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ISP-Friendly Peer Matching without ISP Collaboration

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SFU

Introduction

- **P2P Systems (file sharing, live streaming, VoD, ...) are very popular nowadays**
  - **Generating a major fraction of Internet traffic**
- **In most of these systems, peers offer limited capacity and reliability ➔**
- **Client peer typically served by multiple senders**
- **Choosing "good" senders is important for**
  - **Clients: better performance**
  - **P2P System: more capacity, better scalability**
  - **Network (ISPs): reduced load on inter- /intra-ISP links**

Our Work: Peer Matching Problem

- **Given set of potential senders for a receiver, find subset of them that minimize the load on ISPs**
  - **Load = traffic on inter-ISP links (expensive) and on intra-ISP links**
- **General formulation/solution ➔ can be used in different Systems**
  - **BitTorrent-like: use in tracker**
  - **Gnutella-like: use in peers**
  - **Peer-assisted CDN: use in managing servers**

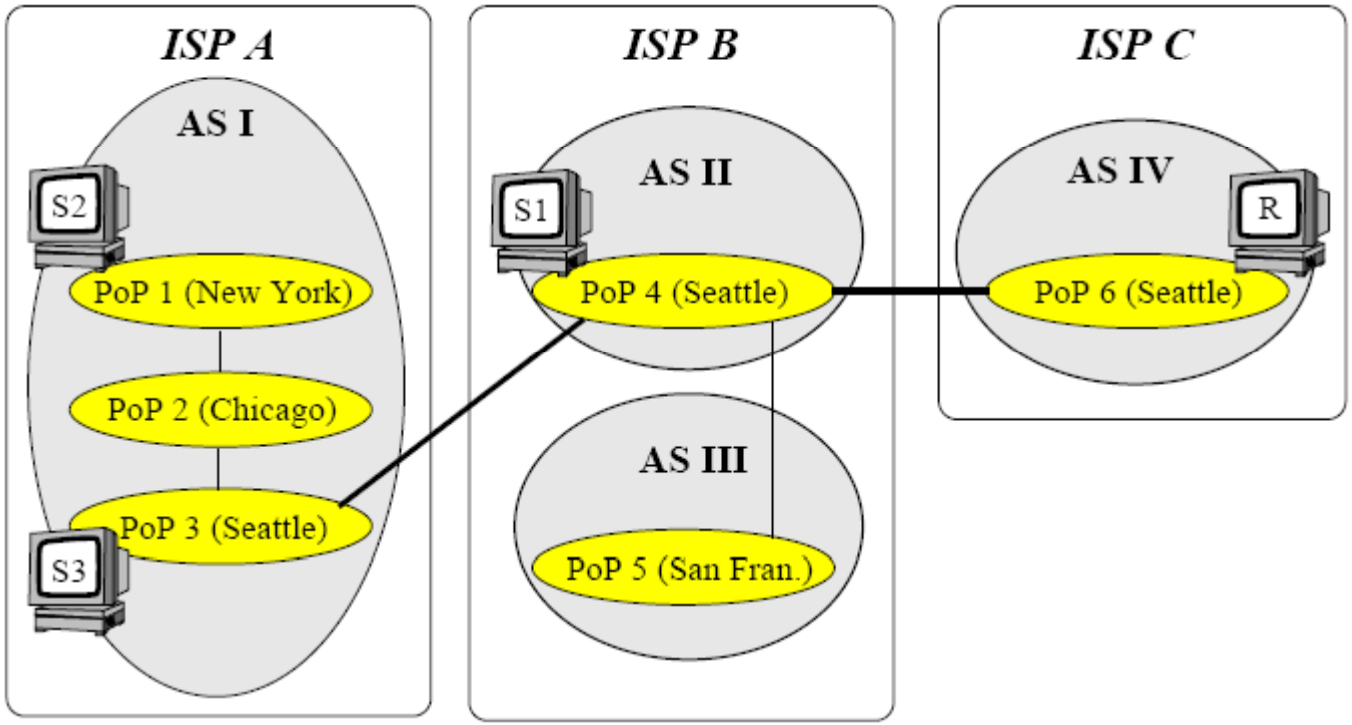
Our Approach

- **Find nearby peers in terms of**
  - **AS hops → reduce inter-ISP load**
  - **PoP (Point of Presence) distance → reduce intra-ISP load**
- **Efficiently estimate AS paths &PoP distances**
  - **Small memory/CPU requirements**
  - **Use public data (BGP tables, GeoIP, …), no probing**
- **No infrastructure need to be deployed**
- **No need for cooperation from ISPs**
- **No need to modify client software**

