Geo-Location of PoPs

Noa Zilberman & Yuval Shavitt

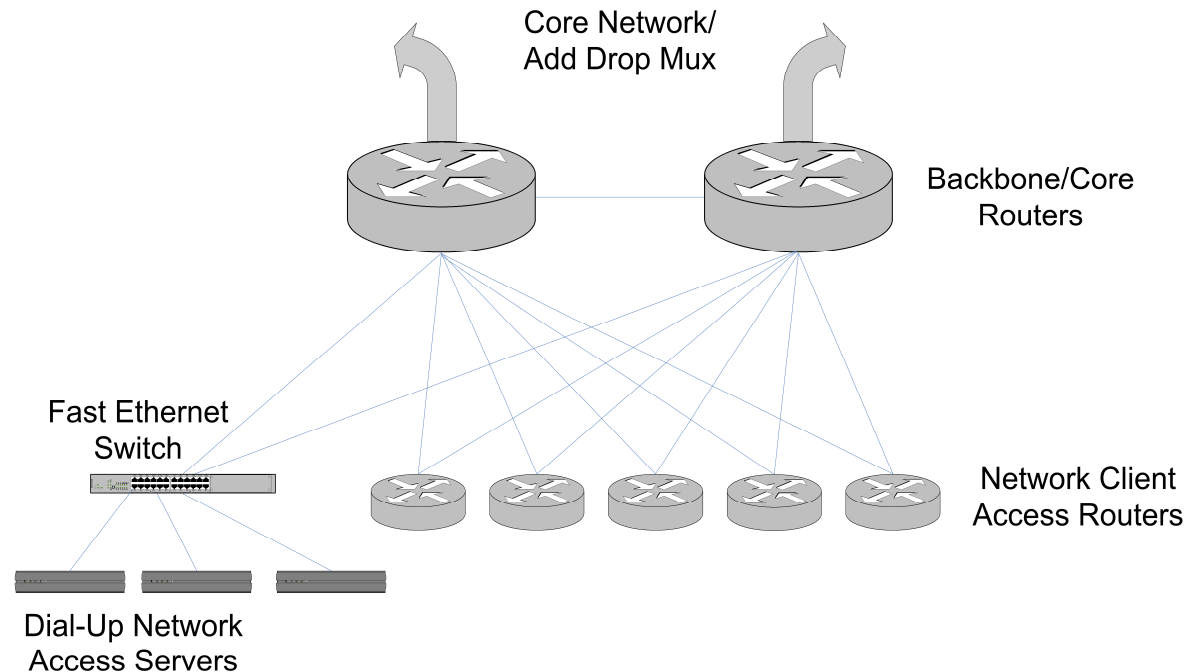Tel Aviv University

February-2010

Agenda

- Background

- PoP Discovery

- PoP Geolocation

- Evaluating Geolocation Databases

- AS Connectivity on PoP Level

Background

- PoP – Point of Presence - a concentration of routers and other networking devices in a campus from which Internet connectivity is offered to the region.

- DIMES worked so far on either IP or AS level.

