bdrmap-IT: Mapping the Borders of IP Networks
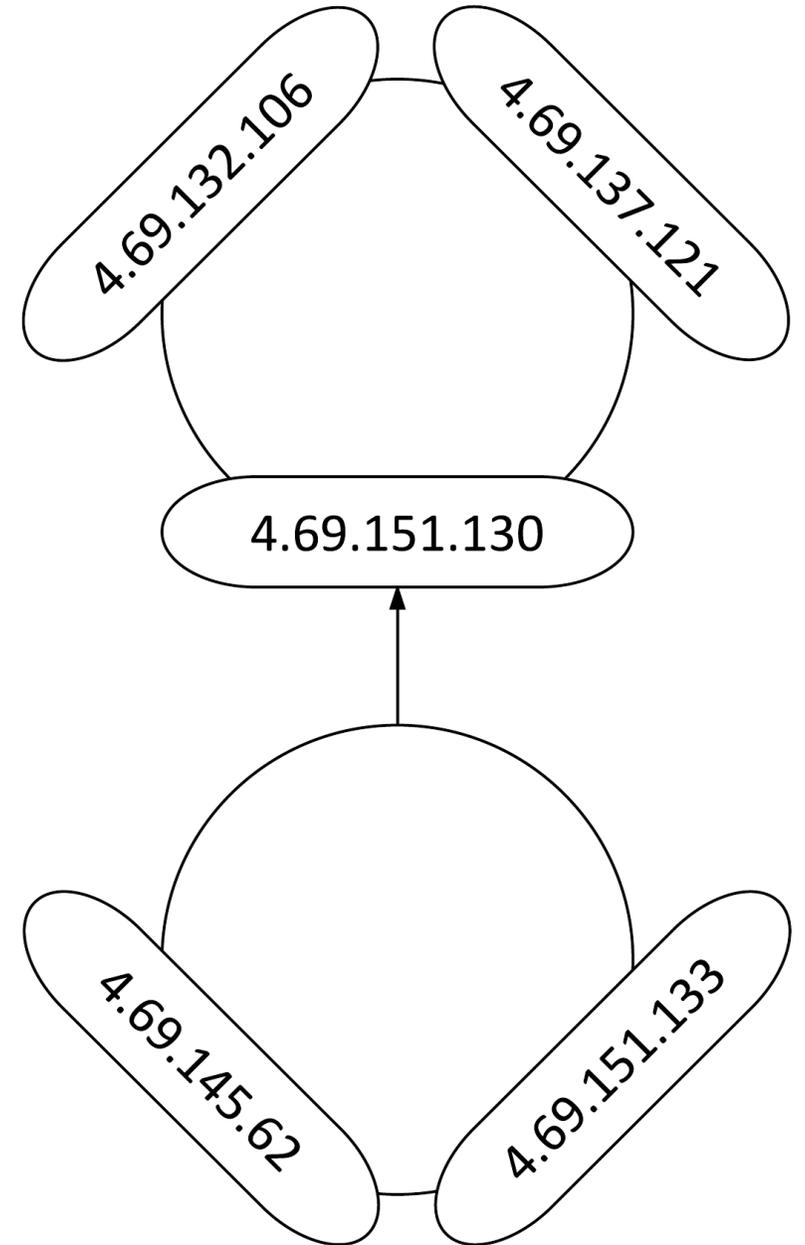
Alex Marder, Matthew Luckie, Amogh Dhamdhere, Bradley Huffaker, kc claffy, and Jonathan M. Smith

Internet Mapping at AS Borders

- Accurate mapping informs policy, performance, and security
- Focusing on router-level graphs
  - Alias resolution combines IP addresses into routers

Challenges

- Inferred AS annotations for routers are inaccurate
  - Alias resolution is incomplete
  - IP-to-AS is inaccurate at AS borders
- Links between routers affected by traceroute artifacts (third party, load balancing, transient route changes, etc.)

Previous Work

- bdrmap [Luckie et al. IMC '16]
  - Annotates routers with AS assignments
  - Limited to a single network, requires active probing
- MAP-IT [Marder & Smith IMC '16]
  - Identifies inter-AS links at Internet-scale
  - Uses interface-level graphs, does not cover silent ASes (appear unresponsive to traceroute)

Goals

- Improve AS annotations for routers
- More accurately identify inter-AS links
- Work with existing data at Internet-scale