Related Work

- **Provider Portal for P2P (P4P) [Xie 08]**
  - ISPs deploy servers (iTrackers) to guide peer matching
  - Require cooperation from ISPs and infrastructure
- **Using DNS redirections [Choffnes 08]**
  - Peers observe similar delay to CDN replicas➔ close to each other
  - Require modifying clients
- **Match peers within the same AS [Bindal 06]**
  - Specific to BitTorrent
  - Peers outside AS are chosen randomly

Overview

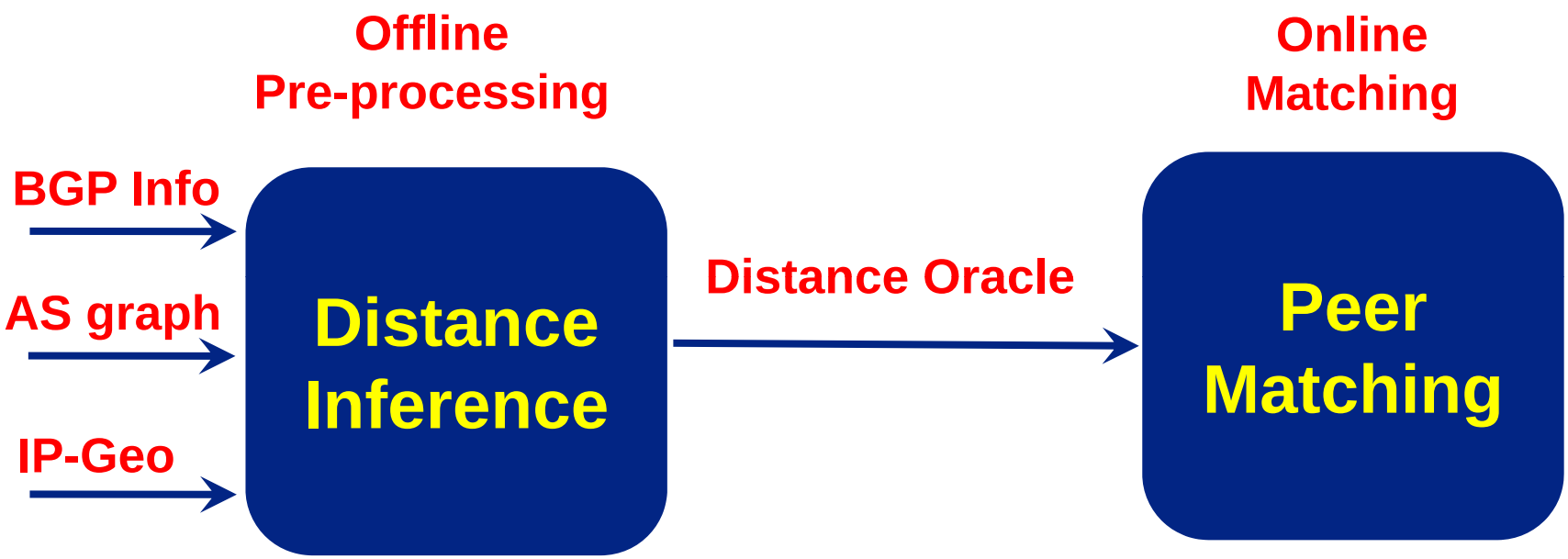


- **Large ISP: PoPs at many locations**
- **S3 is better for R than S2, though same AS distance**

Overview

- **We need to estimate AS hops between peers**
  - **Need AS path inference algorithm (valley-free policy)**
  - **Modified Dijkstra Algorithm [Mao 05] ➔ very expensive, took ~2 days of running time, huge memory footprint**
  - **Our optimization: runs 1-3 hours, < 1% memory**
- **We also need to infer PoP topology**
  - **Propose simple method to cluster IP prefixes**
  - **Use GeoIP databases to map clusters to PoPs**