Core Network/
Add Drop Mux

Backbone/Core
Routers

Fast Ethernet
Switch

Network Client
Access Routers

Dial-Up Network
Access Servers

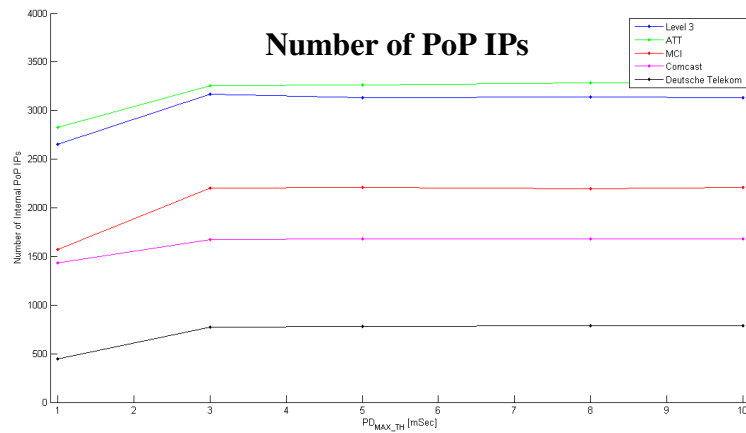# PoP Discovery

- Use *Link Delay* and *Network Motifs* to identify a PoP:
  - *An earlier work by D. Feldman & Y. Shavitt*
  - Look for edges with small link delay
    - Indicates nodes proximity.
    - Require a minimal number of measurements per link, for delay accuracy.
  - Identify bi-partite motifs in the graph
  - Classify to Parent-Child groups
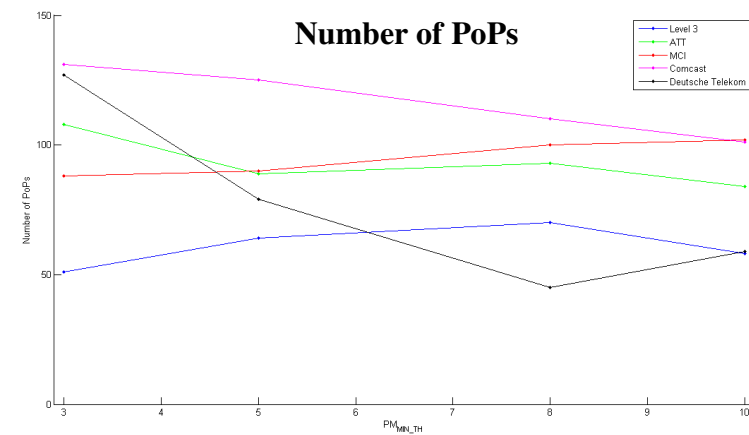 - Localization and unification to PoPs

id 204
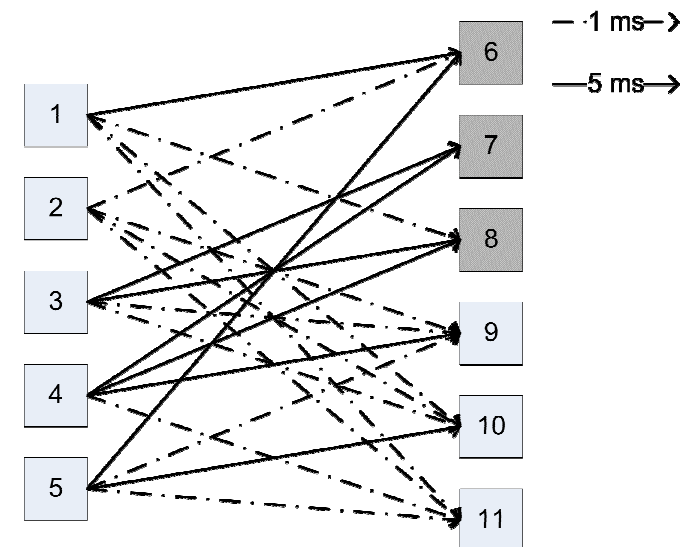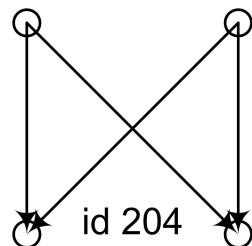
PoP Discovery

