Regional AS topologies

Yohei Kuga (Keio Univ)

Kenjiro Cho (IIJ)

Osamu Nakamura (Keio Univ)

3rd CAIDA-WIDE-CASFI Workshop

Background

- Purpose of existing research for Internet topologies analysis
  - To understand the Internet structure and its development
  - Target is logical level of networks
    - AS-level, PoP-level, Router-level or Interface-level
- Change in the global Internet topology
  - Shifting from a U.S. centered star topology to a more distributed topology interconnecting regional hub ASes
    - Appearing regional IXes and core ISPs in each region
  - Why?
   - For lower latency and cost reduction

Our goal

- **Goal**
  - To understand Internet structures in regional views
    - continent-level, country-level, city-level

- **Applications**
  - The analysis of Internet structures in regional views allows
    - To identify hub ASes in each region
    - To identify major cities covered by the hub ASes in each region
    - (use time series analysis) To understand the developments of Internet structures in regional view

- **Challenges**
  - Method for inferring place of AS links
    - want to know which AS and other AS are connected, and **where** to be connected
    - some IP geolocation techniques and IP alias resolution is helpful

Where ASes are connected?

- Most AS links (peering and transit) are at well-defined places (IXes and data-centers)
- Inferring the pair of border routers exist in same place
  - Geographical clustering is possible

AS border links

AS X   AS Y
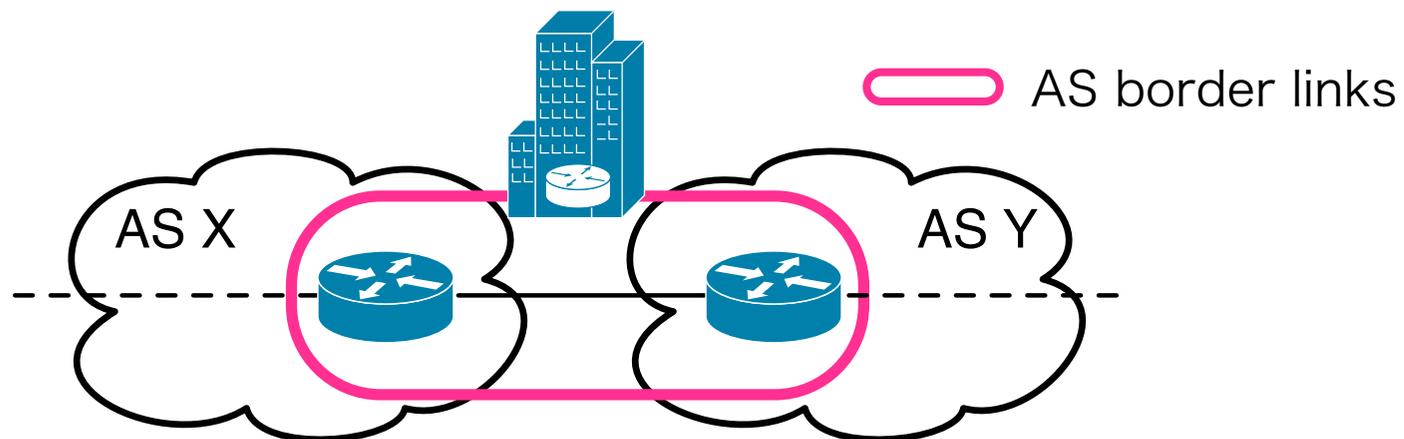
Inferring AS border link at same place

Approach

1. To extract AS links from traceroute data collected from multiple vantage points
2. To split the AS border links in each region
   - Using IX info and AS border's DNS names
3. Clustering AS border links at same place
   - When the same IP address appears at one end

