

# Quaking Tables:

## The Taiwan Earthquakes and the Internet Routing Table

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# Overview

- Large earthquakes hit Luzon Strait, south of Taiwan on 26 December 2006
- Seven of nine cables passing through the straight were severed
- We review the event from a perspective of the Internet Routing tables
  - Routing outages occurred, significant congestion was reported, instability persisted
  - Recovery was delayed and uneven

# Submarine cables in East Asia



- Two of nine cables **not** impacted:
  - Asia Netcom's EAC
  - Guam-Philippines
- No cables have been repaired as of January 16<sup>th</sup> (source: telecomweb.com)
- Complete repairs: Sometime in February?

# Repairing submarine cables is difficult!

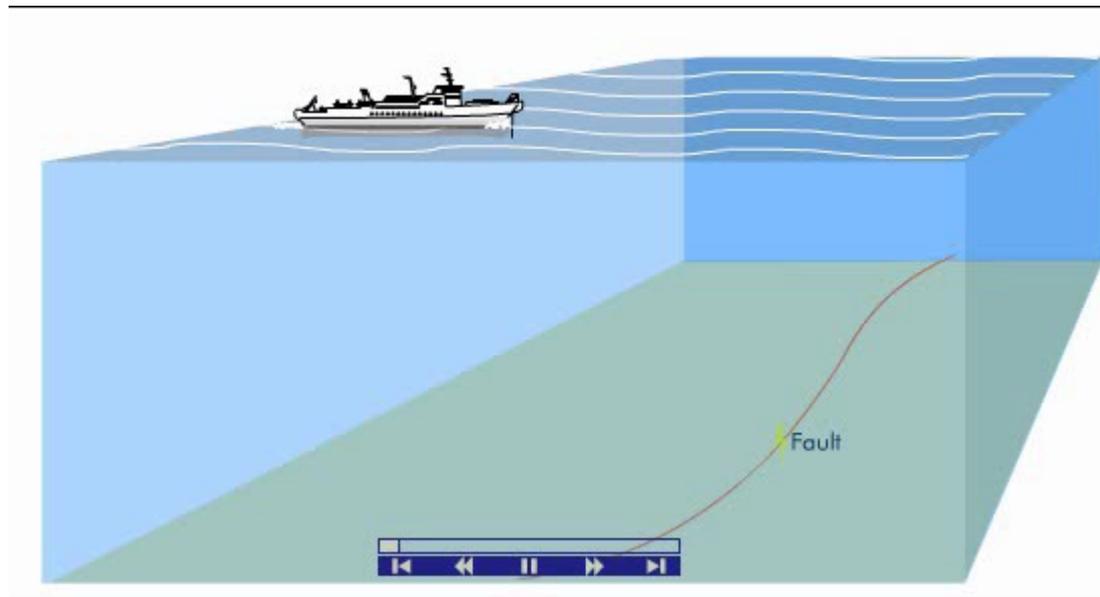


Image credit: Alcatel

# Definitions: Outage, unreachable, unstable

- A **network outage** occurs when routes to the network are withdrawn by a large number of BGP routers worldwide.
- In this case if no less specific route is available, the network is **unreachable** and effectively disconnected from all or parts of the Internet.
- **Unstable networks** are not completely disconnected, but show frequent changes in network routing paths or alternating announcements and withdrawals (**route flapping**) – serious packet losses.

# Timeline

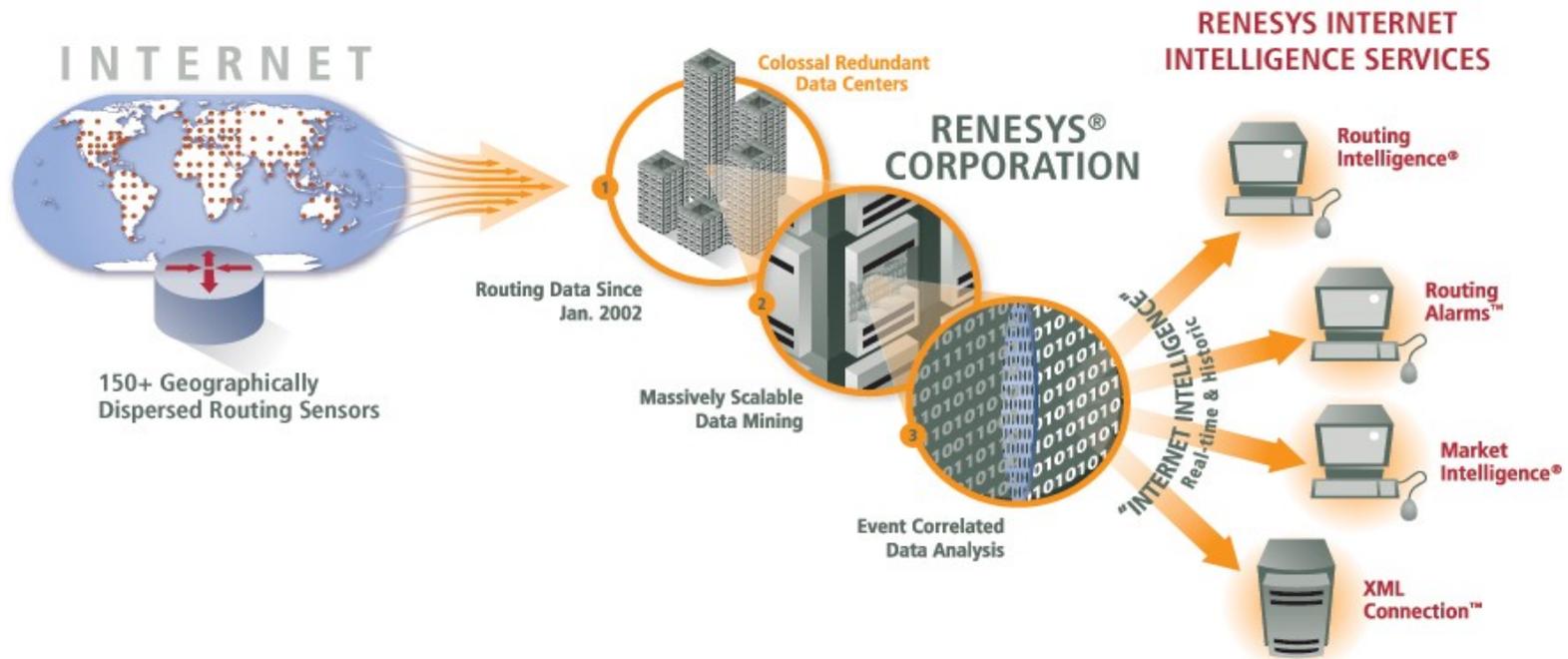
- Six earthquakes of magnitude 5.0 or higher hit the Taiwan region (all times UTC):
  - **12/26 12:26:21**                      **7.1** -- main quake
  - 12/26 12:34:14                      6.9
  - 12/26 12:40:22                      5.5
  - 12/26 15:41:44                      5.4
  - 12/26 17:35:10                      5.4
  - 12/27 02:30:39                      5.6
  - 12/28 16:51:16                      4.4
- Outaged prefixes ramp up from 400 to almost 1200 from the first quake through seventh

# Timeline (2)

- 03:31 27 Dec 2006: 60 mins after the last quake, outaged network count spikes to 4k
- The “spike” is short-lived (< 2 hrs) but > 2k prefixes out for 6 hours.
- 31 Dec 2006 12:00: Outages return to pre-quake levels.
- Instability level remains high into January.

# Data Collection Infrastructure

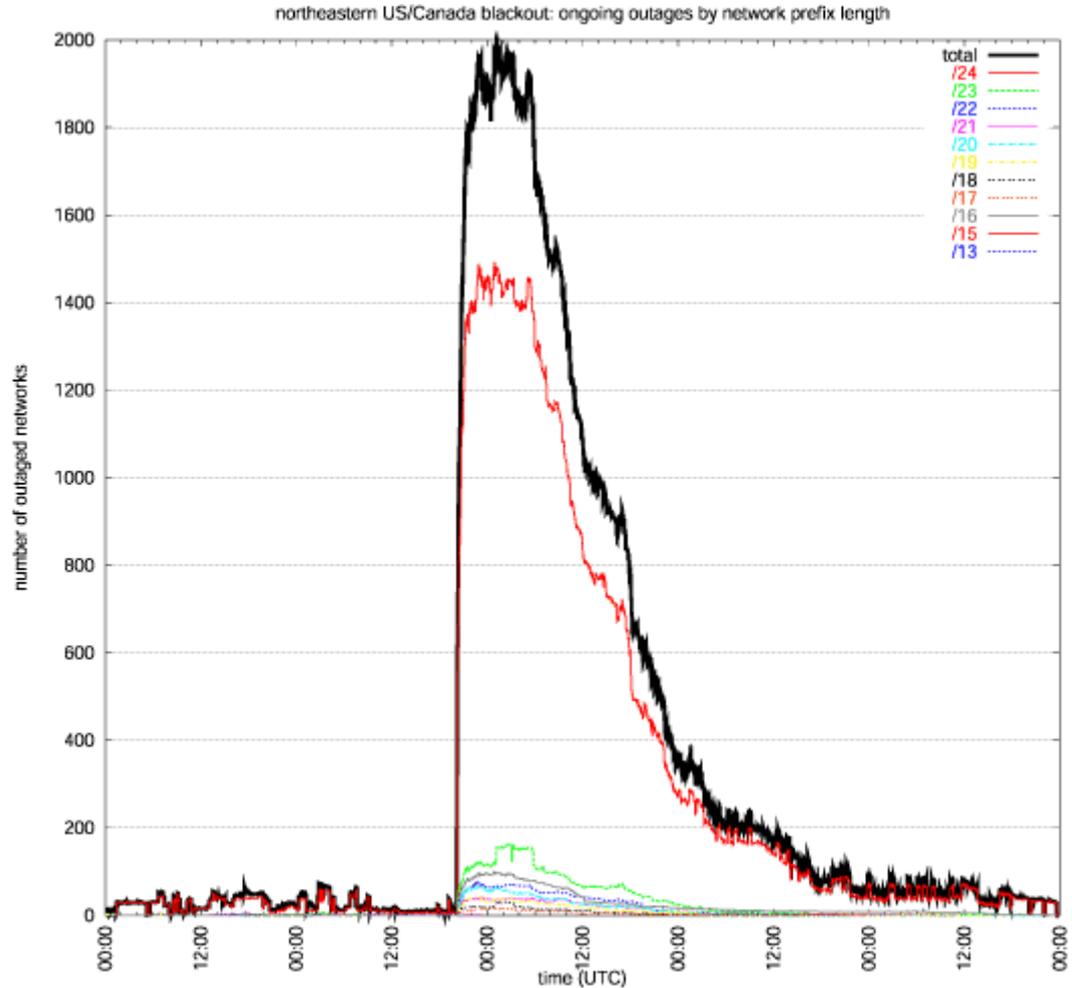
- 165+ peering sessions from 105+ different ASNs
- In this talk, we focus on East Asian prefixes only