Peer Matching



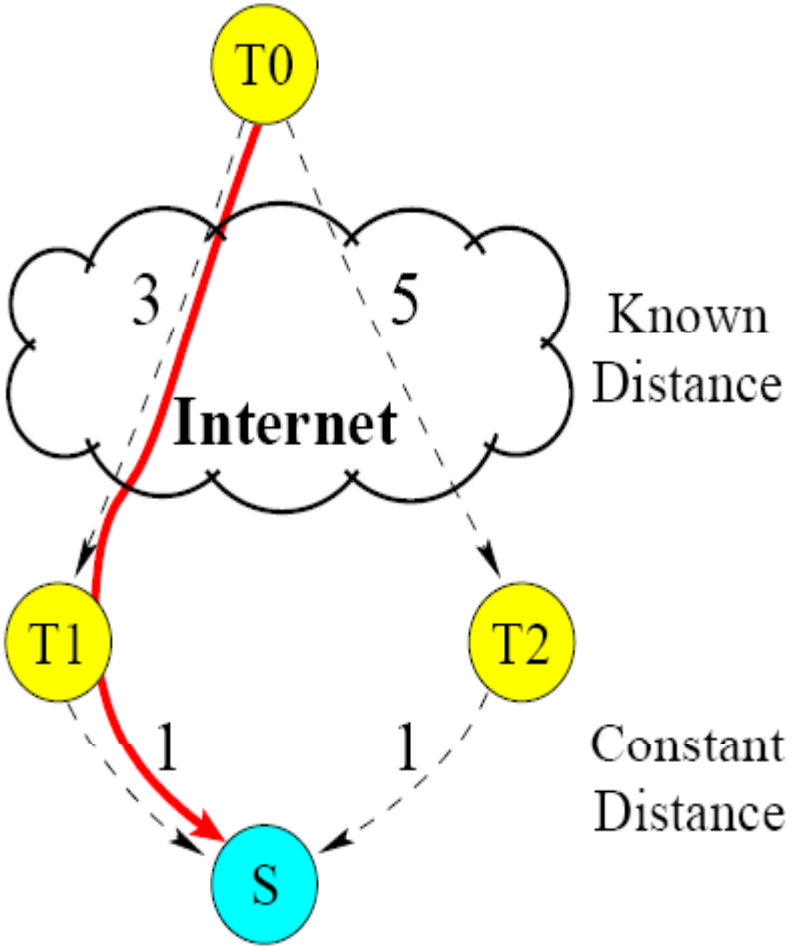
- **Distance oracle: concise data structure, enables online matching in O(1) steps**

AS Path Inference

- **Original algorithm [Mao 05]**
  - **$O(V^3)$, V number of ASes**
  - **Currently, there are 28,000+ ASes [CAIDA]**
  - **Very expensive**
- **Observation**
  - **Many ASes have small degree (client/stub ASes)**
  - **83% of ASes have 1 or very few C2P links [CAIDA]**
  - **➔ their AS paths can be inferred using their providers' paths**
  - **➔ stub ASes can be removed from the AS graph**