1. To extract AS border links

2. To split the AS border links in each region

3. Clustering AS border links at same place
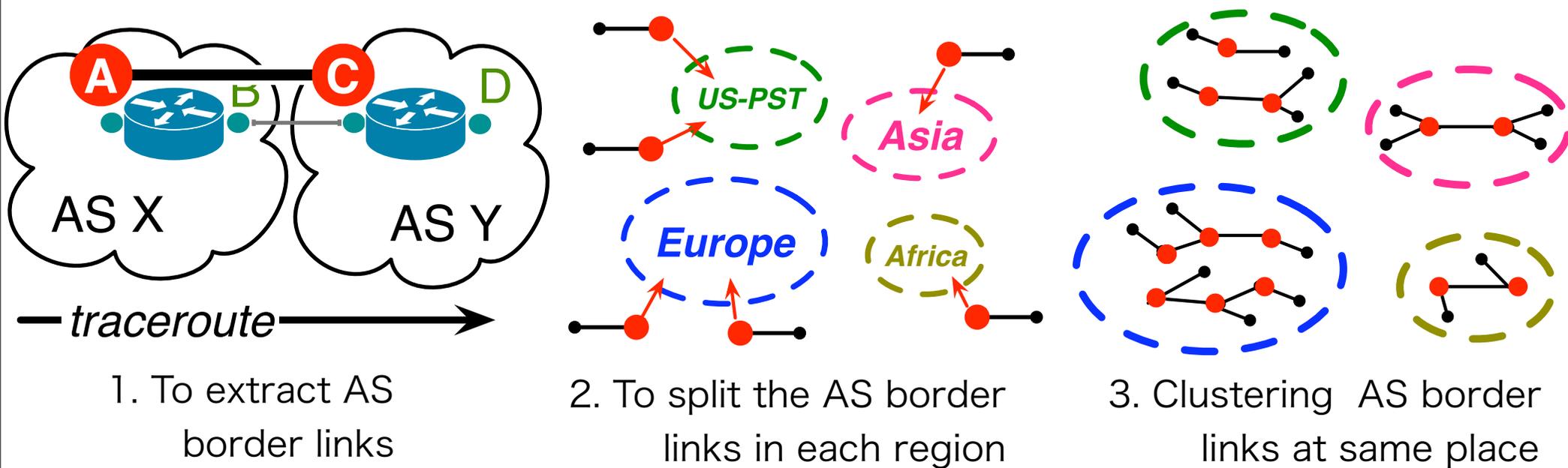
Comparison of continent-level AS topology

Topology data

|	Skitter	iPlane
Method	**traceroute**	
Date	**2008/10/18 - 3/20**	**2008/10/18**
Vantage point	**31**	**planetlab(943?)**
# of traceroute data	**43M**	
# of AS links	**70,894**	
# of ASes	**22,284**	

Distribution of AS out-degree

- Target is 8 area (Europe, Asia, Oceania, Africa, US-{time zone})
- CCDF of AS out-degree(neighbors) for each continent
- The distributions of number of regional AS out-degrees
  - follow power-law
  - are similar among the continents
- The existence of hub ASes

CCDF(Area)
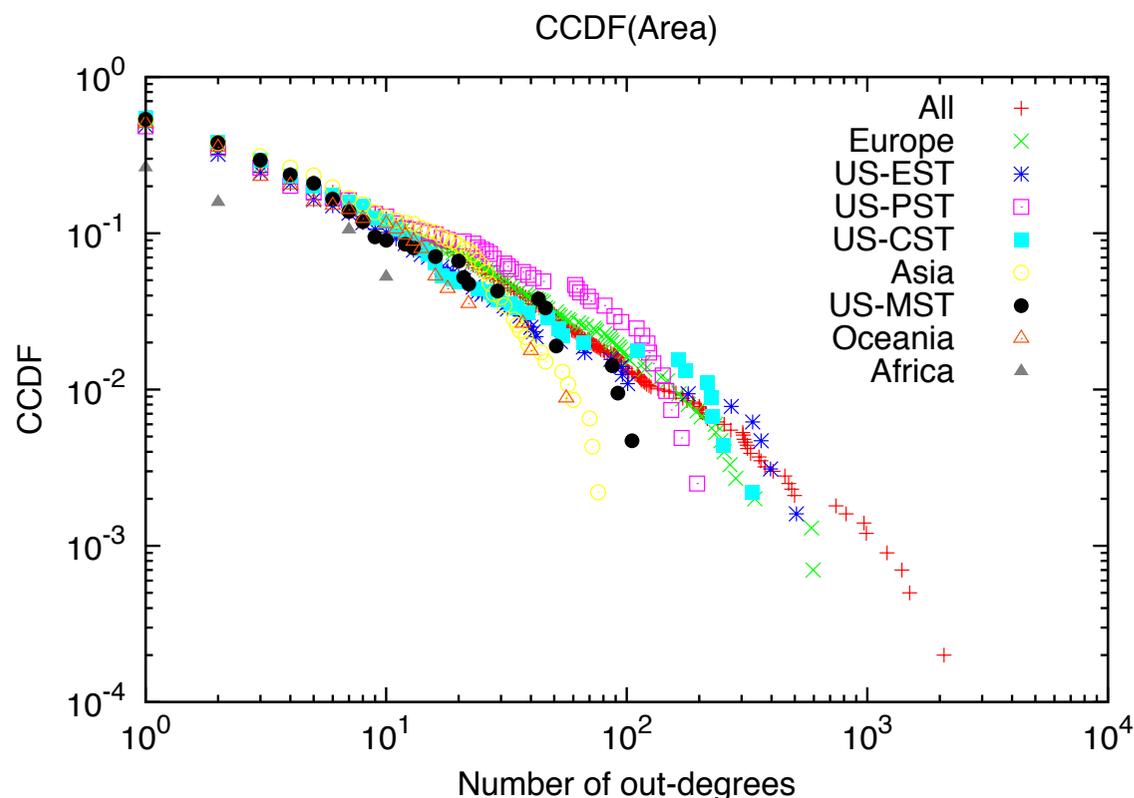
Illustrate of continent-level AS topologies