bdrmap-IT Algorithm

Input: set of traceroutes, inferred routers

Graph refinement loop – until repeated state

     Annotate routers with AS

     Identify inter-AS links

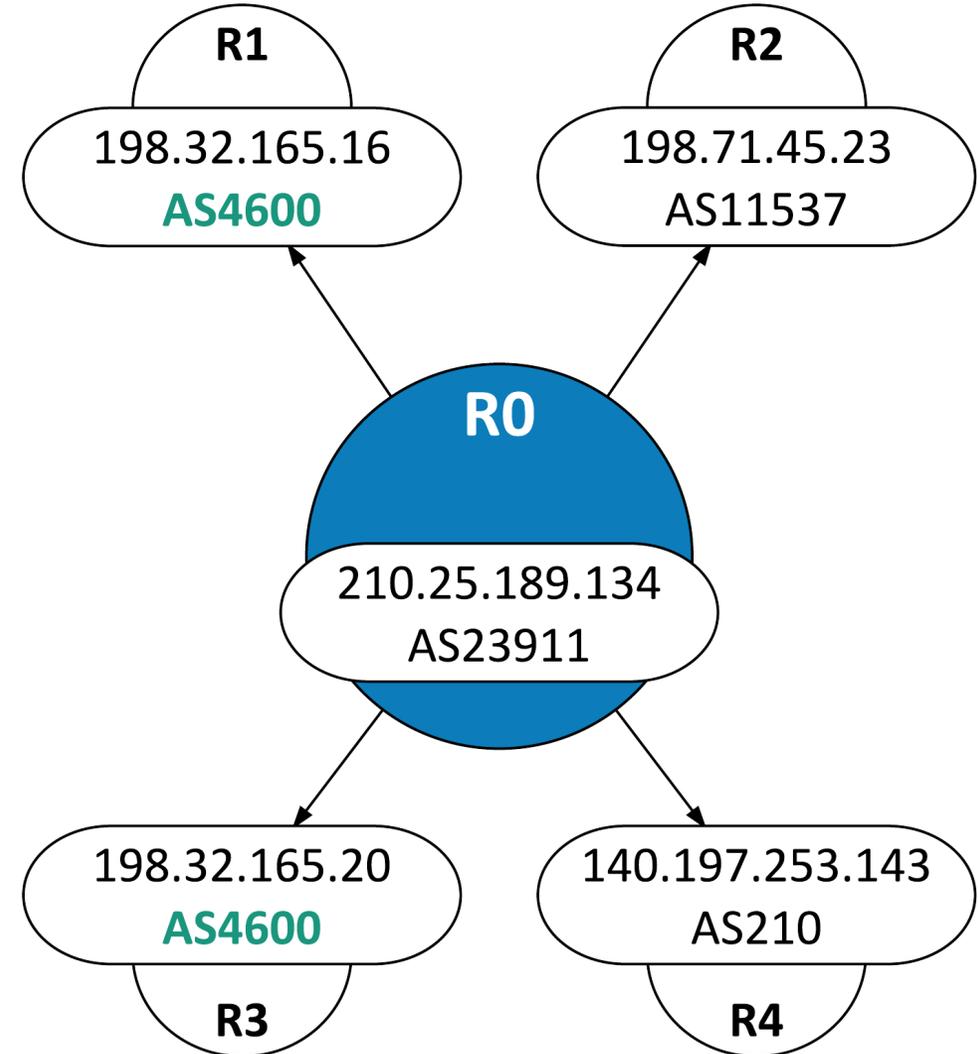Apply heuristic for routers succeeded by a single interface (**single neighbor)**

Apply heuristic for **silent ASes**

Output: AS annotations for routers, inter-AS links

Graph Refinement Loop: Annotate Routers with AS

- Look at interfaces on the router and interfaces immediately after
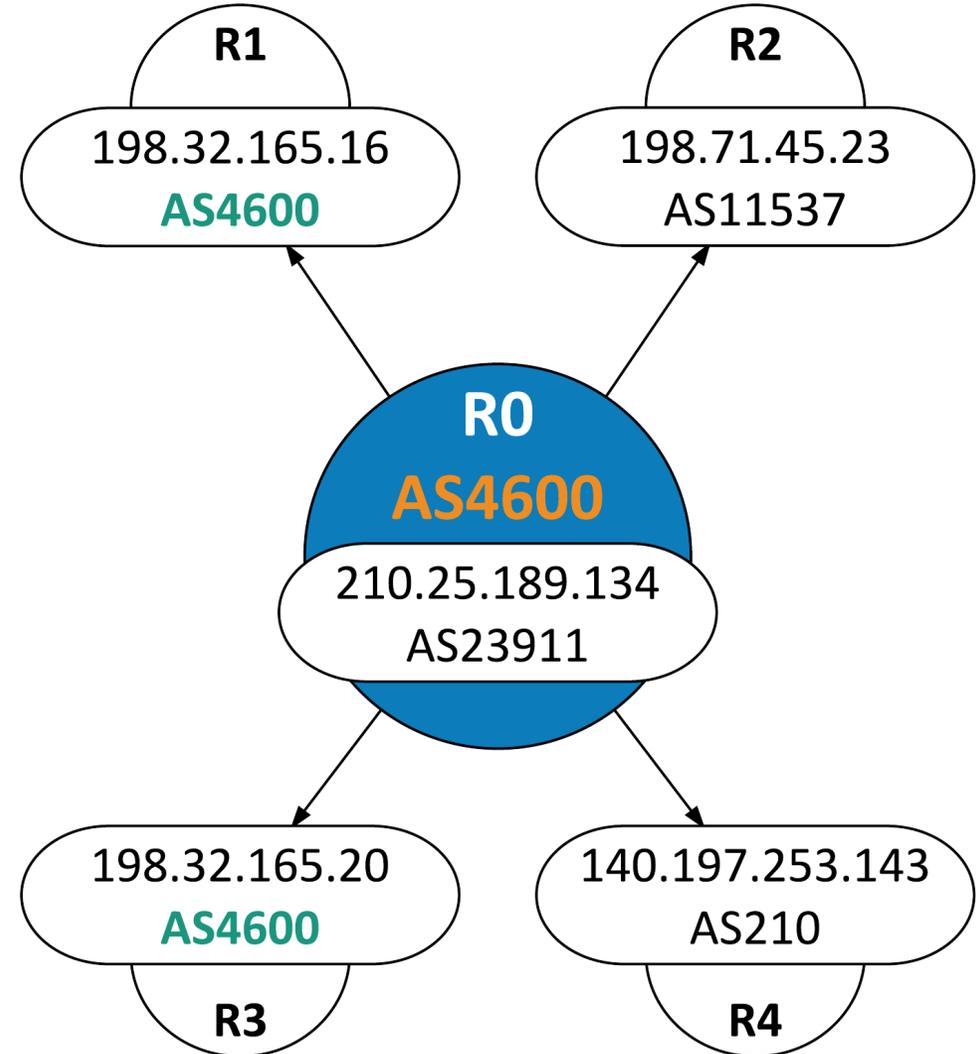
- Annotate with AS that appears most frequently