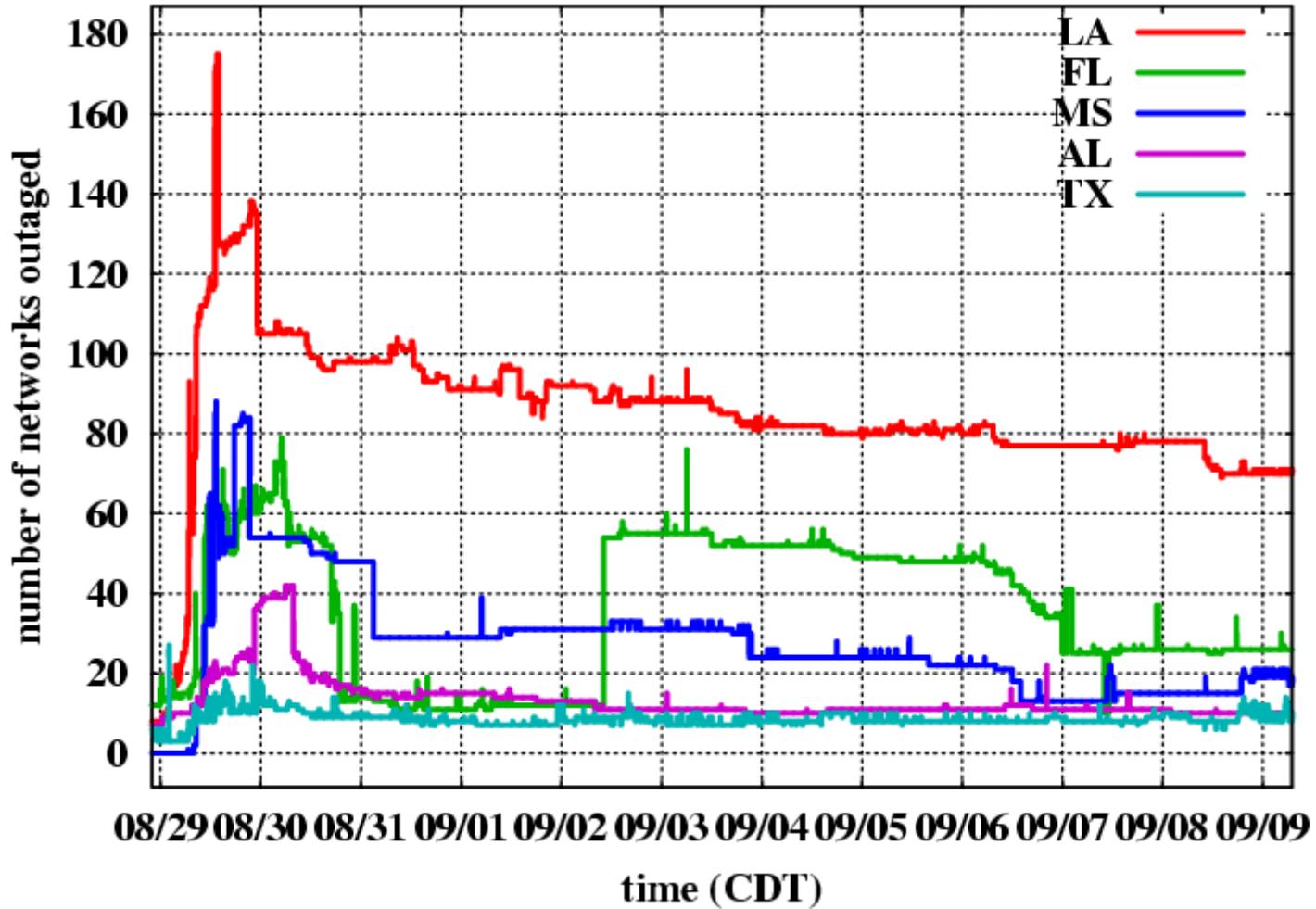
# •Disasters Have Signatures

- Sharp onset associated with some real-world event
- Slow return to baseline
  - Varies considerably
  - Power outages: fast
  - Major natural disasters, **much** slower
- Noise in the recovery (not in the onset)

# •Power (Northeast US, 2003)



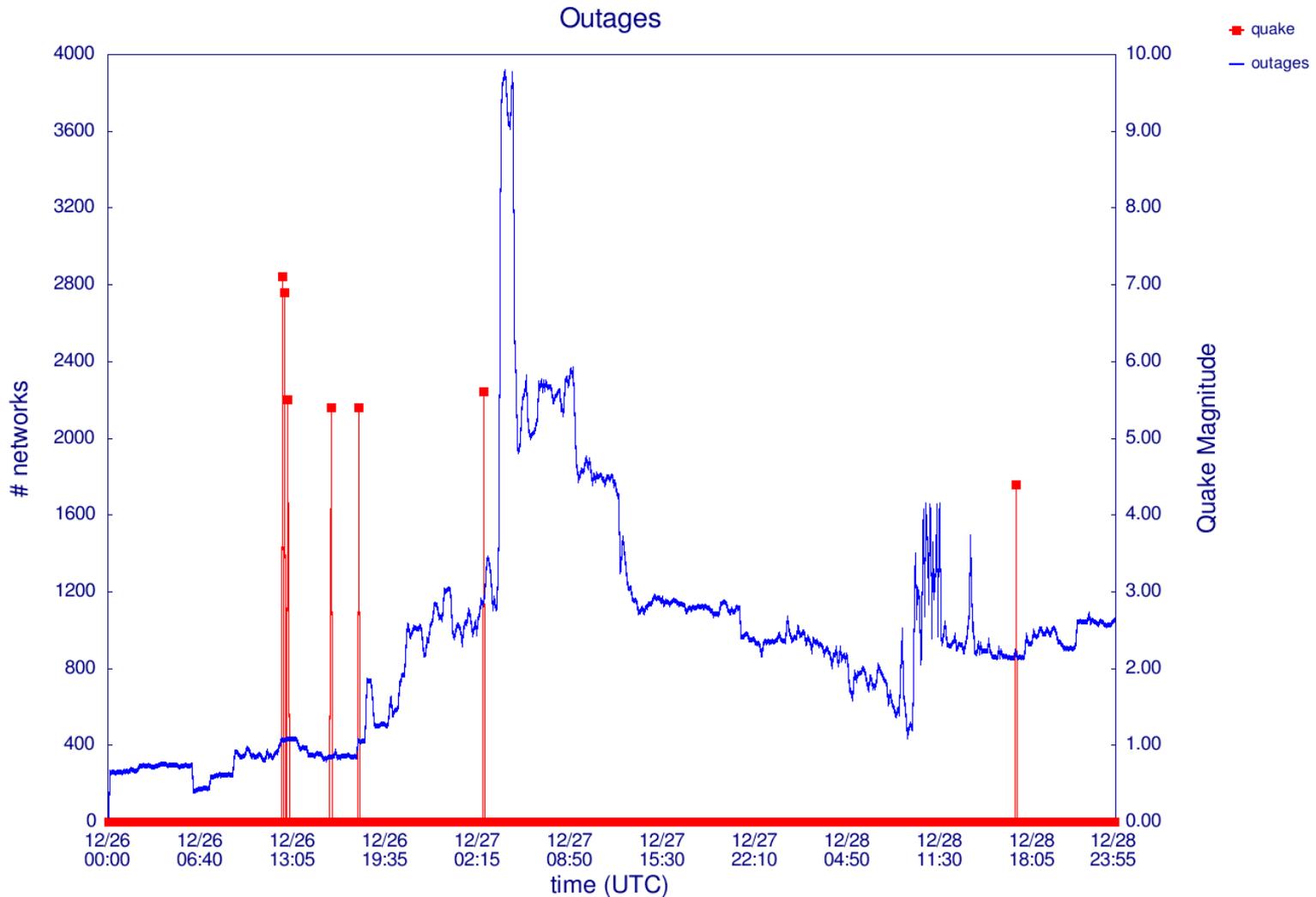
# •Hurricane (Katrina, 2005)