- Visualization of the clusters in each continents
- Using layout of AS Core Map
  - AS's longitude: to convert AS's physical address to longitude using Google Map API
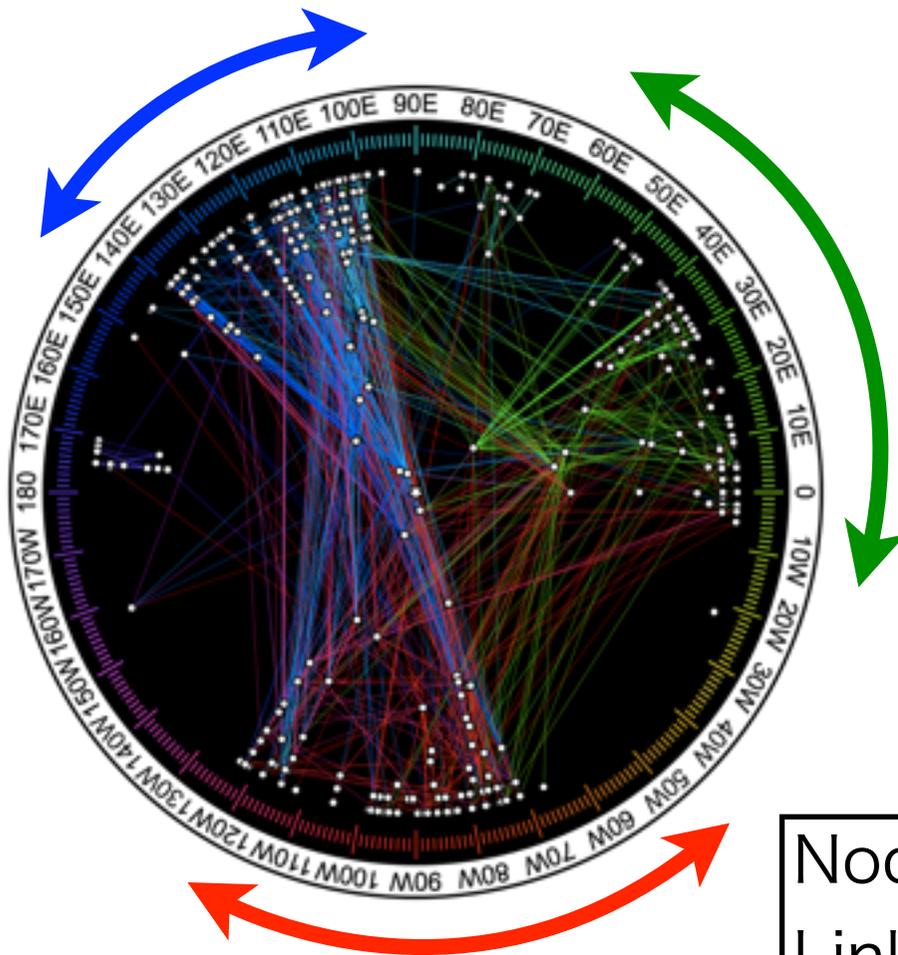
$$radius = 1 - log\left(\frac{outdegree\,(AS) + 1}{max.outdegree + 1}\right)$$