AS	Count
4600	2
11537	1
210	1
23911	1

Graph Refinement Loop: Annotate Routers with AS

- Look at interfaces on the router and interfaces immediately after

- Annotate with AS that appears most frequently

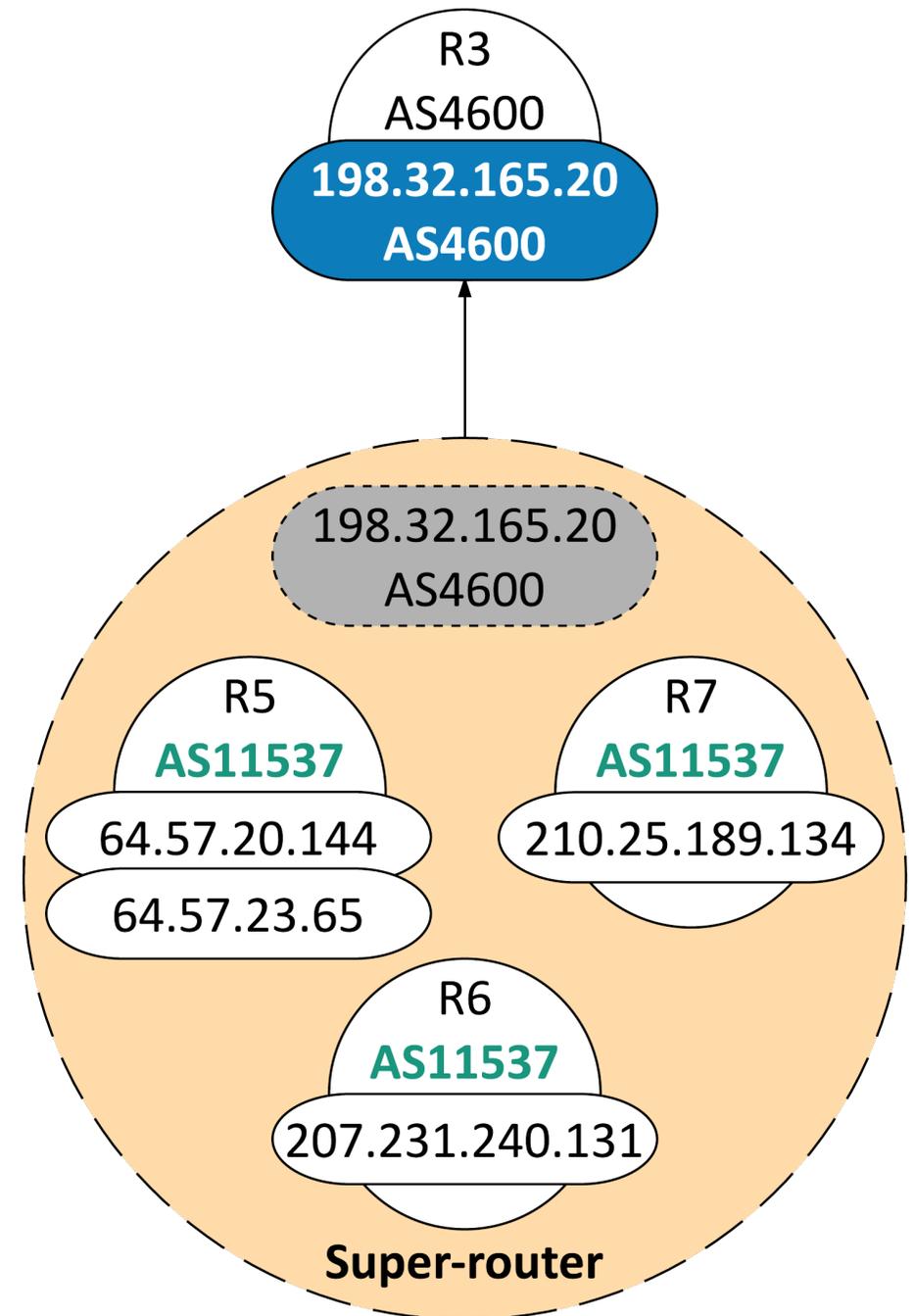| AS	Count
4600	**2**
11537	1
210	1
23911	1

Graph Refinement Loop: Identify Inter-AS Links

Method 1: Interface IP-to-AS mapping different than router AS annotation

Method 2: Build super-router of unique prior interfaces

- Assume inter-AS links are generally point-to-point (outside IXs)
- Count **router AS annotation** once for each interface