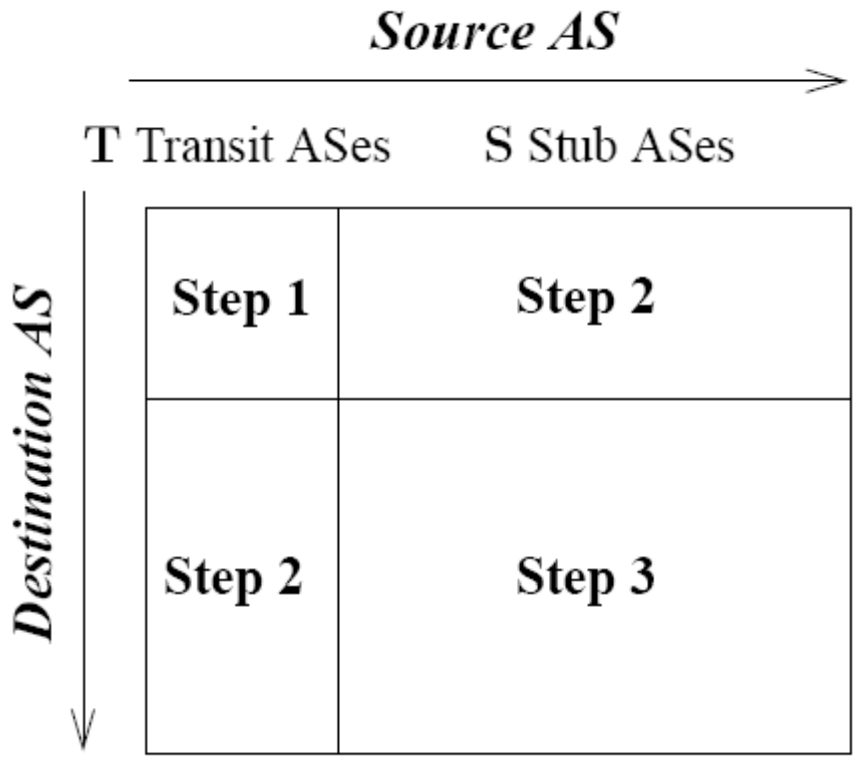
AS Path Inference

- **T: transit AS, S: stub AS**
- **Given T0 –T1 & T0—T2 ➔ T0—S can be computed**
- **We can recursively remove ASes**
  - **Stub AS first**
  - **Transit ASes that are customers of larger ASes, and so on**



AS Path Inference

- **Estimate AS paths for "core" ASes first**
  - **Using any algorithm**
- **Then paths starting/end at a transit AS**
- **Then, the rest**
- **Time Complexity:**
  $O(T^3 + T S + S^2)$
  - **T small fraction (<18%) of ASes ➔ much faster**
  - **3 hours (instead of 2 days) for whole matrix**



Distance Oracle

- **Maintaining the whole distance matrix is costly**
  - **Assume each entry takes 1 byte**
  - **#of ASes = 28,594 ➔ 817 MB for distance matrix**

- **Idea: Maintain only the "core" matrix, other entries can be computed online**

- **Tradeoff: small core vs. more online computations**

Distance Oracle: Tradeoff

Level	Core Size (#ASes)	Memory (MB)	Online Computations (Average)
0	28,594	817	0.0
1	5,144	26	2.6
2	2,949	8	12.4
3	2,471	6	97.0

- **We can use a distance oracle of size 8 MB, and perform < 13 operations online on average**
  - **#operations depends on AS degree, not size of AS graph**

PoP Distance: Overview

- **Infer approximatePoP topology of ASes**
- **Algorithm overview:**
  - **Collect all IP prefixes from BGP tables and map them to their ASes**
  - **For each AS, cluster IP prefixes into one or more PoPs**
  - **Analyze BGP updates to infer connectivity among PoP in same AS**
  - **Combine PoP topology with AS graph**