$$angle = \left(\begin{array}{c}\text{longitude of the AS's}\\ \text{BGP prefixes}\end{array}\right)$$
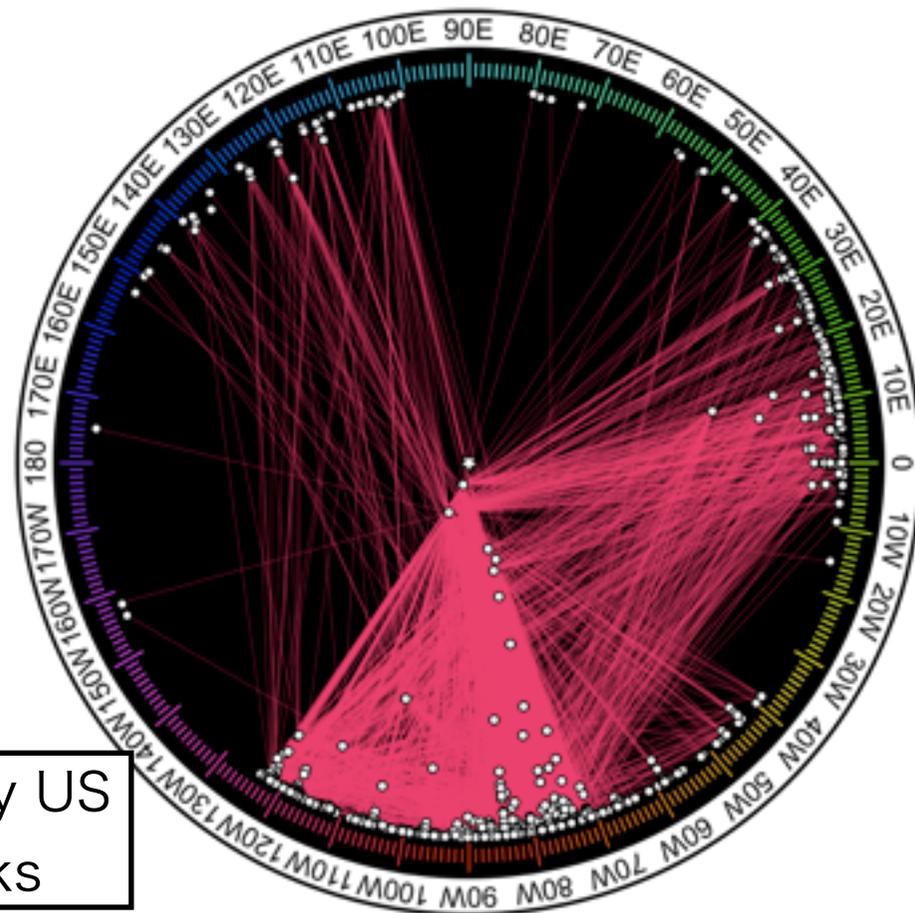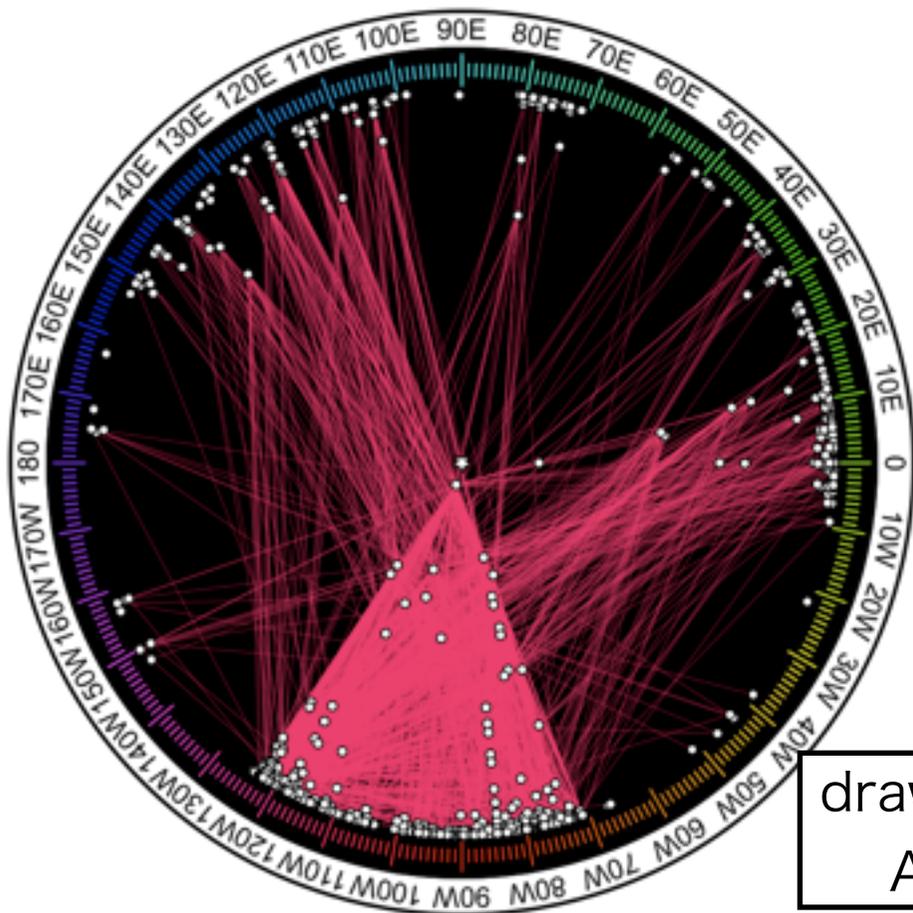
Blue Asia, Oceania