AS	Count
11537	4
4600	1

R3
AS4600
198.32.165.20
AS4600

198.32.165.20
AS4600

R5
AS11537
64.57.20.144
64.57.23.65

R7
AS11537
210.25.189.134

R6
AS11537
207.231.240.131

Super-router

Graph Refinement Loop: Identify Inter-AS Links

Method 1: Interface IP-to-AS mapping different than router AS annotation
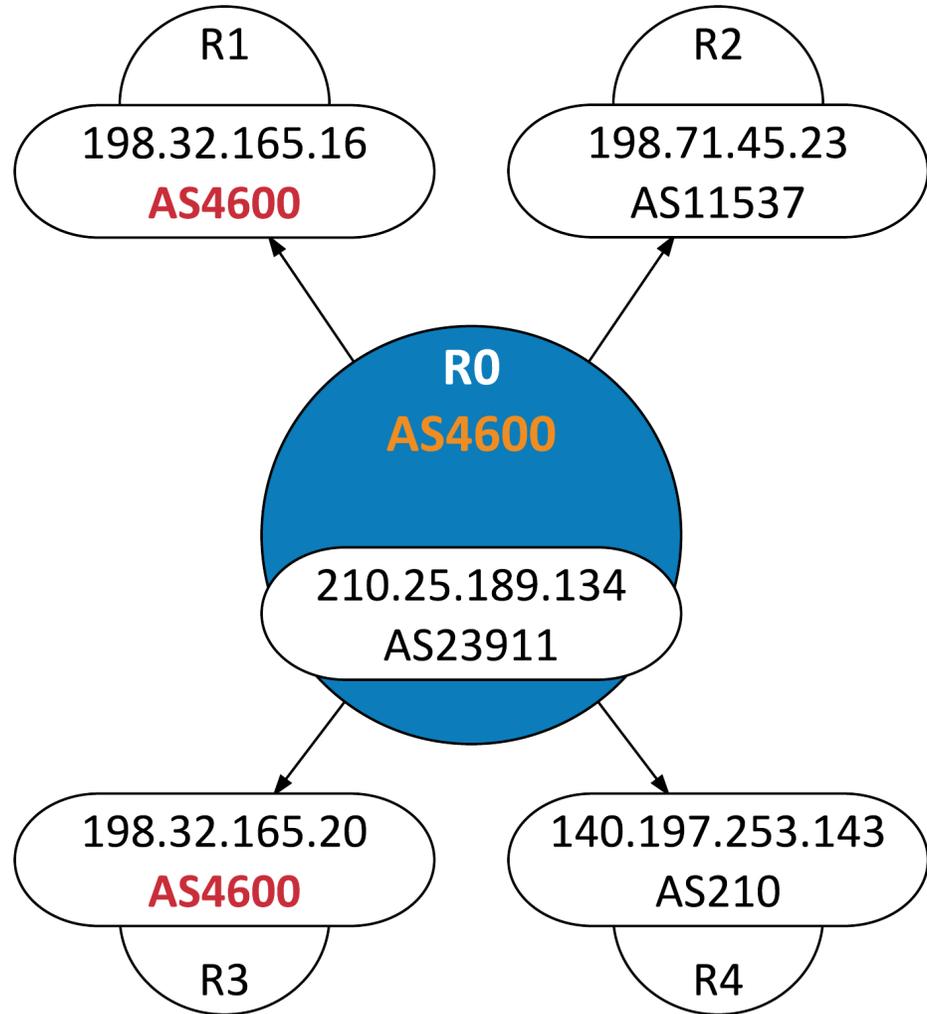
Method 2: Build super-router of unique prior interfaces