- Sensitivity to delay threshold:
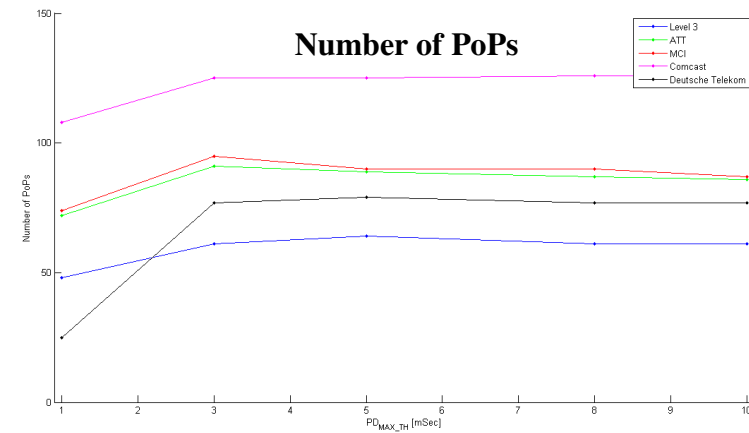
- Sensitivity to number of measurements threshold:
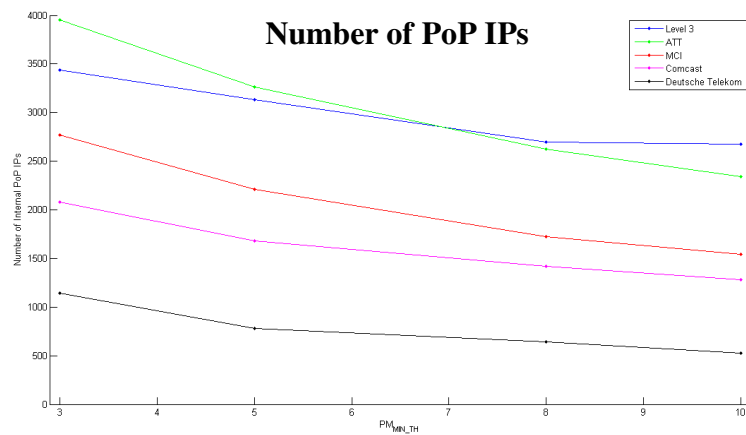
PoP Discovery

- Running on bi-weekly basis
  - Increased number of discovered PoPs compared to 1 week period.
  - More sensitive to changes than 4 weeks period.

- Using Traceroute measurements
  - 30M-40M measurements per week.
  - 5.5M-6.5M distinct edges discovered.
  - ~1000 agents in over 200 ASes are used for the measurements.
  - 2.5M IP addresses in over 26,000 ASes are being targeted.
  - Using Median algorithm to estimate distance between nodes.

PoP Discovery

- **Discovered PoPs**
  - ~4400 discovered PoPs.
  - Over 50K IPs within discovered PoPs.

- **Discovered mostly large PoPs and not access PoPs.**

- **Enhancements**
  - Targeting iPlanes's PoP's IP addresses – increased the number of discovered PoPs by less than 20%.
  - Targeted measurements to specific AS doubled the number of discovered PoPs in small ASes.
    - Had some effect in large PoPs but not to that extent.

PoP Discovery

- Limitation: number of measurements
  - The number of discovered PoPs directly relates to the number of discovered edges
  - DIMES new Agent will more than double the amount of measurements
    - Beta version available this month!
  - We are interested to use traceroute measurements with delay information from other databases to improve PoP discovery.

- We'll be happy to discuss in detail, but lets move to GeoLocation…

PoP GeoLocation

- We strongly believe that if we identify IPs as belonging to the same PoP - they are in the same geographic proximity.

- Use location information from several geolocation databases to determine PoP's location.