Green Europe, Africa

Red US

Node: AS

Link: AS links

Comparing west coast with east coast in US

- In west coast area, Asian global ASes expand
- In east coast area, US AS to Asian AS peering are fewer than US AS to Euro AS peering, and Euro regional ASes expand directly in east coast area
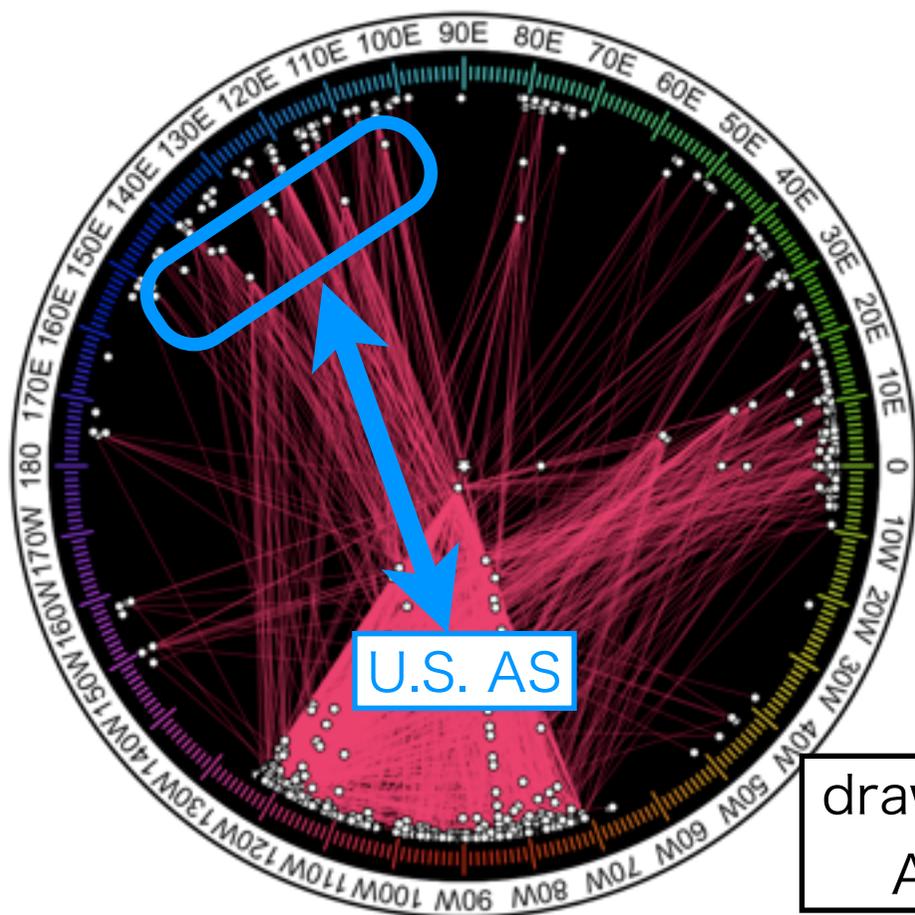