- Assume inter-AS links are generally point-to-point (outside IXs)
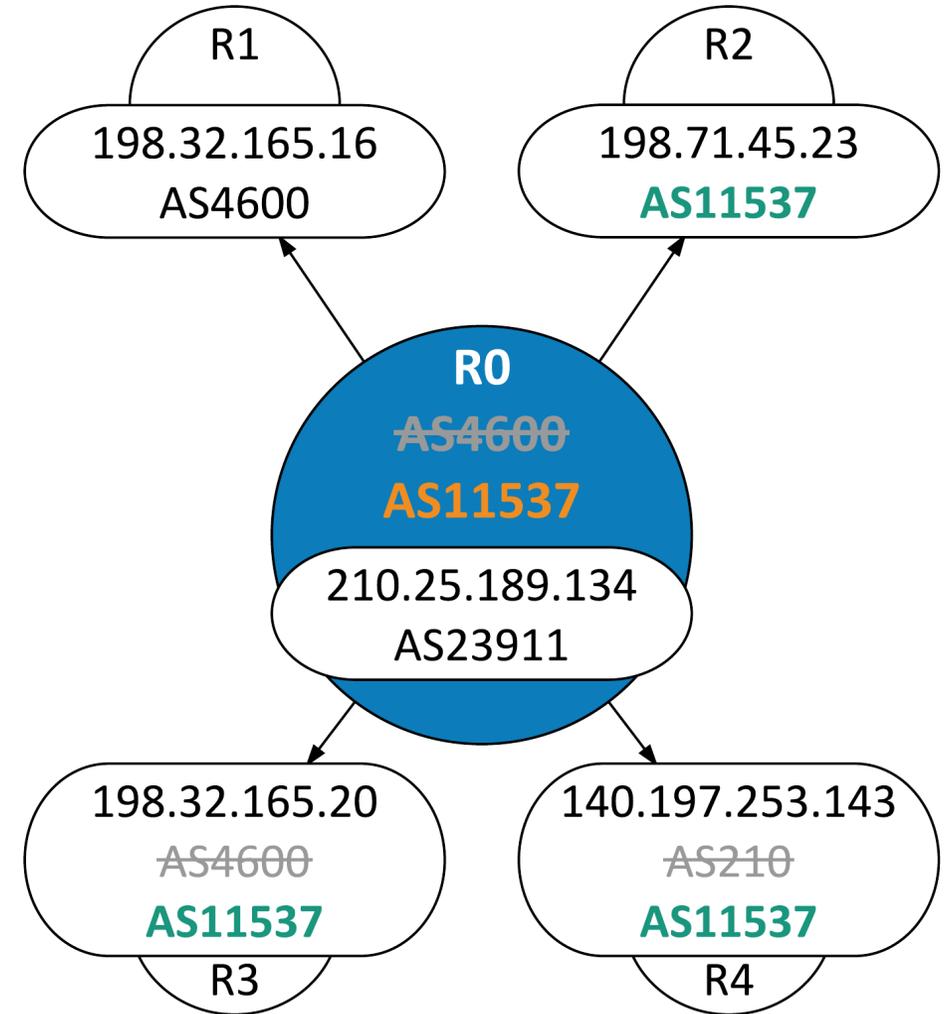- Count **router AS annotation** once for each interface

AS	Count