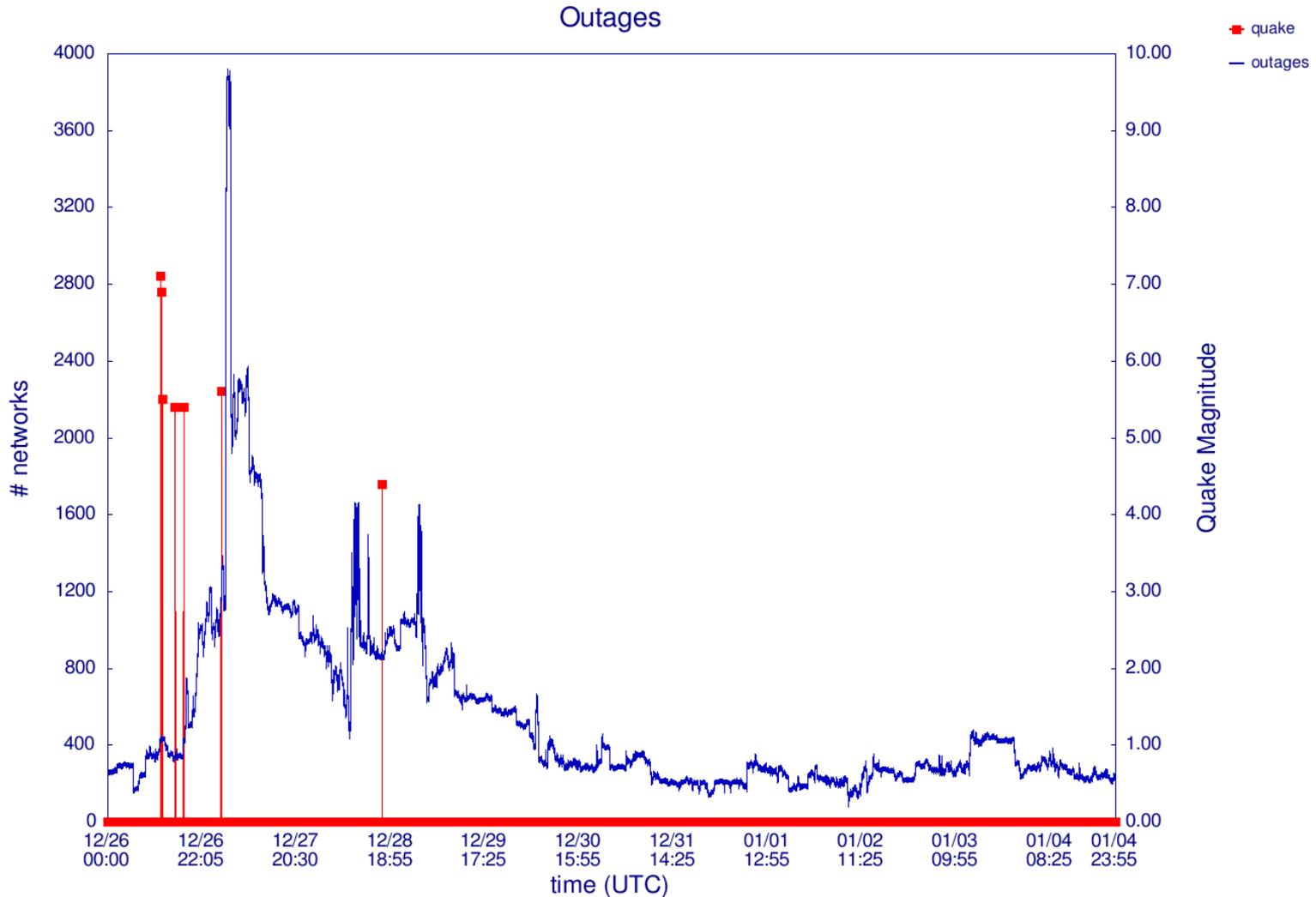
# The Pattern of the Taiwan Quakes

- Ramping up outages and spikes in instabilities
- Gradual increase in number of outages after major quake in Dec. 26
- Big spike in outages/unstables associated with smaller quake on Dec. 27
- Recovery typically noisy
- Pattern was probably affected by the number of different cable systems involved – this is not really one event but at least seven.

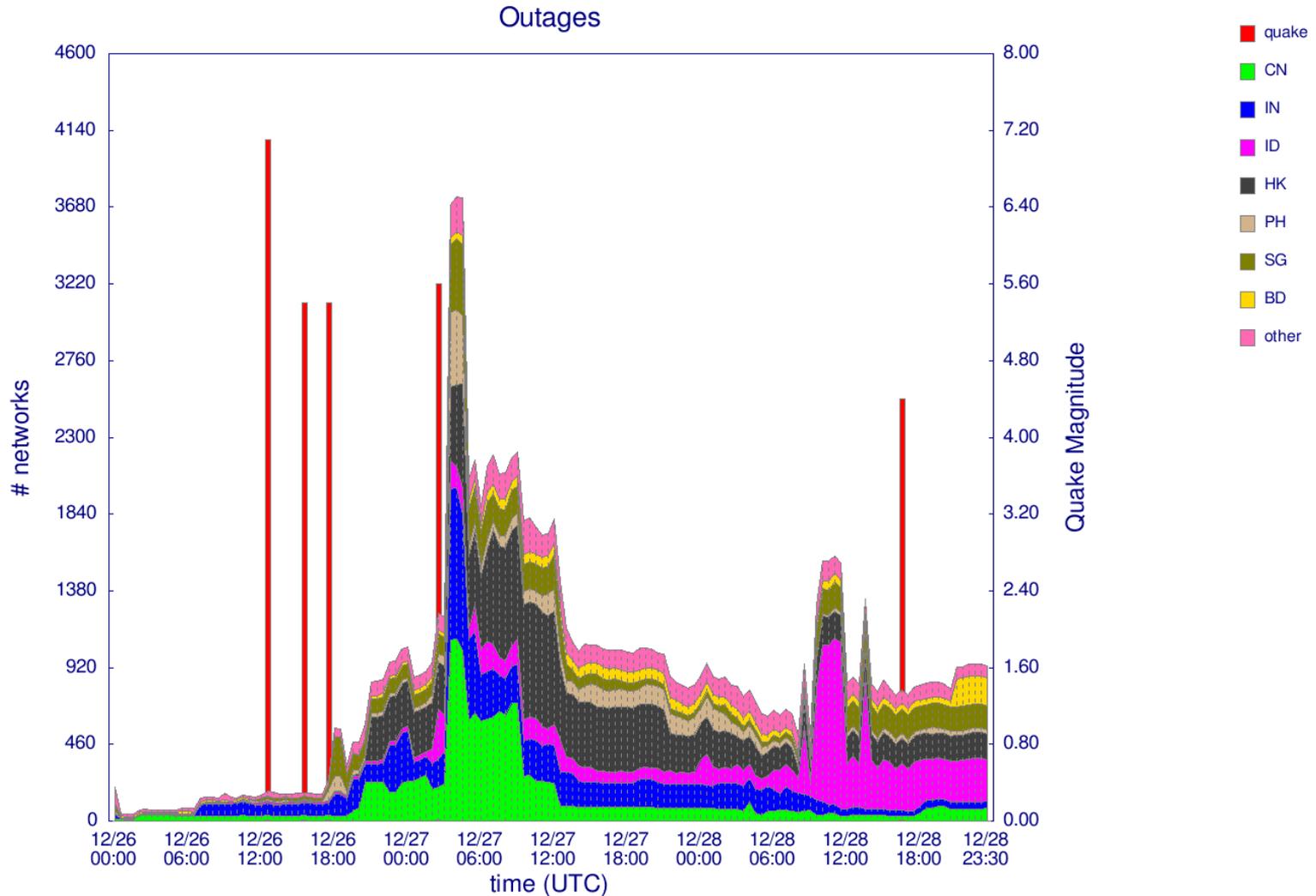
# • Outages & Quakes – 3 Day



# • Outages & Quakes – 10 Day



# • Outages by Country – 3 Day



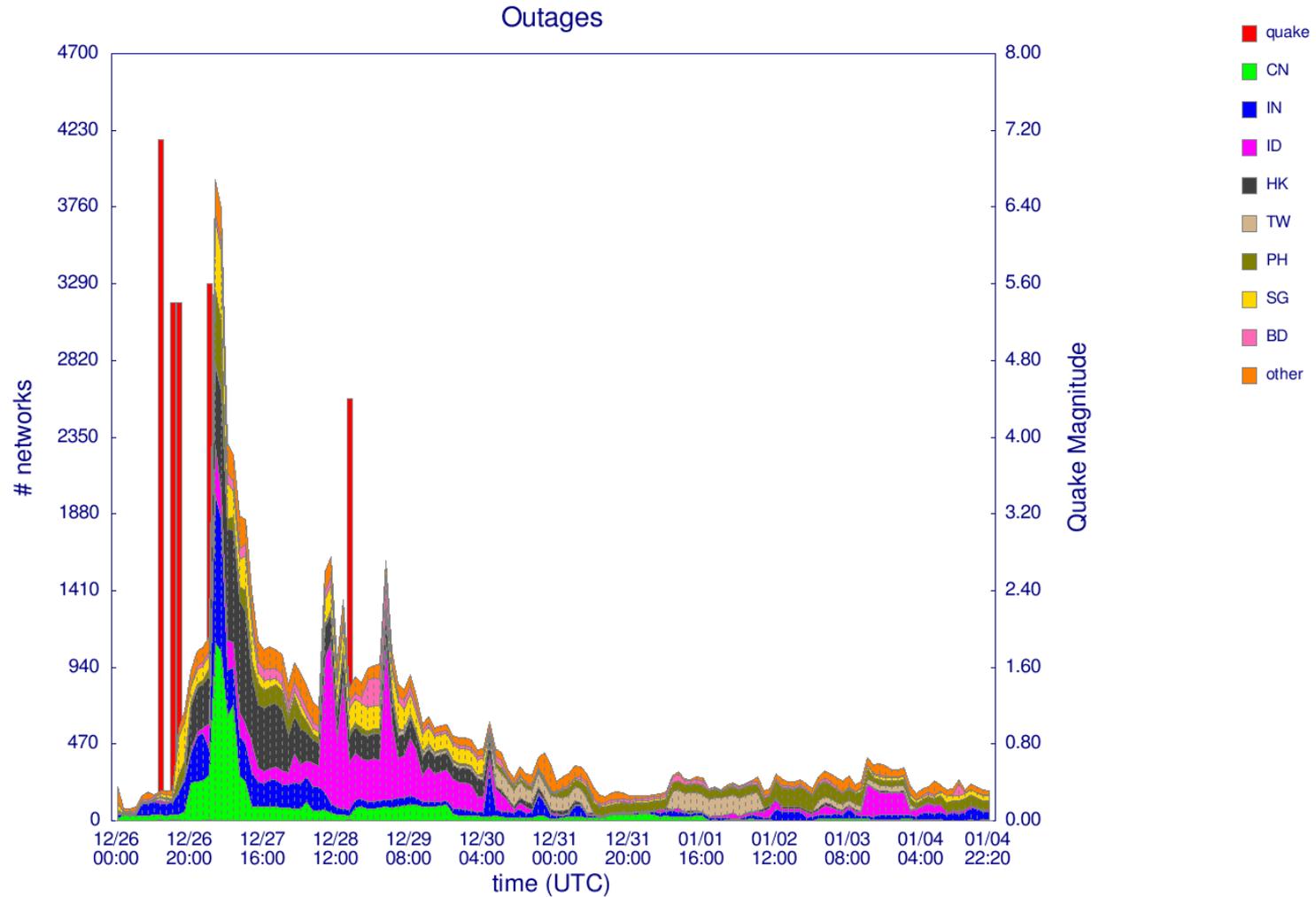
# Why India?