draw only US AS links

west coast area   east coast area

Comparing west coast with east coast in US

- In west coast area, Asian global ASes expand
- In east coast area, US AS to Asian AS peering are fewer than US AS to Euro AS peering,
  and Euro regional ASes expand directly in east coast area
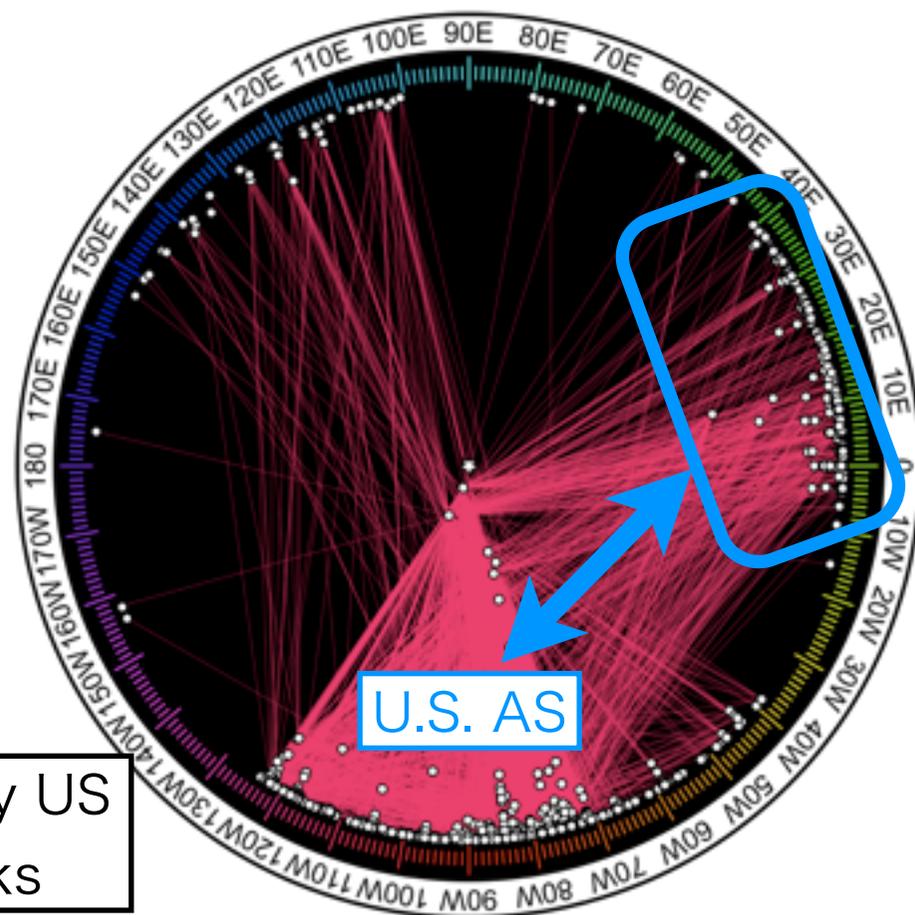

draw only US AS links

west coast area

east coast area

Comparison of 2004 and 2009 in Asia

Regional AS-rank in Asia (2004 vs 2009)

- ongoing analysis. the results are preliminary with many limitations

- topology data: skitter July 2004 and November 2009
- Many Asian countries had appeared at 2009 (RU, HK, TW, IN)

ASN	Name	
2914	NTT(VERIO)	US
2516	KDDI	JP
6461	Abovenet	US
3786	DACOMNET	KR
701	ALTERNET	US
3356	LEVEL3	US
2497	IIJ	JP
7473	SINGTEL	SG
7018	ATT	US
2500	WIDE	JP