11537	**4**
4600	1
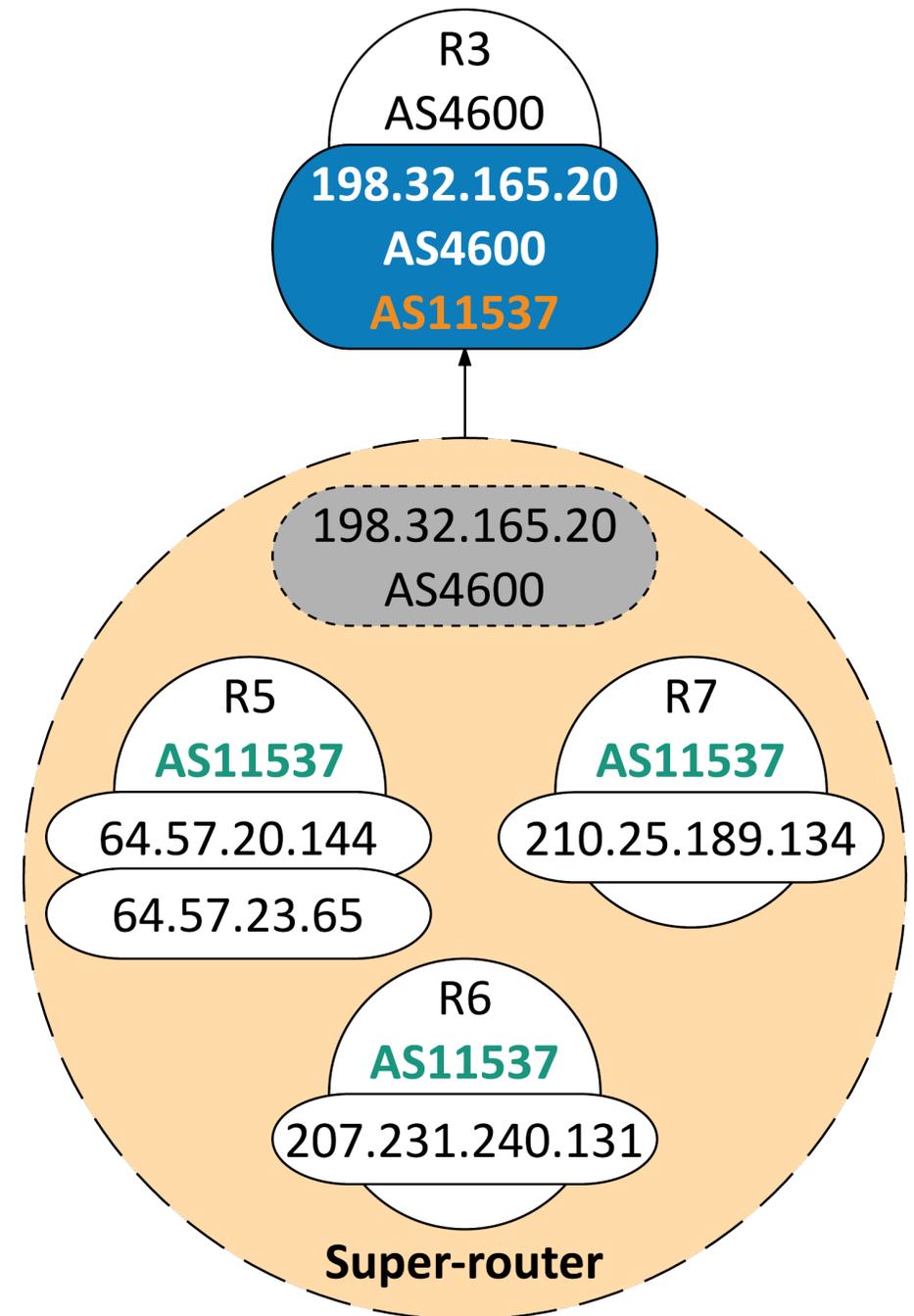
Graph Refinement Loop: Second Iteration
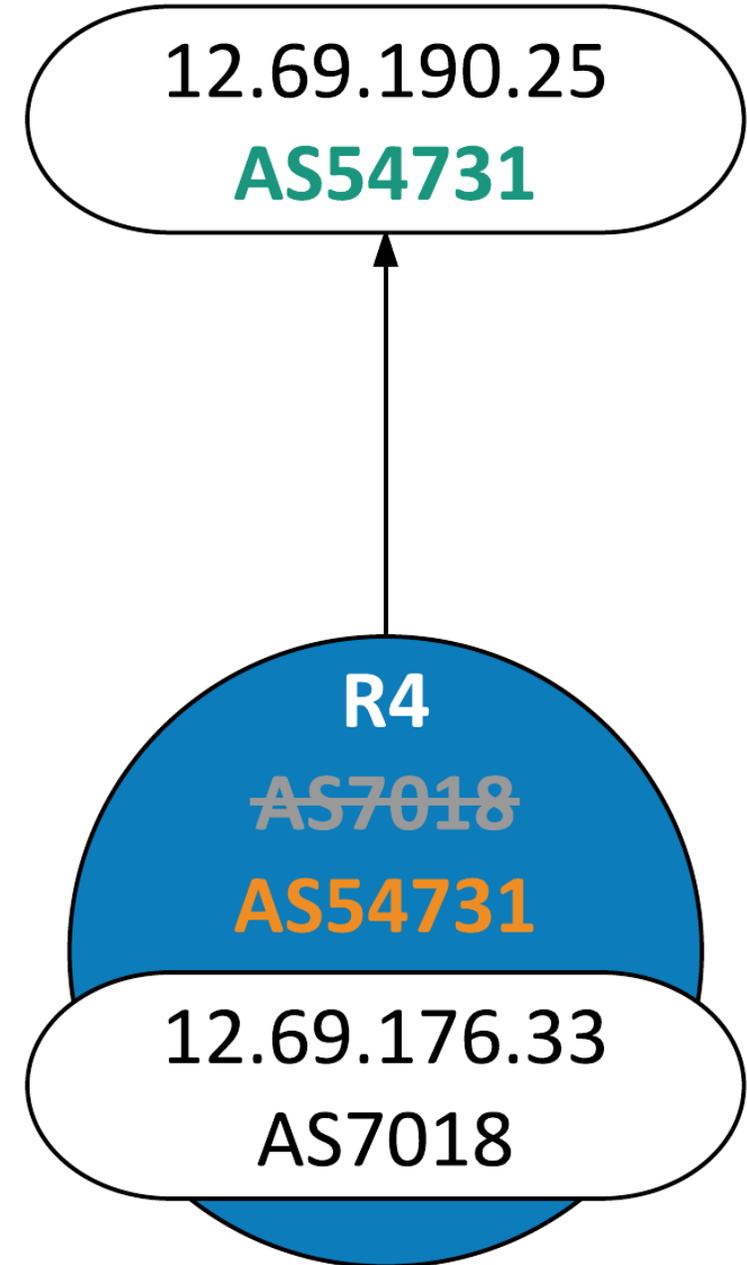
First Pass – incorrect AS annotation