- Location is selected by majority vote.
  - Majority vote uses the location of all IPs within the PoP taken from all geolocation databases.
  - A range of error is given for each PoP location.
    - No more than 100km radius.
    - The location is given as Latitude, Longitude.
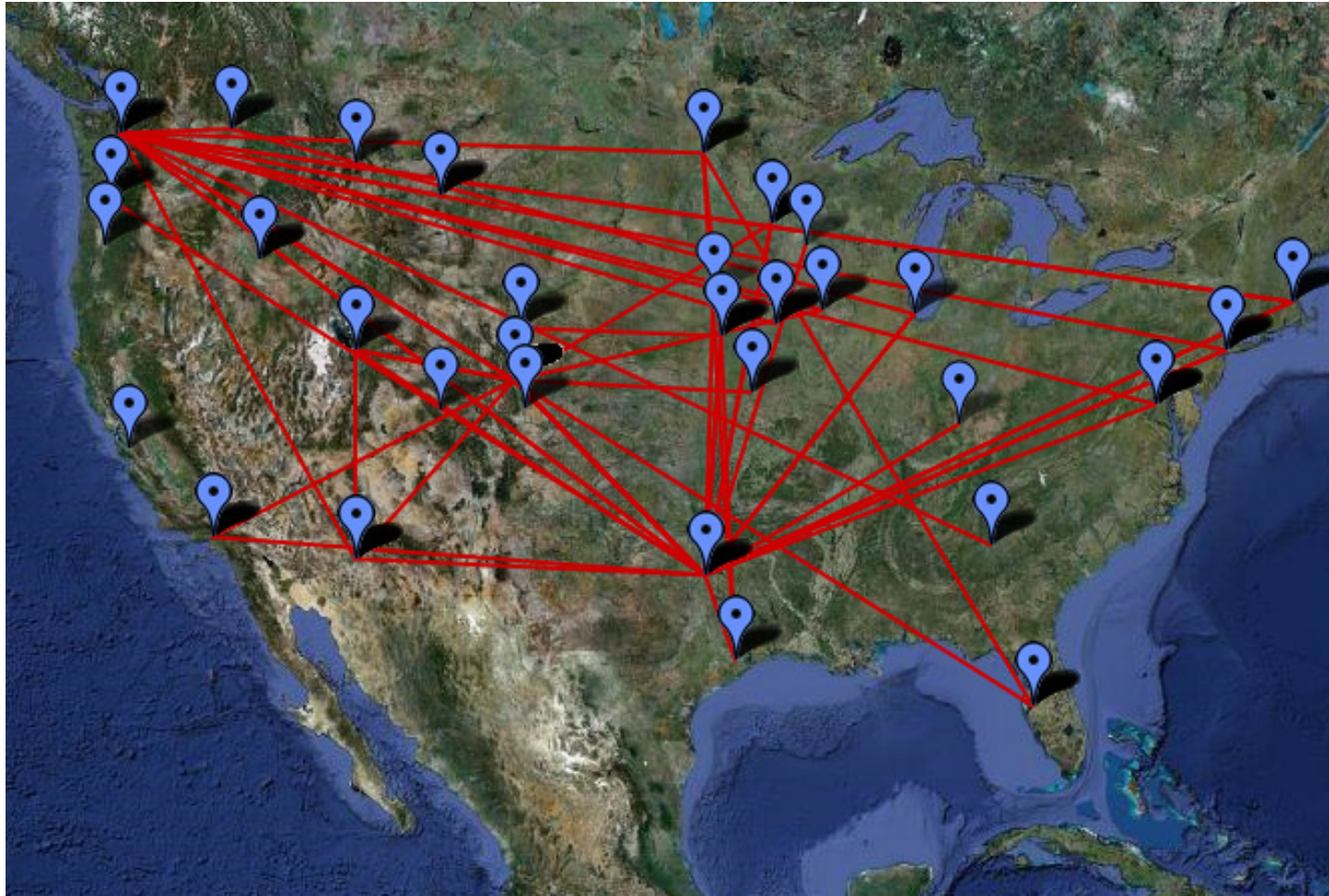 - With some refinements….

PoP GeoLocation

- Used commercial GeoLocation Databases:
  - MaxMind GeoIP
  - IPLigence
  - HostIP.info
  - IP2Location
- Quova was not used, though it is supposed to be more accurate
  - Budget limitations
- DNS was used for limited testing

World PoPs Map

Qwest US PoPs Map

PoP GeoLocation - Validation

- Compared generated PoP maps to published ISP PoP maps:
    - Sprint, Qwest, Global crossing, British Telecom, ATT etc.
    - PoPs are correctly located

- Compared against Universities locations
    - Selected 50 PoPs belonging to universities world-wide
    - 49 universities were correctly located by the algorithm
    - University of Pisa was located in Rome
        - Wrong information in MaxMind and Ipligence, HostIP.info was right.

PoP GeoLocation - Results

- 82% of the PoPs have majority vote considering all the IPs in the PoP.

- 12% more have majority vote only when considering nodes with location information.
  - Geolocation databases sometimes lack information on some IP addresses.

- 68% of PoPs are located with 1km range of convergence.

- For only 28% of the PoPs there is over 90% agreement between all location services.

- We fail to locate 5% of PoPs with high accuracy.

Evaluating GeoLocation databases

Missing Location Information

- MaxMind:
  - 12% of IPs
  - 10% of PoPs
  - Informed us that the quality information is on end-user and not router-IP.
- IPligence:
  - 6.5% of IPs
  - 1% of PoPs
- HostIP.info:
  - 28% of IPs
  - ~33% of PoPs
- IP2Location:
  - 4.2% of IPs
  - 0% of PoPs

Evaluating GeoLocation databases

Agreement within the same database

- Does nodes within the same PoP have the same location?
  - MaxMind: 72%
  - IPligence: 86%
  - HostIP.info: 77%
  - IP2Location: 74%

- In some cases, the location variance is negligible
  - i.e. considering larger PoP range of convergence can get a higher level of agreement

Are GeoLocation DB truthful?