2004/7

| ASN	Name	
3491	PCCWGlobal	US
10026	ASIA NETCOM	HK
2914	NTT(VERIO)	US
3216	Golden Telecom	RU
2516	KDDI	JP
9505	Chunghwa Telecom	TW
6453	TATA Communications	IN
4637	REACH	HK
3320	Deutsche Telekom	DE
3356	LEVEL3	US

2009/11

AS topology in Asia

- Blue line is AS links from Asian ASes
- 2004 to 2009
    - increase interconnect in each Asian ASes
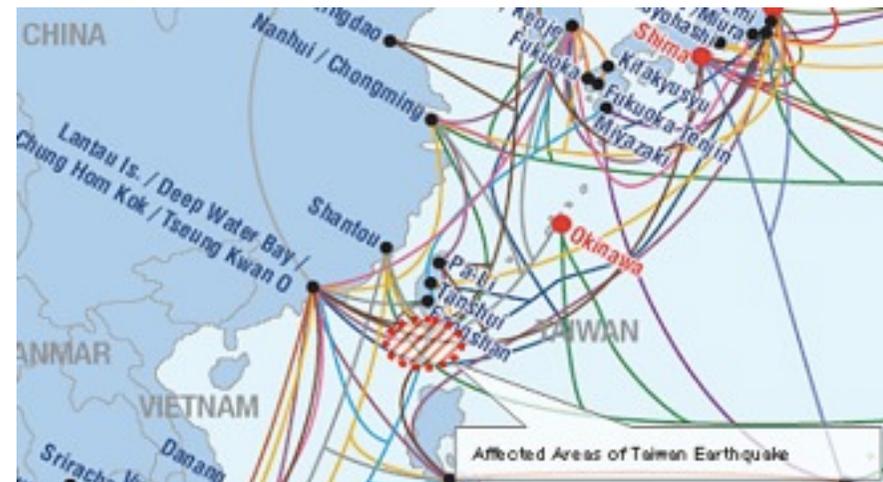   - Russian AS is bigger in Asia
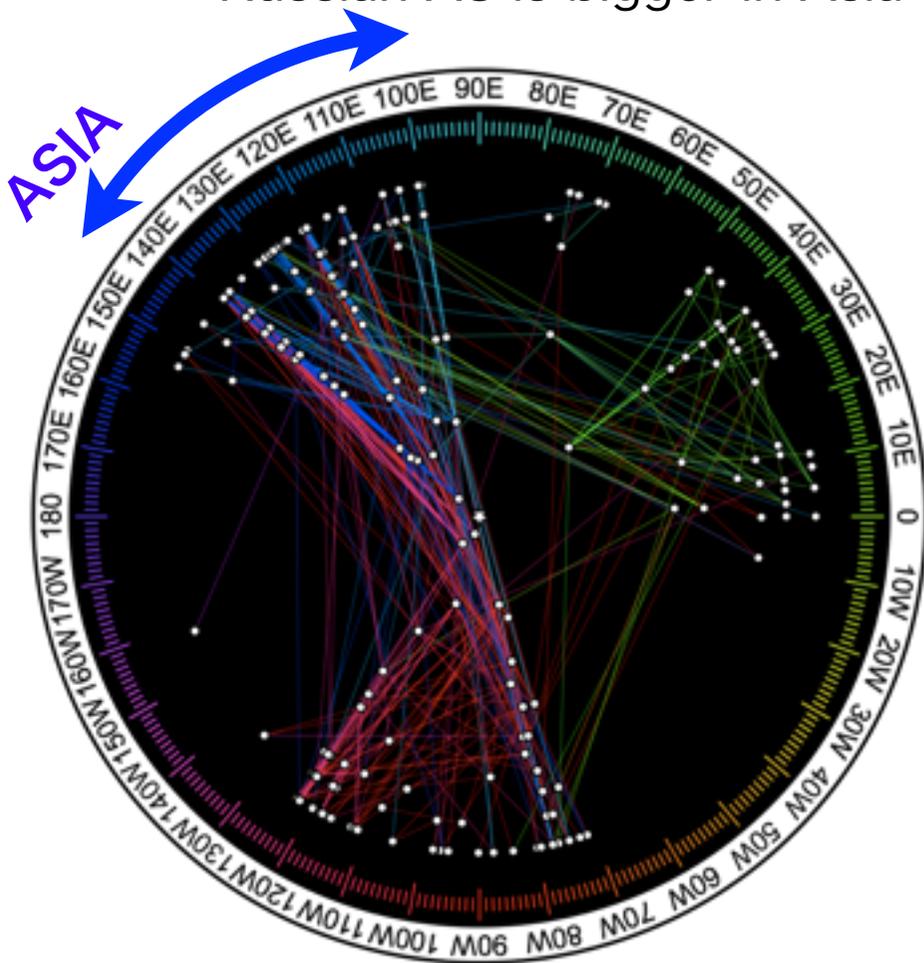
2004/7