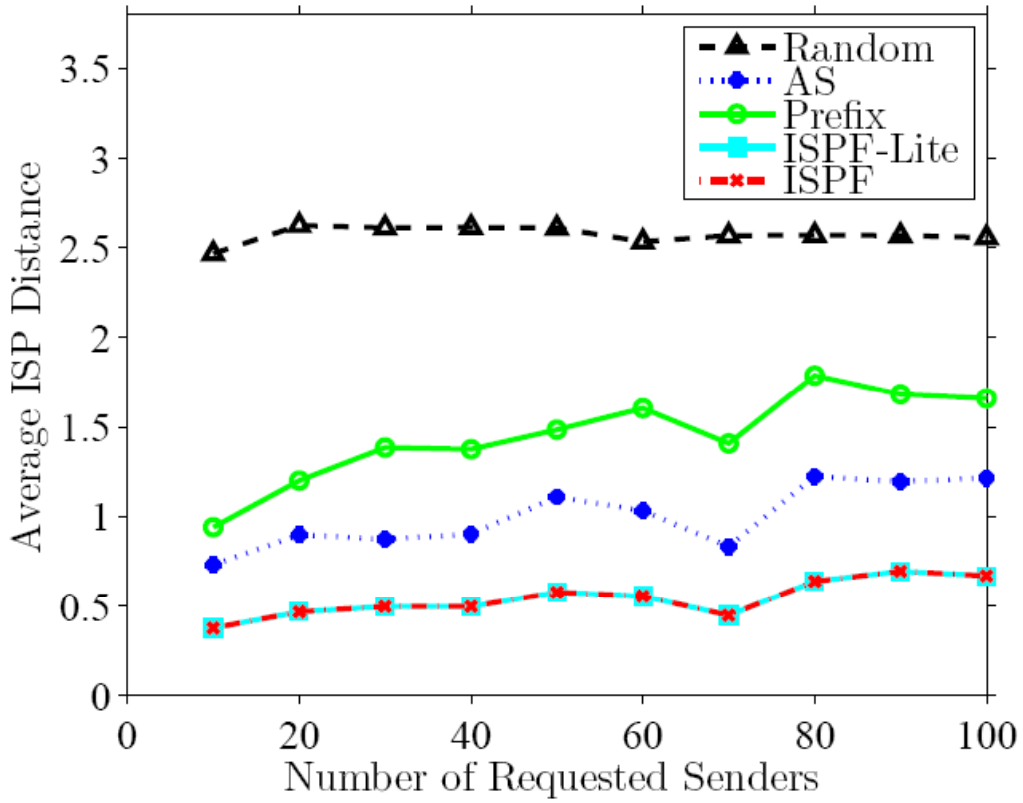
Evaluation

- Trace-based simulations
- Use real IPs from
  - BitTorrent tracker: ~150,000
  - Online content provider (CBC -- Canadian Broadcasting Corporation); ~ 160,000
- BGP tables from RouteViews& RIPE
- AS relationship data from CAIDA
- Use GeoIP [maxmind.com] for IP/AS/location mapping

Evaluation

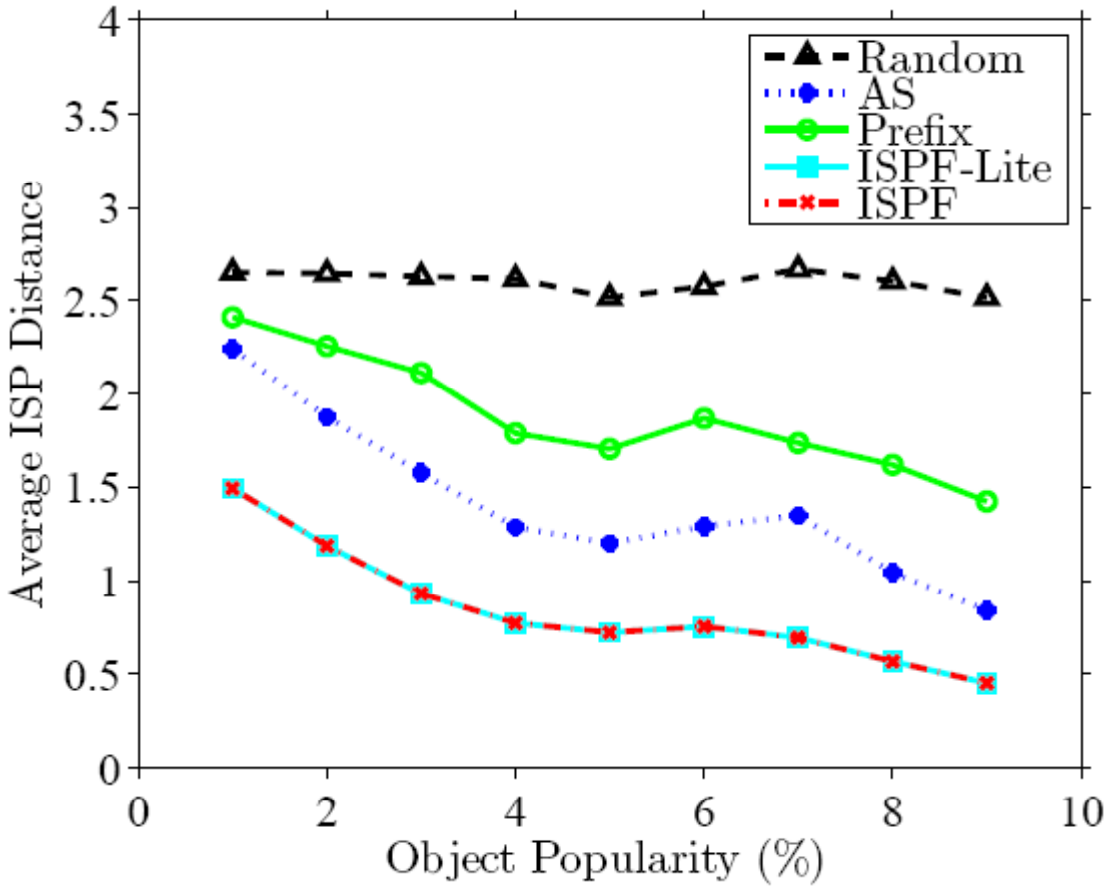
- **Simulate multi-sender sessions for objects with different popularities: 1% -- 10%**
- **Change number of chosen senders: 10 – 100**
- **Implement**
  - **ISPF: ISP-Friendly Matching**
  - **ISPF-Lite: ISP-Friendly Matching, without PoP info**
  - **AS: Match based on AS distance only**
  - **Prefix: Match based on longest common IP prefix**
    - **Uses IPs of peers ➔ almost free**
  - **Random: currently used in many systems**