<u>Qwest as an example</u>

- 70 PoPs were discovered by the algorithm

- MaxMind assigned the PoPs to 55 different locations

- HostIP.Info assigned the PoPs to 46 different locations

- IP2Location assigned the PoPs to 35 different locations

- IPligence located the PoPs in only one distinct location;
  - All the PoPs were placed in Denver, where Qwest HQ are located.

- MaxMind had the same problem as IPligence in their May-2009 DB, but it was fixed in July-2009 DB.

Can GeoLocation DB be trusted?

- Global Crossing
  - A selected PoP, includes 4 IPs, all databases had 100% similarity
  - IP2Location located near Washington DC
  - IPligence located in Pheonix
    - Distance is ~2500 mile from Washington
  - MaxMind located near Chicago
    - Distance is ~720 mile from Washington
- China Telecom
  - A selected PoP, includes 23 IPs, all databases had over 95% similarity
  - IP2Location located in Beijing
  - IPligence located in Harbin
    - Distance is ~750 mile from Beijing
  - MaxMind located in Putian
    - Distance is ~1400 mile from Beijing

Keeping Track of DB updates

- Databases can significantly change between updates
- IPligence as an example
  - ~0.6% of the entries changed between consecutive months (Nov/Dec 2009)
  - ~9.5% of the entries changed over 8 months period (April/Dec 2009)
- Other databases behave similarly
  - We have gaps in past databases, so it's hard to compare

AS Connectivity on PoP Level

- PoP level maps can also be used for the analysis of AS-level connectivity.

- Very high connectivity of PoPs within Top-20 measured AS:
  - Median of 22 links per PoP
  - A link is defined as a distinct connection between 2 different ASes
    - Multiple connections between two PoPs are counted only once
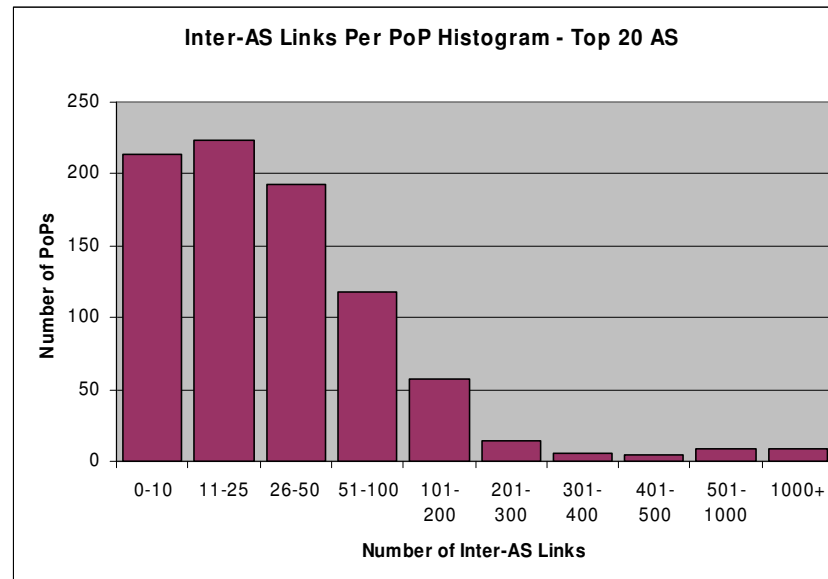
AS Connectivity on PoP Level

- Connectivity pairs between Top-10 and Top-20 measured ASes:
  - Average of 35 links between Top-10 AS
  - Median of 26 links between Top-20 AS
  - No case of a single-connection between Top-10 AS
  - Highest connected groups:
    - Comcast-GLBX, Comcast-MCI, Comcast-QWEST, ATT-GLBX, ATT-MCI

Top 10 Inter-AS Pairs Histogram

Top 20 Inter-AS Pairs Histogram