Second Pass – corrects AS annotation

Single Neighbor Heuristic

- Some routers are succeeded by a single interface
  - Insufficient probes, NATs, flow control

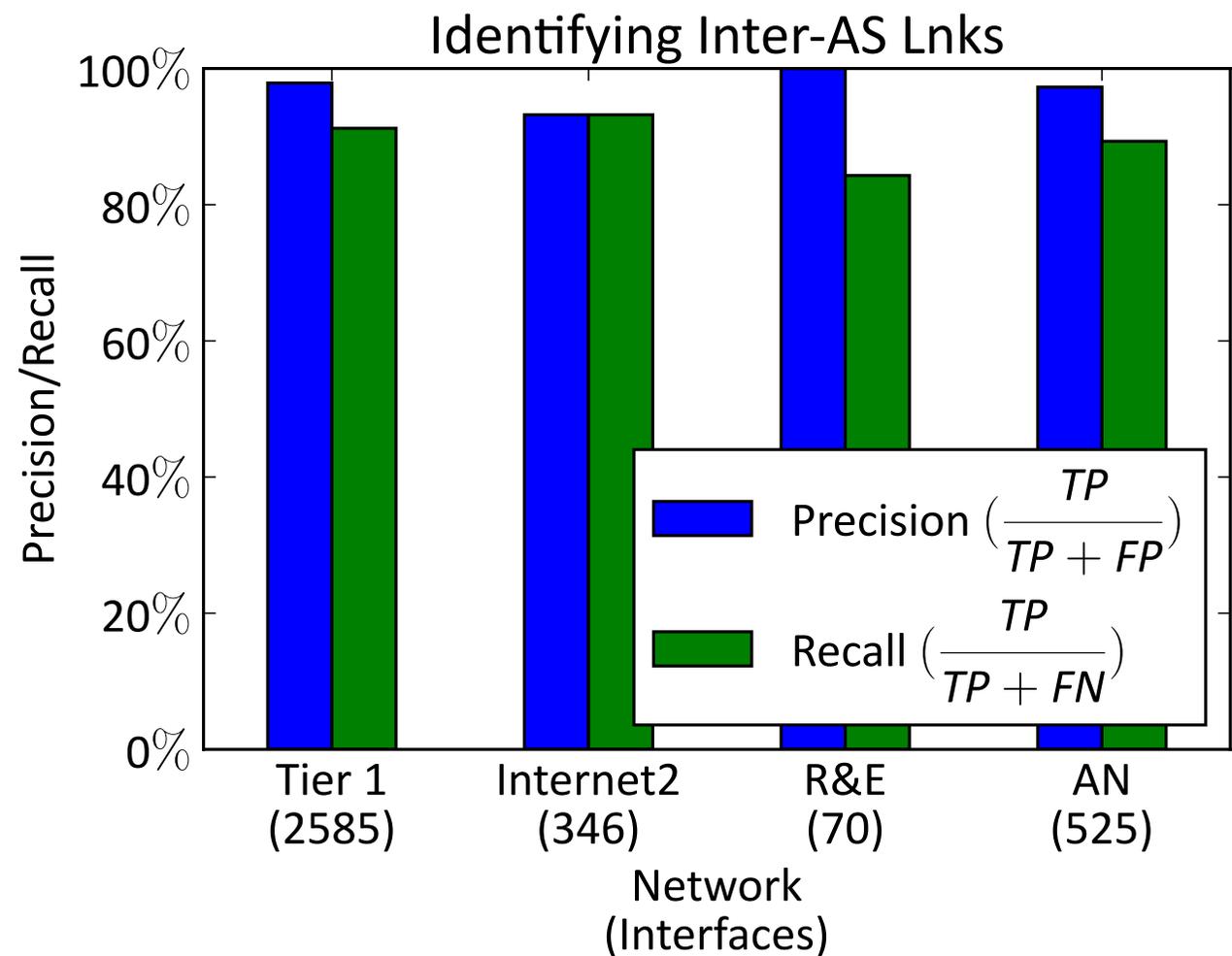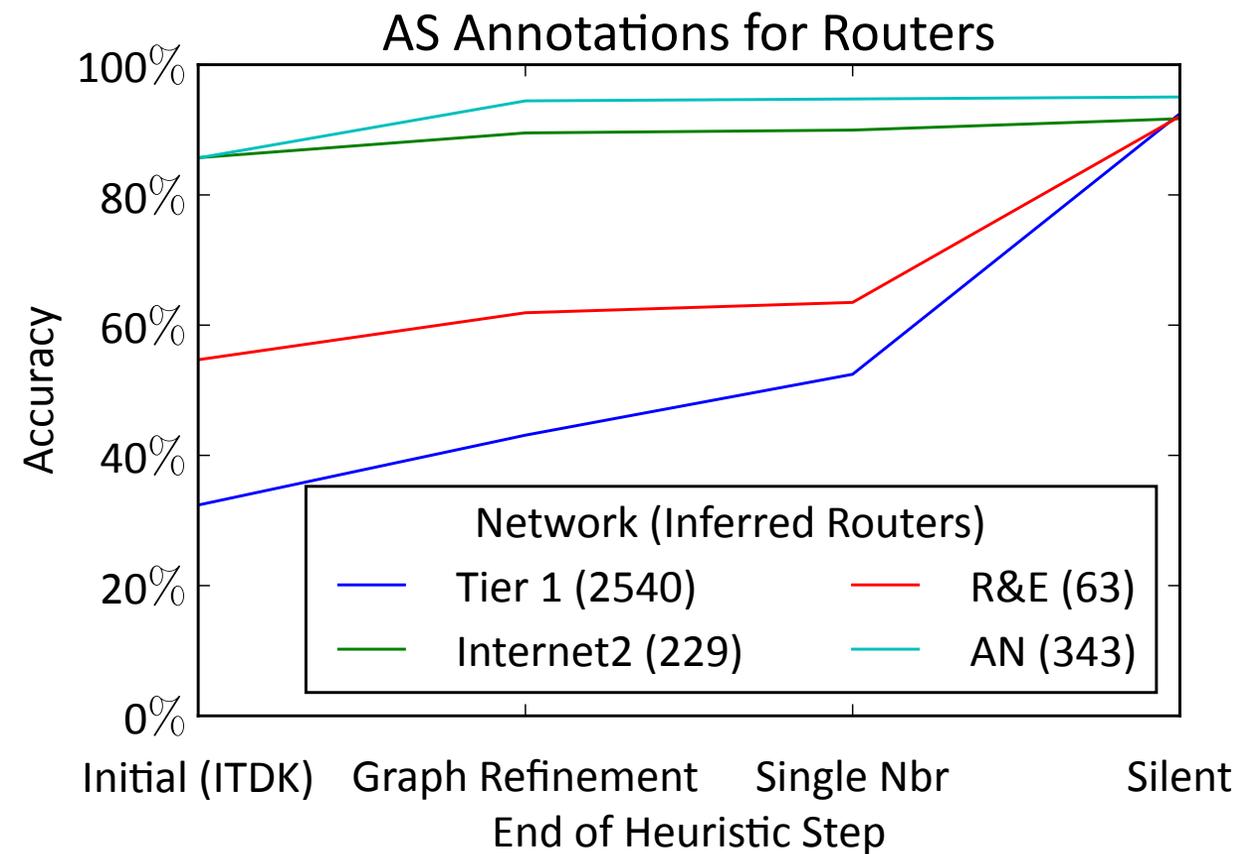- Heuristic: assign likely customer AS