2009/11

Conclusion and future work
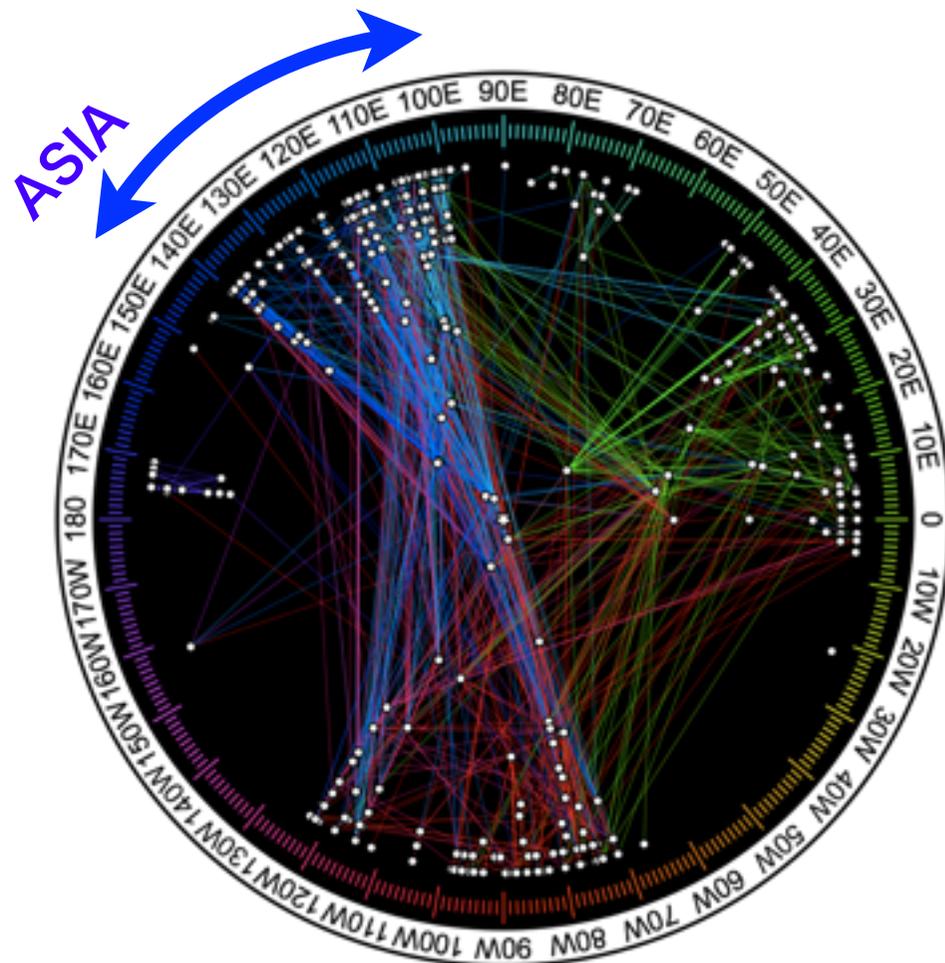
- Conclusion
  - Proposed methods for inferring regional AS topologies
  - From the results,
    - The distributions of regional AS out-degrees follow power-law
    - Many Asian AS had appeared among 2004 to 2009 (RU, HK, TW, IN)
- Future work
  - evaluation plan
    - can't compare this result and actual answer
    - to compare missing AS links at 2006/12 and 2007/1 in Asia
      - check the impact of Taiwan earthquake
    - to compare with academic networks

December 26, 2006   https://www.ntt.com/taiwan/0104-e.html

Thank you