*Major subcontinent bandwidth heads East*

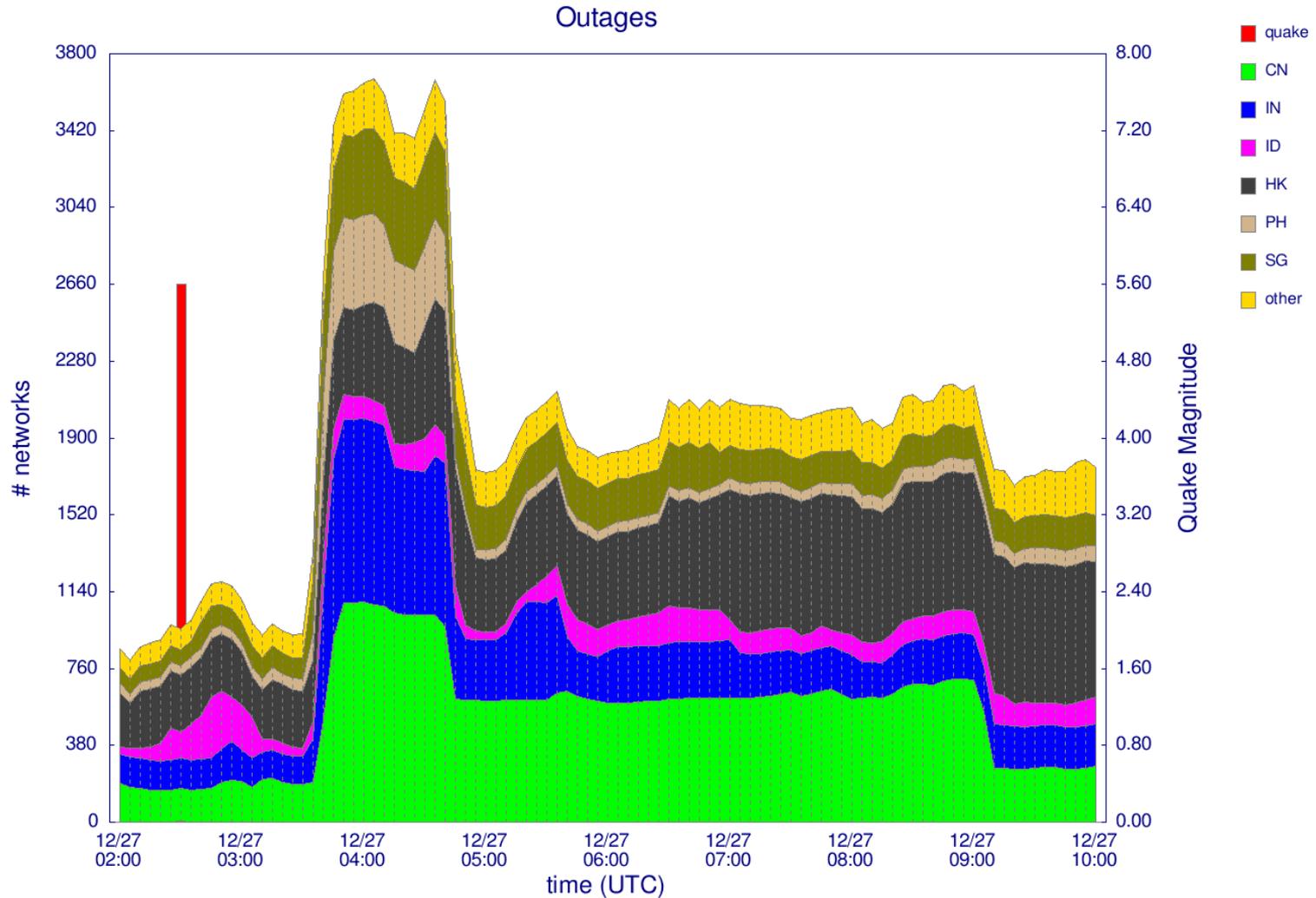


Image credit: Asia Netcom

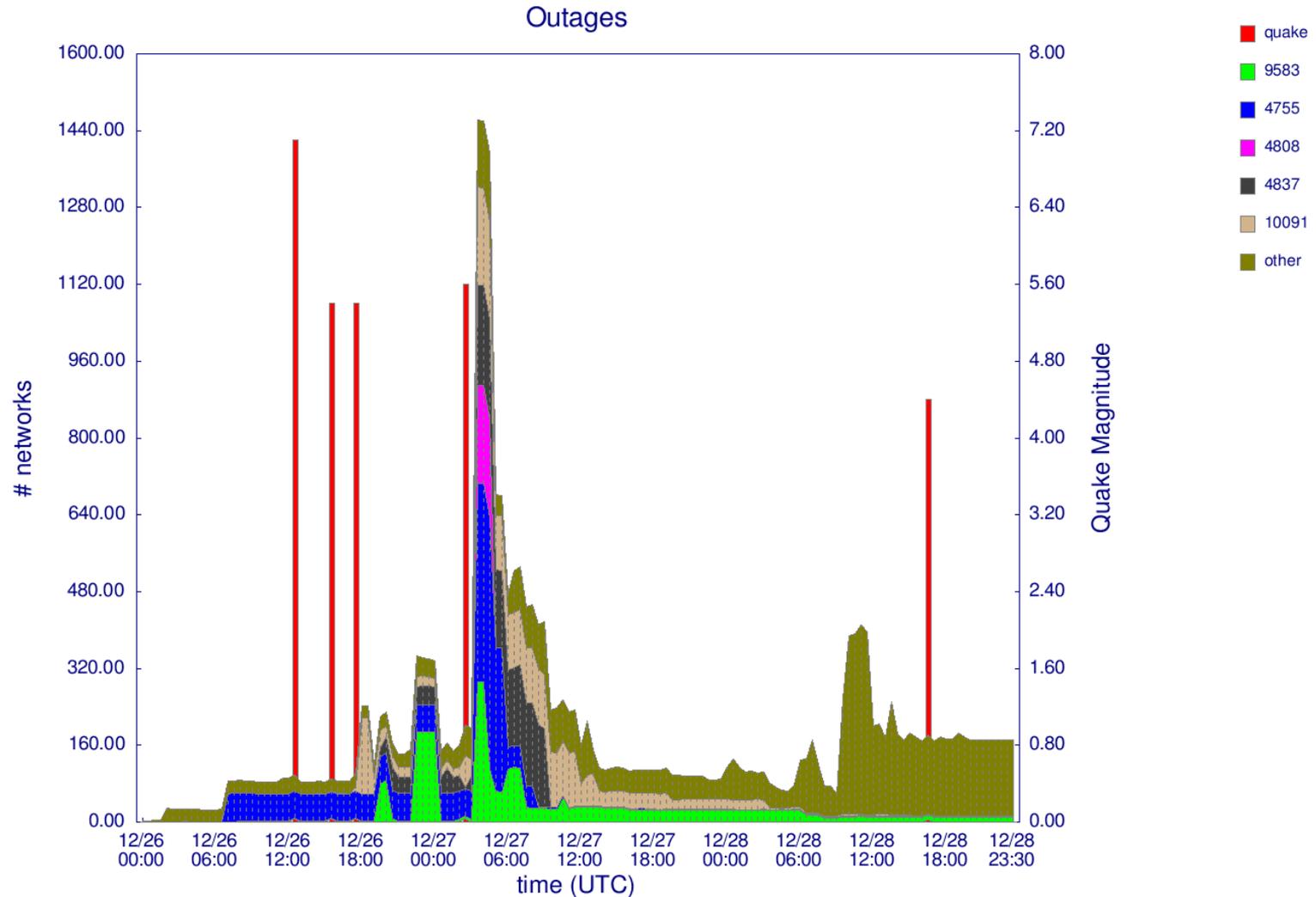
# • Outages by Country – 10 Day



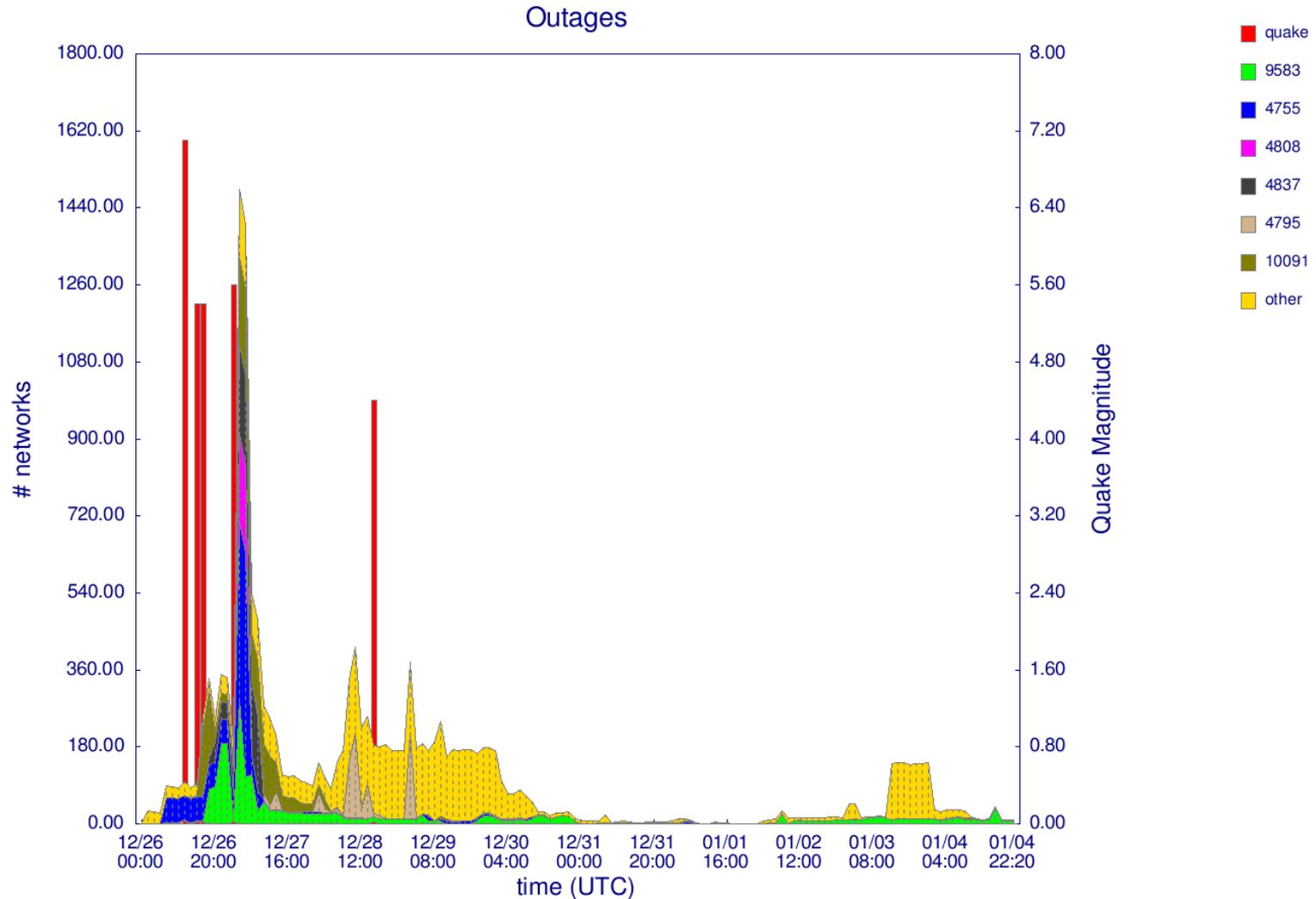
# • Outages by Country – Peak



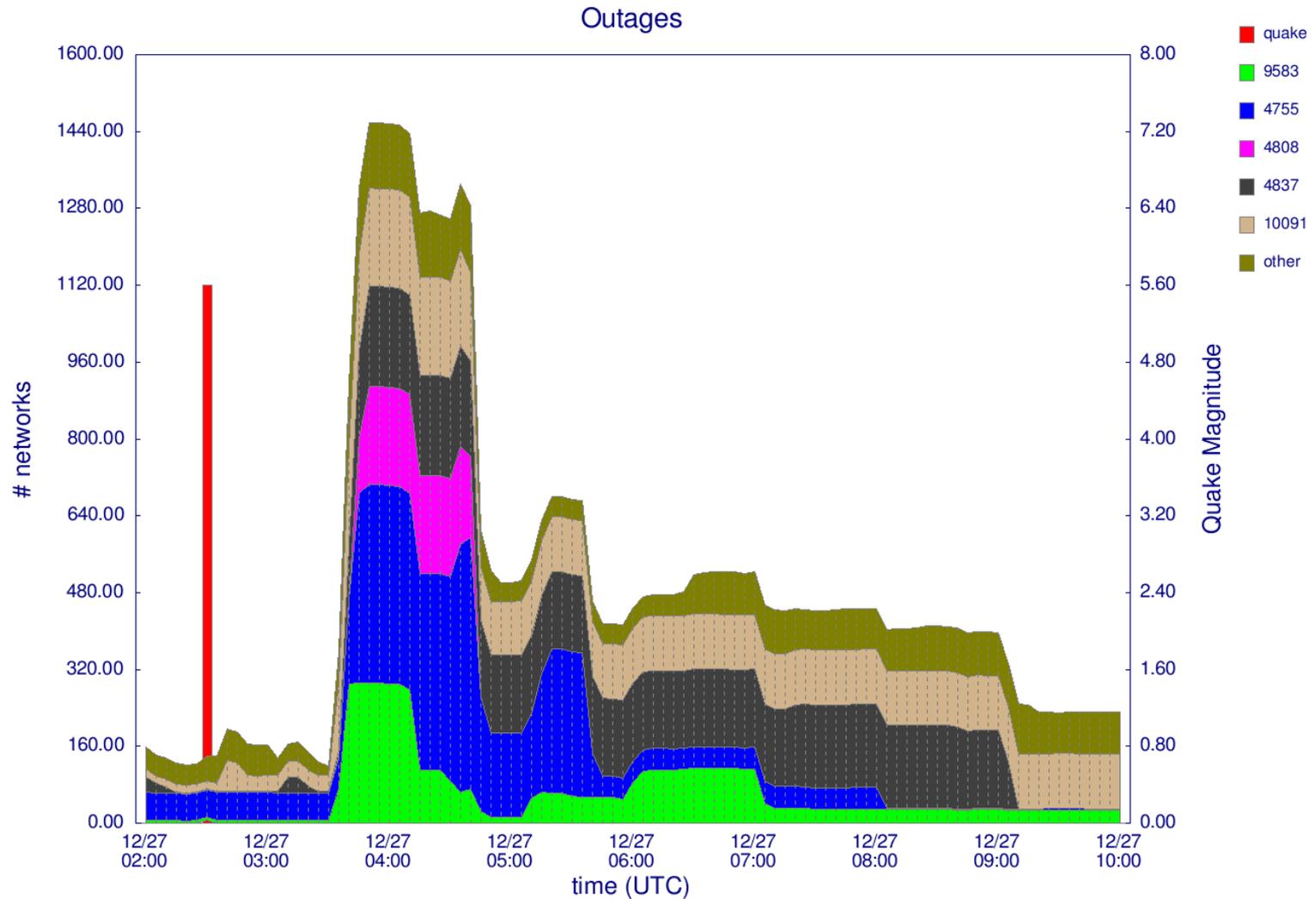
# Outages by Origin ASN – 3 day



# Outage by Origin ASN – 10 day



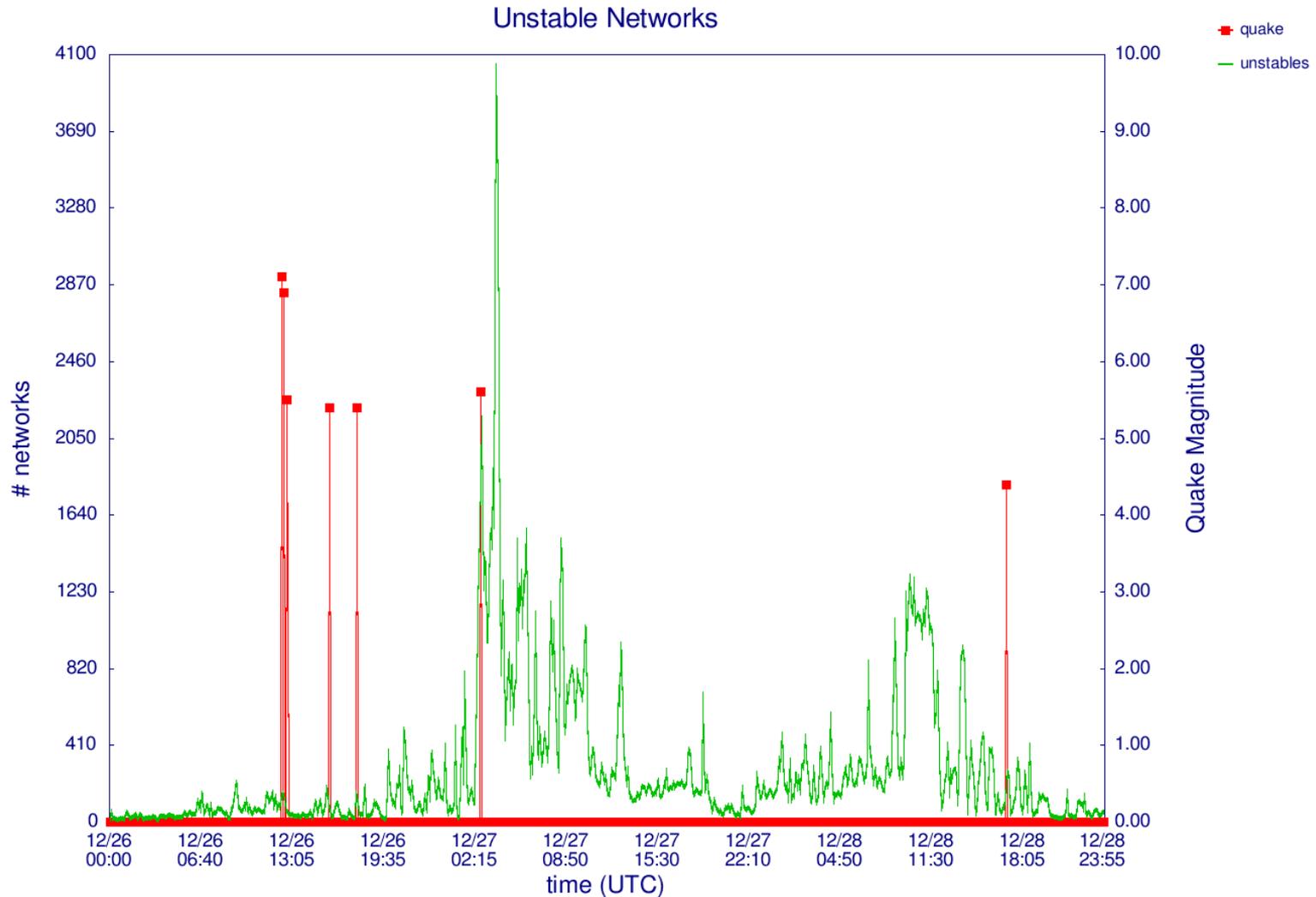
# Outages by Origin ASN – Peak



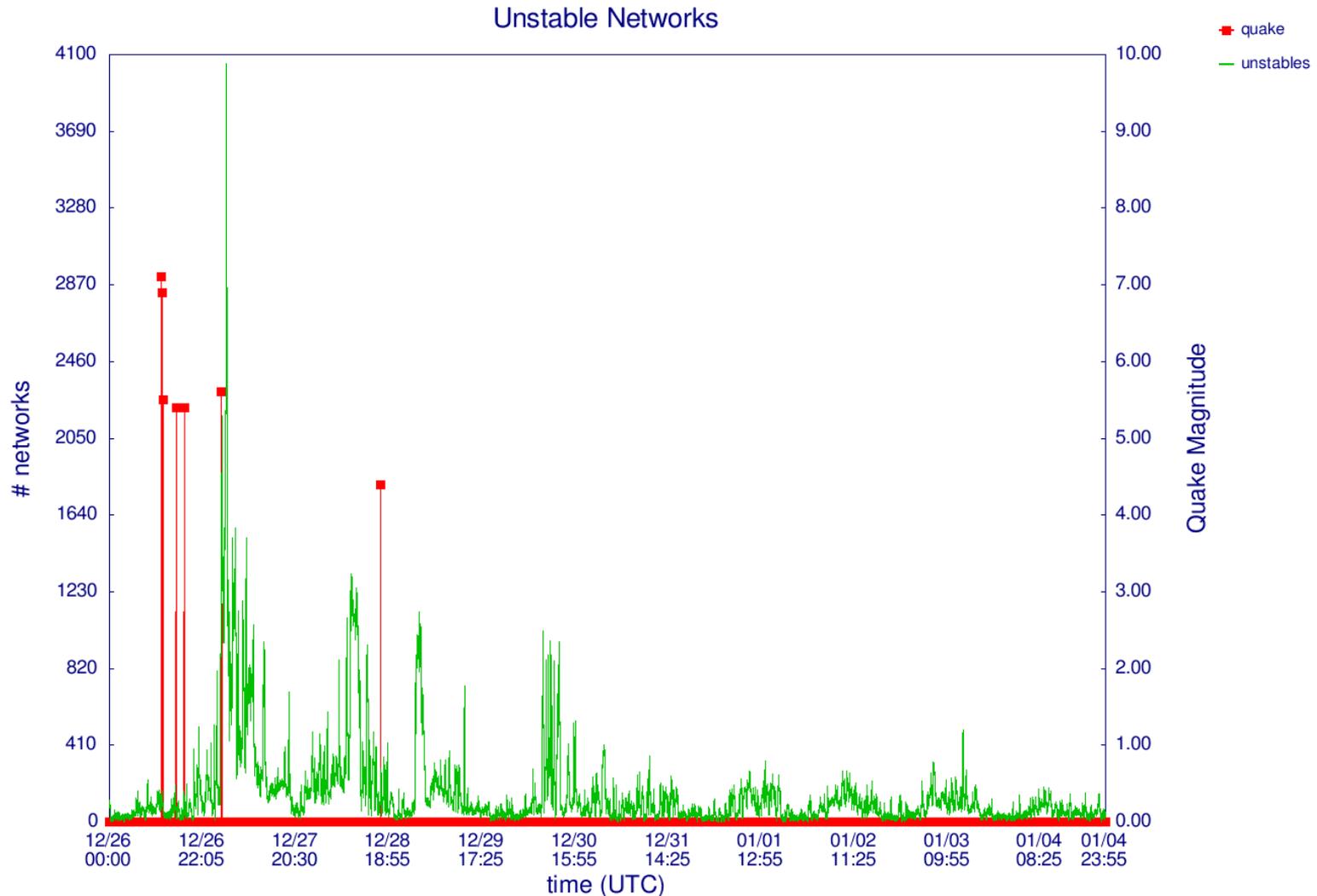
# • Instability Metrics

- Use algorithm described in <http://www.nanog.org/mtg-0402/ogielski.html>
- $\text{PenaltyBox}(T, K, H, C)$ : the number of globally routable prefixes at time  $T$  that have flap penalty  $K$ , using the classic flap dampening algorithm with half-life of  $H$  and ceiling of  $C$ .
- Reasonable:  $H=600\text{s}$ ,  $C=15$ ,  $K=\{0, \dots, C\}$ .
- (Basically flap-dampening algorithm for scoring the “penalty” of a prefix).
- **Shown in graphs are pfxs w/ inst  $\geq 3$**

