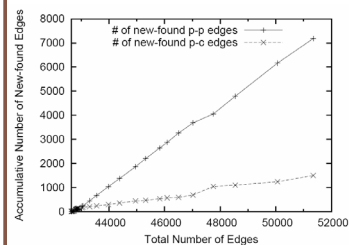
- ❑ The current Internet topology derived from Oregon Routeview BGP table dumps is not complete
- ❑ BGP table derived Internet topology under-estimates peer-to-peer type AS links due to selective exporting policies.
- ❑ An accurate Internet topology is crucial to simulate Internet and design new protocols.

Sources and Tools



Finding Missing Links

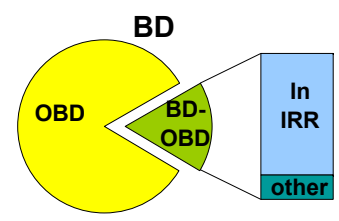
Most missing links are peer-to-peer



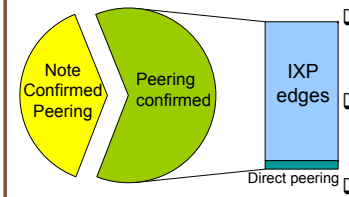
- ❑ Start with the edges in OBD as our baseline (42643 edges)
- ❑ Combine new edges from BGP tables other than OBD, one table at a time
- ❑ Among the new edges, p-p edges are approximately 80%, p-c edges are approximately 20%

Most missing links are in IRR

- ❑ If we only knew OBD, IRR would have been a good data set to estimate what else in BD
- ❑ 83% (7251 out of 8702) of the edges in BD and not in OBD are actually in IRR.
- ❑ IRR data is pre-processed by Nemesis



Most peer-to-peer edges in IRR but not in BGP tables are IXP edges



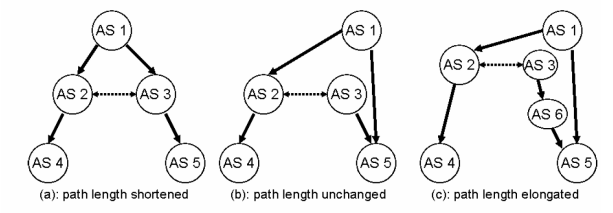
- ❑ To verify peering, we traceroute by using RETRO, a Reverse TraceRoute tool
- ❑ 8791 out of total 39894 peer-to-peer IRR edges but not shown in BD are verifiable by RETRO.
- ❑ RETRO confirms 5646 out of 8791 AS edges are indeed existing.
- ❑ Among the 5646 confirmed AS edges, 5317 of them are IXP edges, the rest are direct peering

➢ An **IXP edge** between AS A and AS B: $[IP_{AS_A}, IP_{IXP}, IP_{AS_B}]$

➢ A **direct peering edge** between AS A and AS B: $[IP_{AS_A}, IP_{AS_B}]$

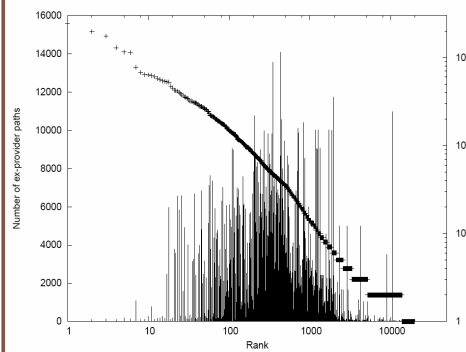
Impact on the Internet

Impact on AS Path Length



- ❑ With new discovered AS link, AS path lengths may change, but not all necessarily shortened.
- ❑ Due to “No Valley Prefer Customer” routing, establishing a new peer-to-peer link between AS 2 and AS 3 could even make the path from AS 4 to AS 5 longer than before!

Impact on ISPs' Revenue



- The number of **ex-provider paths** is the number of paths for which an AS stops going to its providers once the new edges are added
- ❑ Peer-to-peer links make ASes avoid using their providers to reach many destinations
- ❑ For many ASes, more than 50% of the paths stop going through their providers.
- ❑ By stop going to providers, ISPs lower their costs and increase their revenues.
- ❑ The “middle-class” ASes (rank 100 to 1000) benefit the most from these changes