Sample Results: Vary #Senders



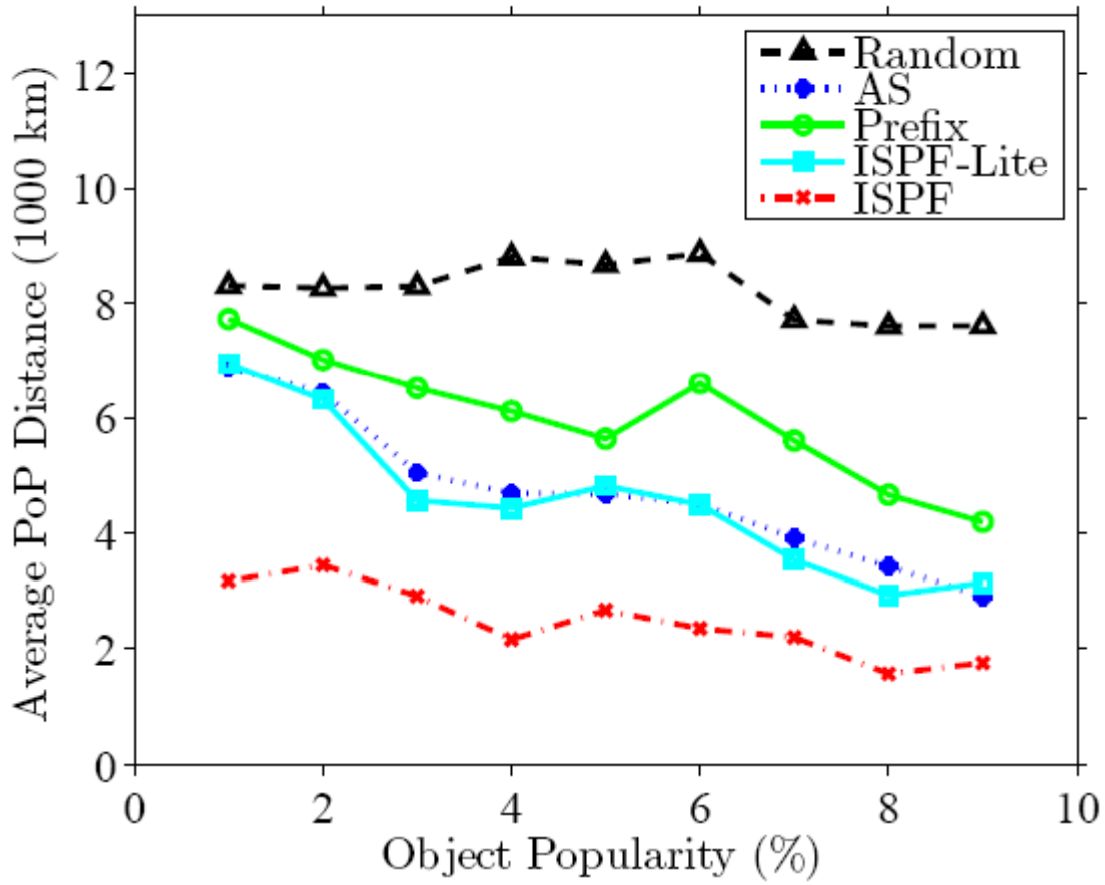
- **Some gain from (the free) Prefix**
- **Significant gain from ISPF/ISPF-Lite**