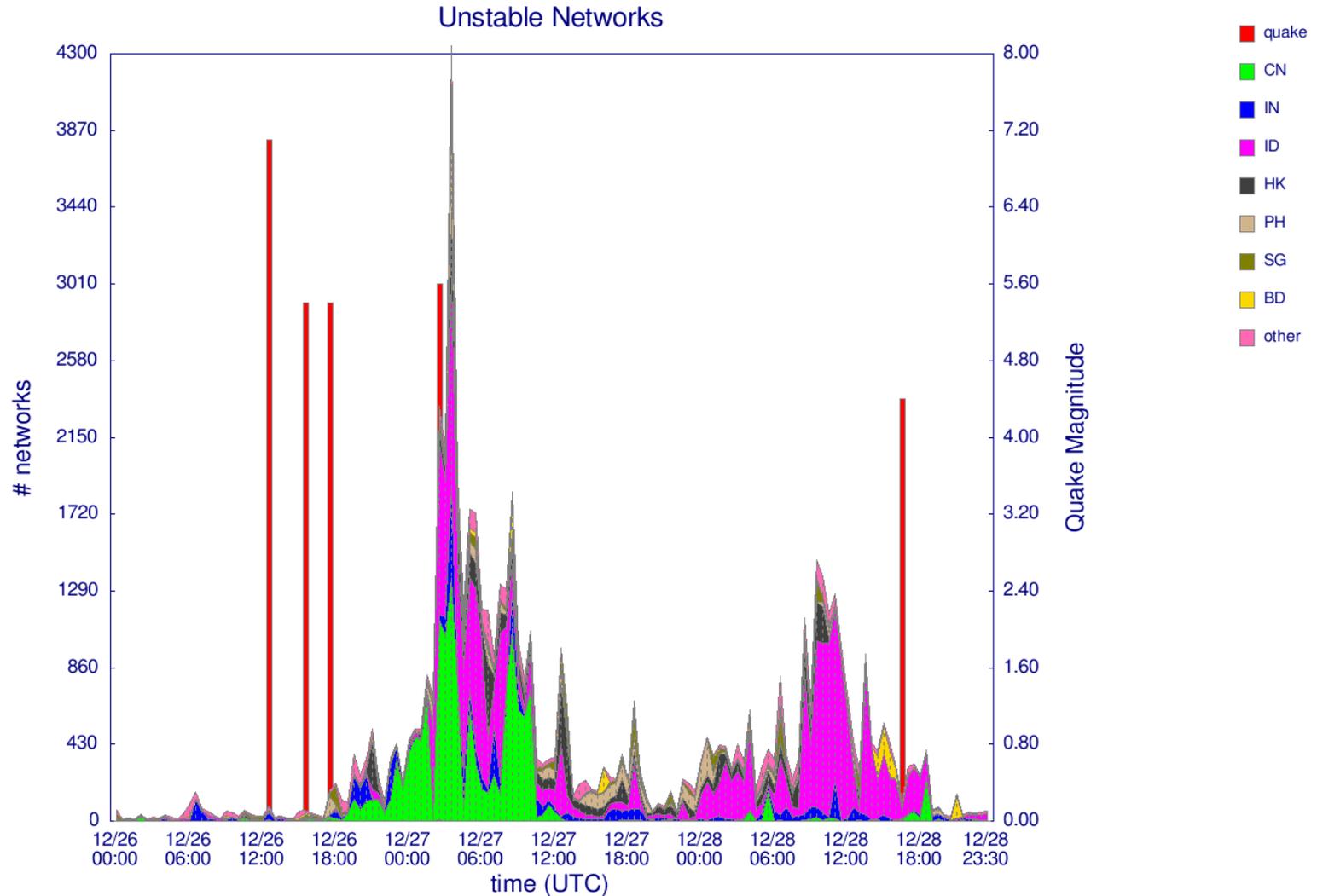
# •Unstables & Quakes – 3 Day



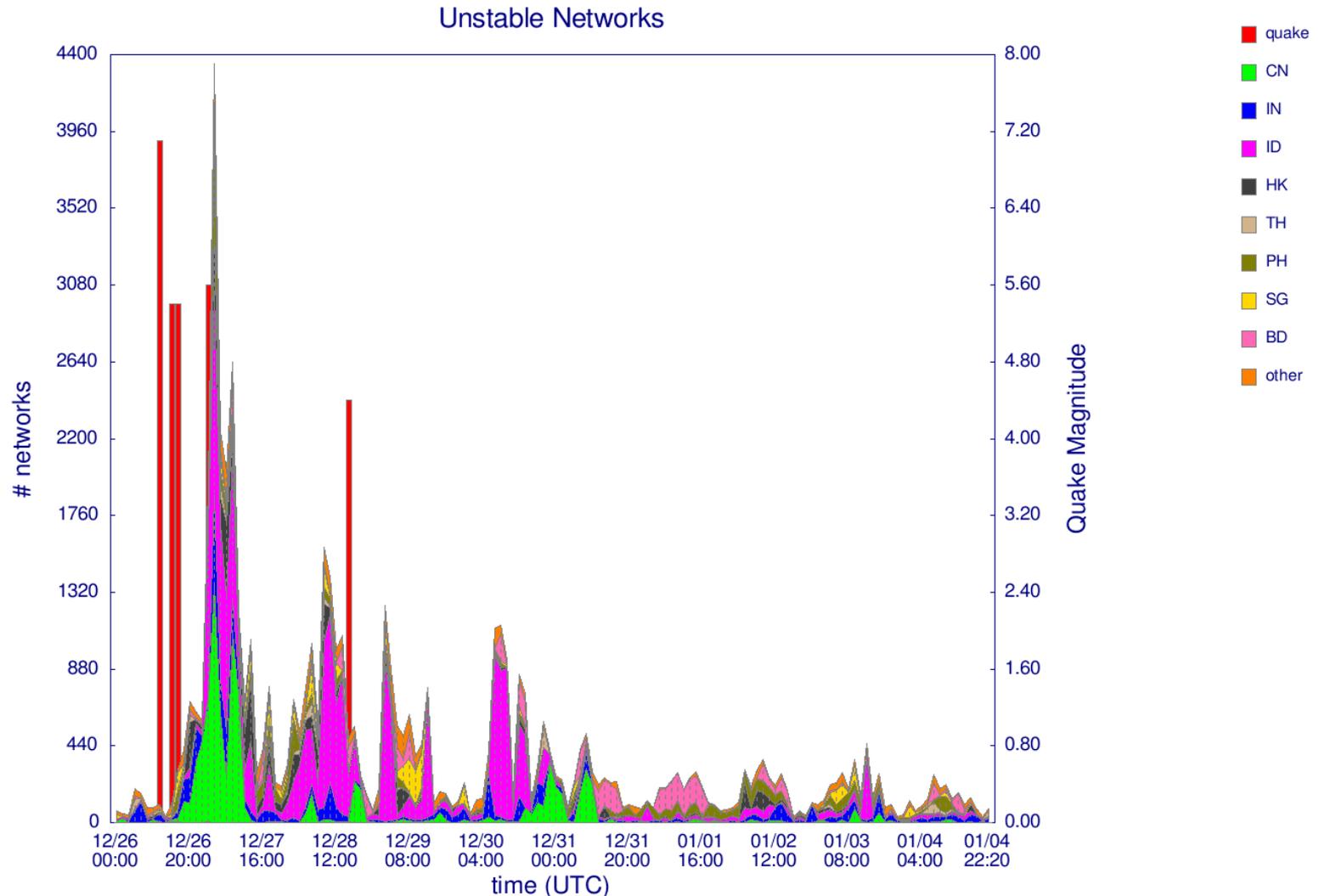
# •Unstables & Quakes – 10 Day



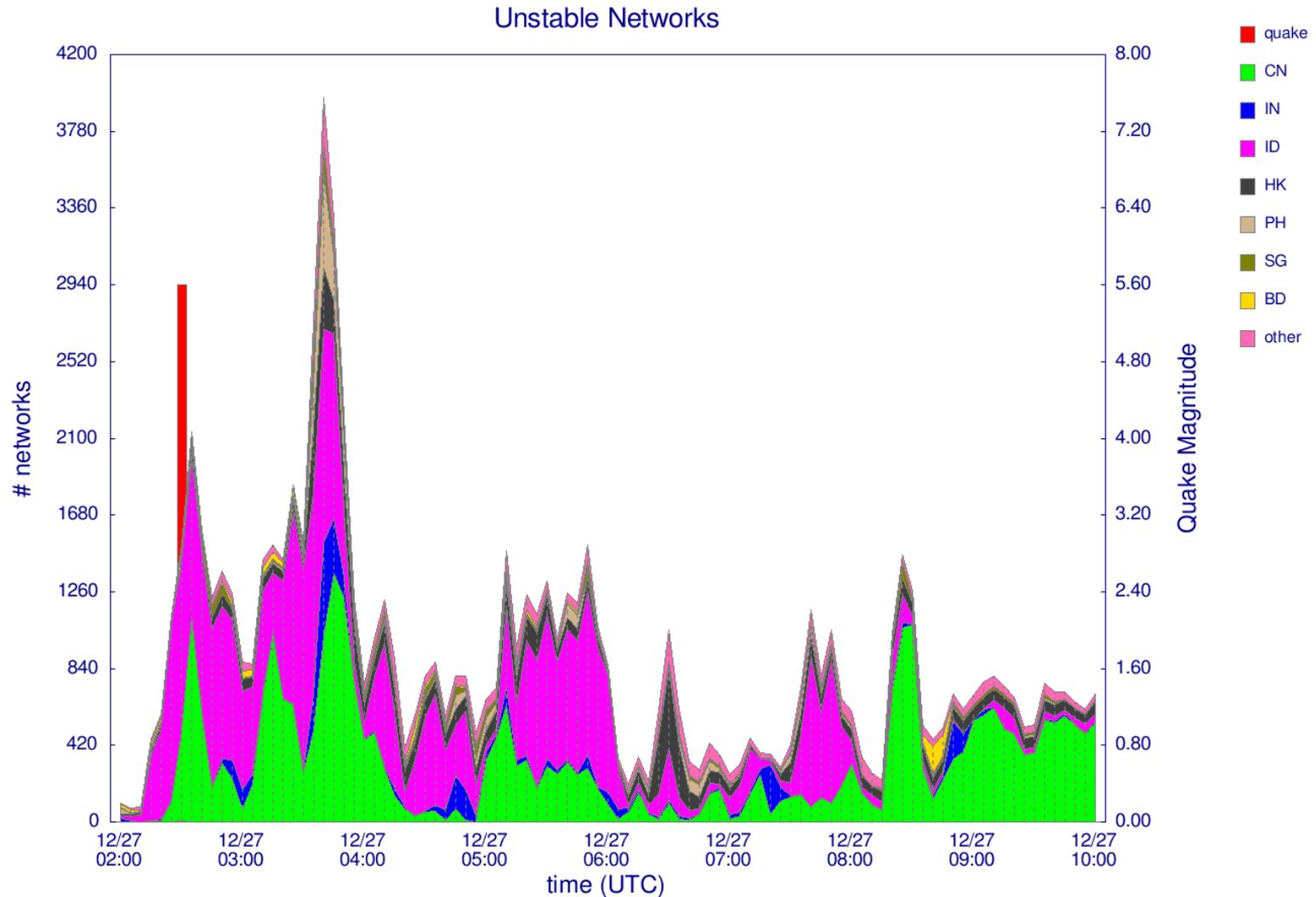
# •Unstables by Country – 3 Day



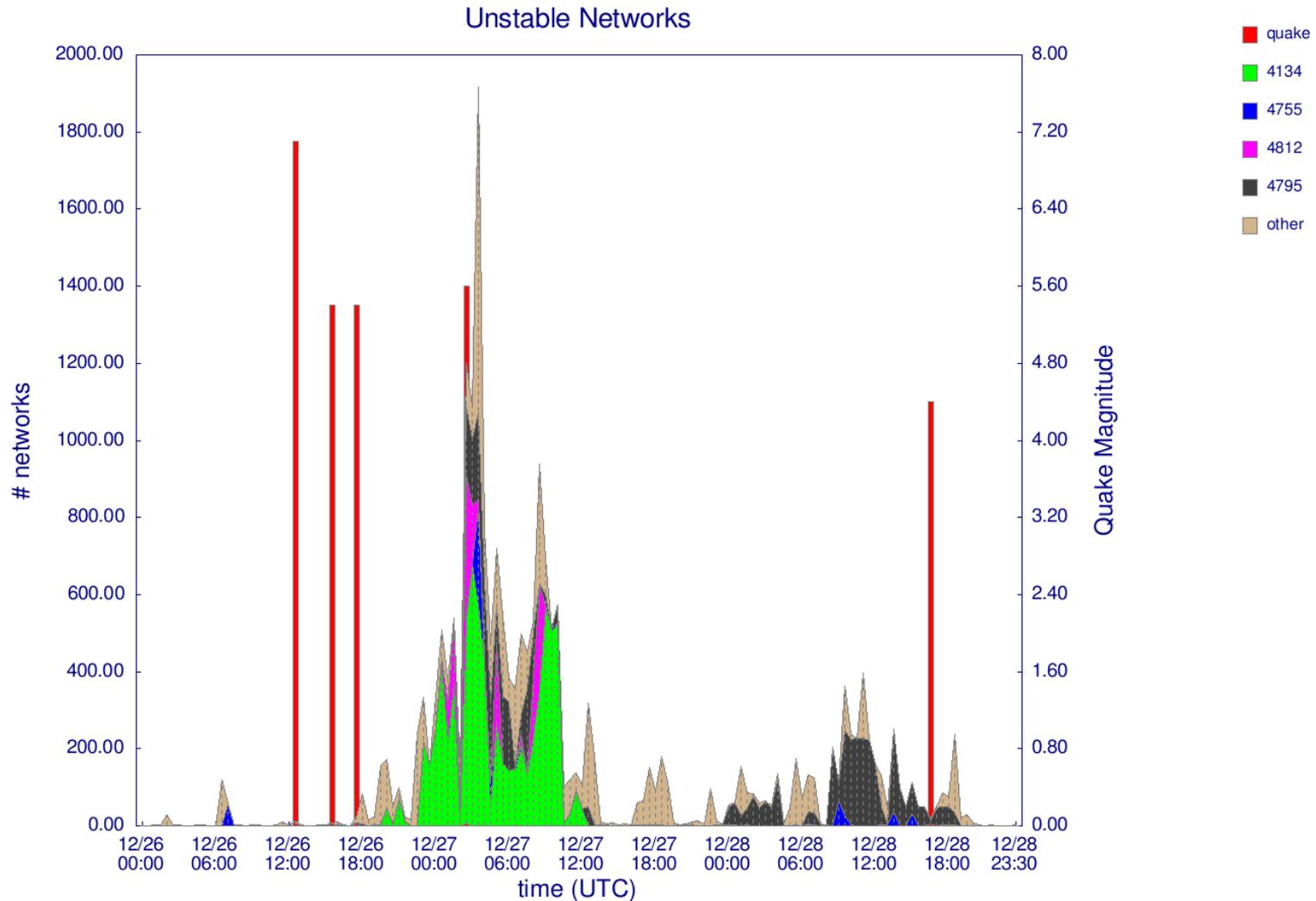