Silent AS Heuristic

- Find traces that end without an address in destination AS
  - Last hop is possibly on gateway router
- Infer last hop's router is gateway if:
  - No interfaces succeed it in any trace, **and**
  - Router is possible gateway for a single AS

Start	169.229.0.140
Last Hop	210.7.37.154
Last Hop AS	**38022 (REANNZ)**
Destination	139.80.132.160
Dest AS	**38305 (U. of Otago)**

169.229.0.140
AS25

9 hops, 3 ASes

210.7.37.154
AS38022

G

Missing hop(s)

139.80.132.160
AS38305
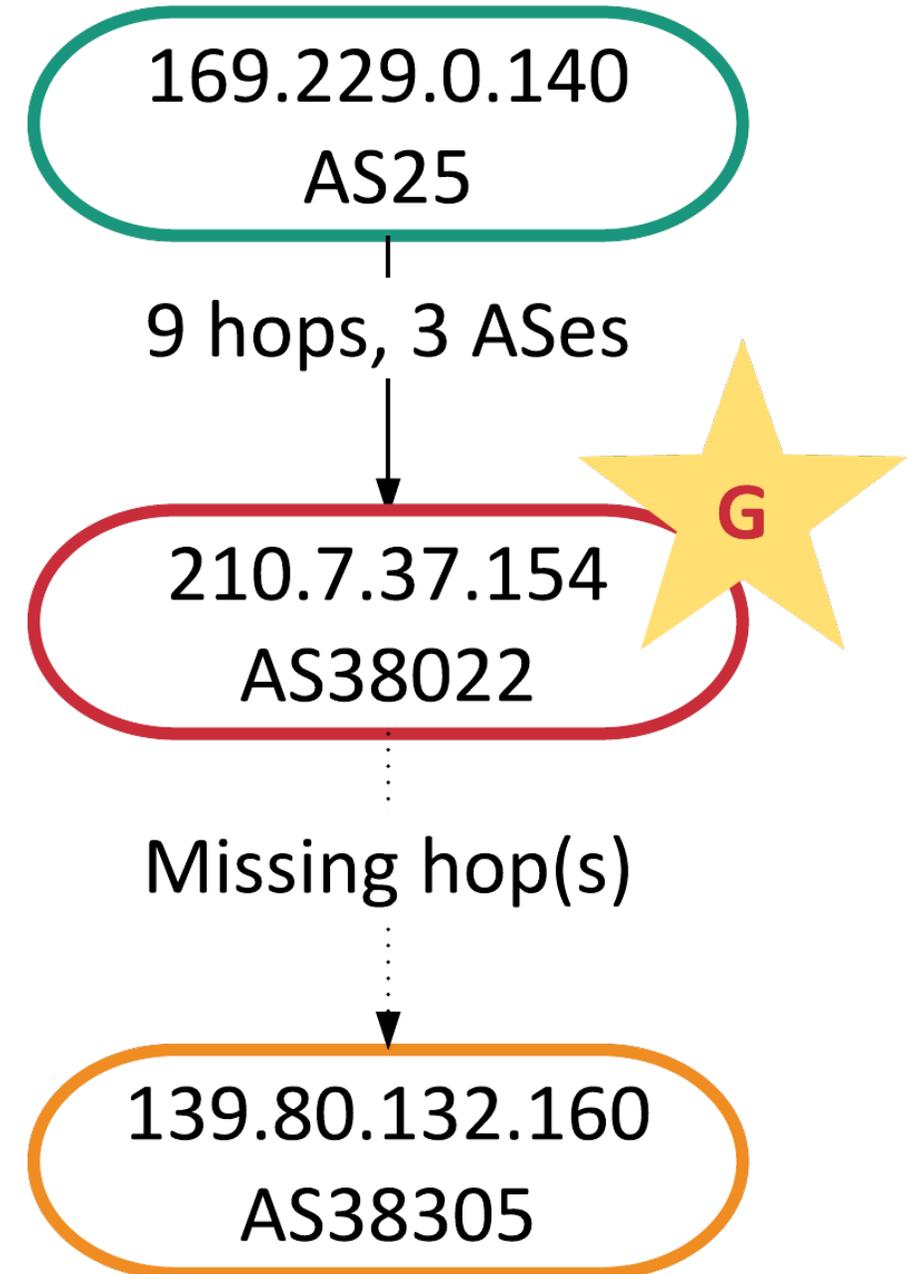
Comparison to Ground Truth: March, 2016

Ground truth networks: Tier 1, Internet2, Research & Education (R&E), and access network (AN)

Conclusions

- Heuristics for router-to-AS assignments and identifying inter-AS links
- AS annotations are >91% accurate
- Inter-AS link inferences are >94% precise
- What I want:
  - Feedback/criticism
  - Heuristic improvements and new ideas
  - New sources of data/ground truth