Sample Results: Vary Object Popularity



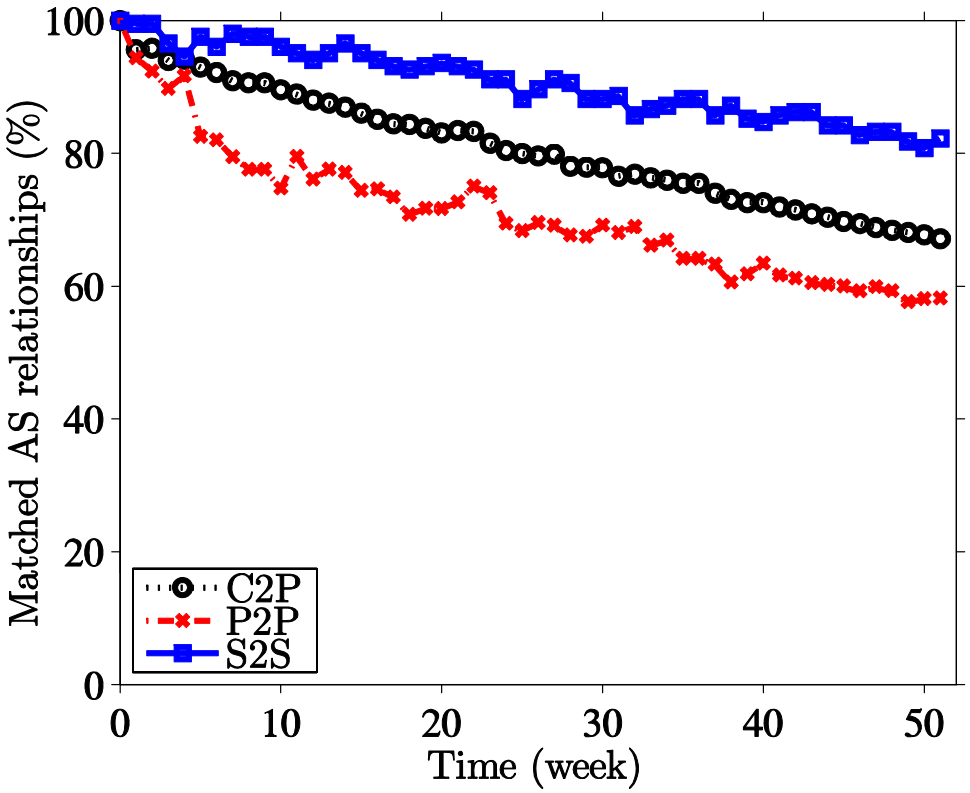
- **Even more gain for rare objects**

Sample Results: PoP Distance



- **ISPF achieves shorter distances**

Dynamics of AS Graph



- CAIDA AS relationship data for a full year
- ➔ run AS inference algorithm once a month or so

Conclusions and Future Work

- **Peer matching is important in multi-sender systems**
  - **P2P systems, distributed streaming, CDN, pCDN, …**
- **Peer matching algorithms based on**
  - **AS distance**
  - **PoP distance**
- **Do not need infrastructure, modifying peers, ISP cooperation**
- **Efficient computation and storage of AS distance**
  - **~ 8 MB (<1% of whole matrix) for 28,000+ ASes**

Conclusions and Future Work

- **Currently implementing in pCDN (for CBC) and in BitTorrent tracker**
- **Exploring link cost model**
  - **Assign weights to inter-AS links**
- **Exploring more efficient methods for discovering & storing PoP topology**

Thank You!

Questions??

- **More info at:**

  http://nsl.cs.sfu.ca/