# •Unstables by Country – 10 Day



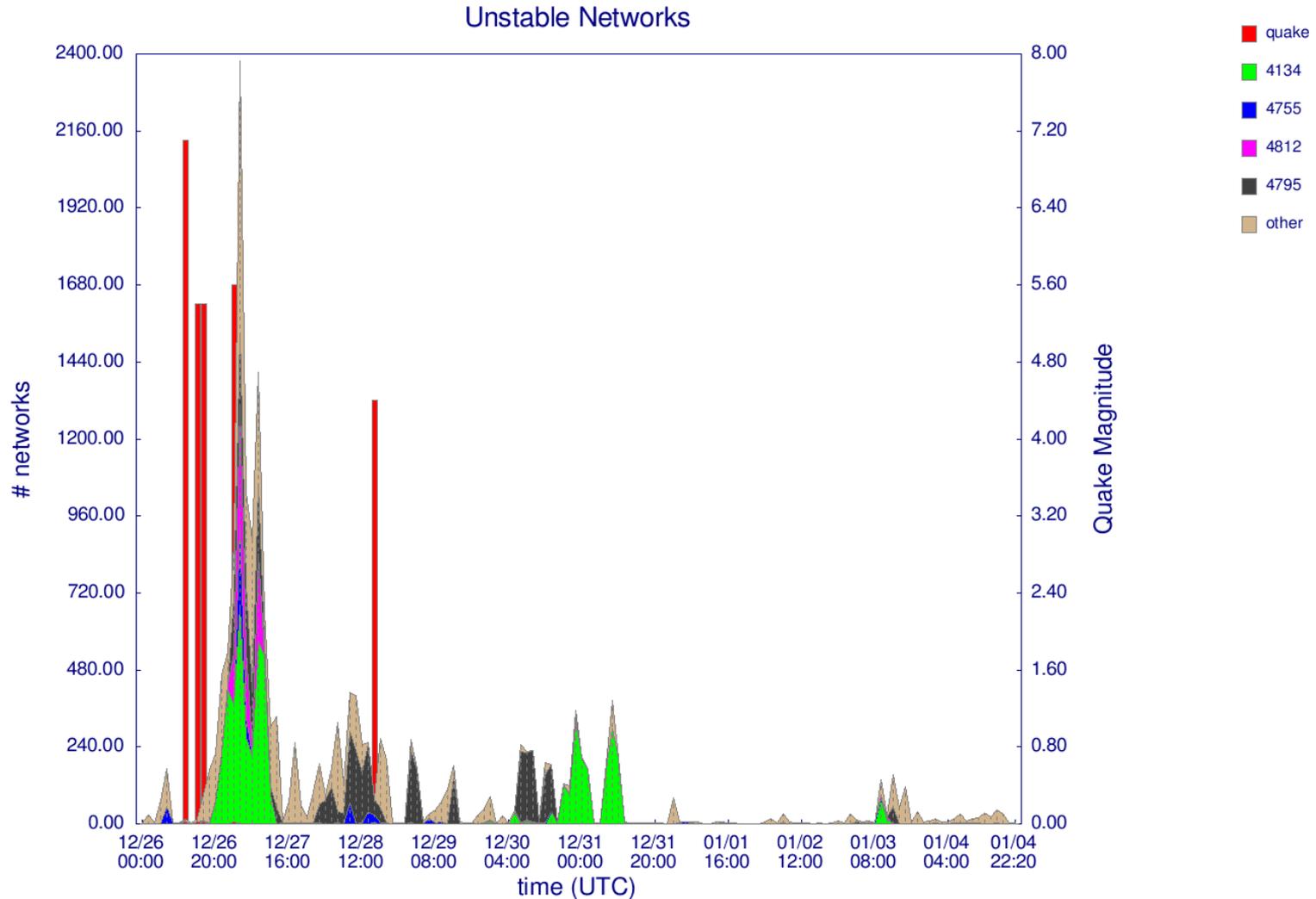
# •Unstables by Country – Peak



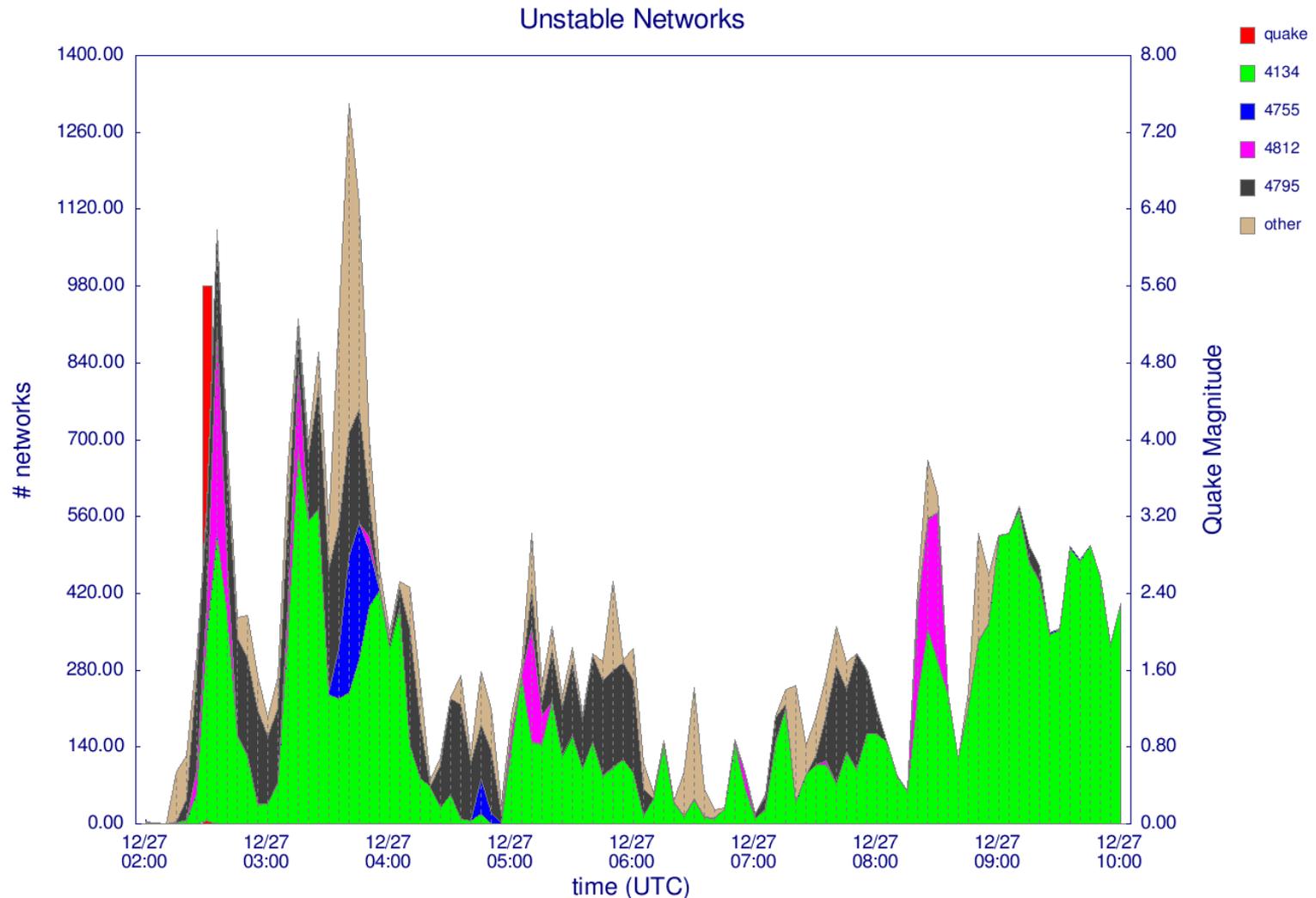
# Unstables by Origin ASN – 3 day



# Unstables by Origin ASN – 10 day



# Unstables by Origin ASN – Peak

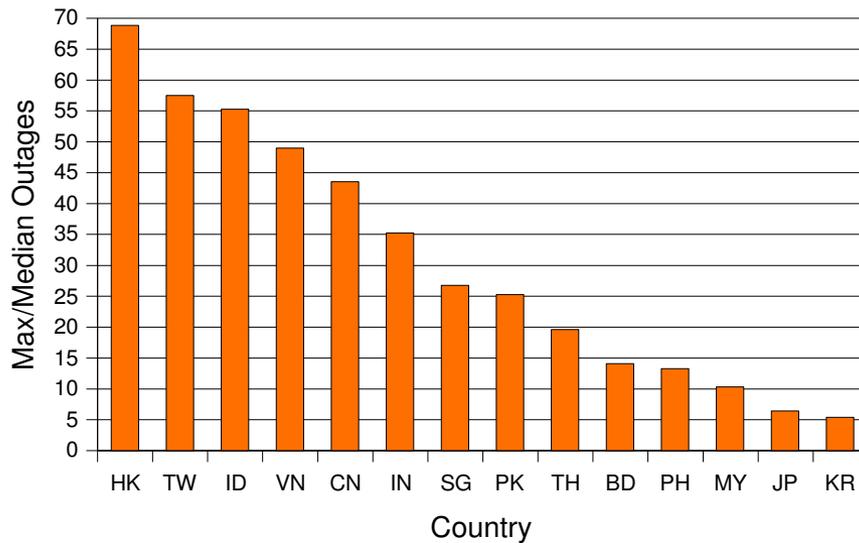


# •Winners & Losers: By Country

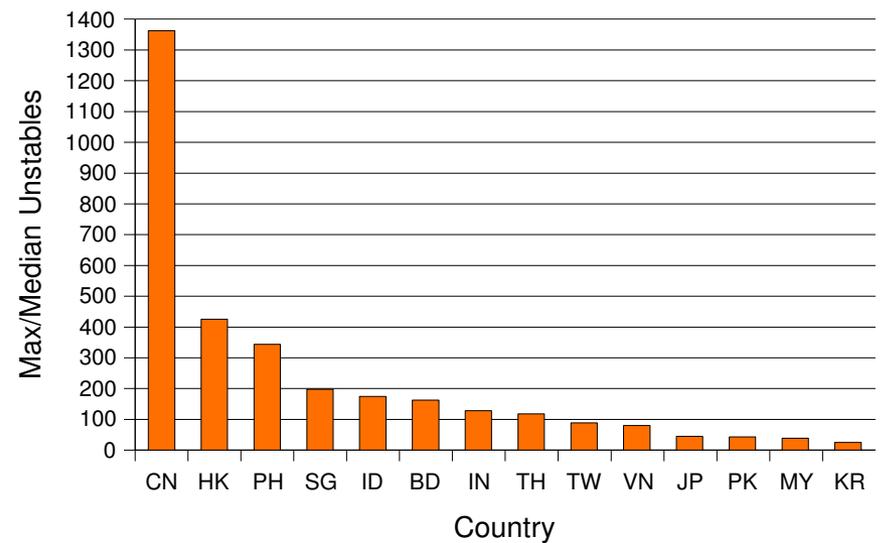
- Used maximum to median ratio of outages and unstable networks
- Worst Impacted:
  - China, Hong Kong
- Least Impacted:
  - Korea, Japan, Malaysia

# •Winners & Losers: By Country (cont'd)

## Max/Median Outages by Country



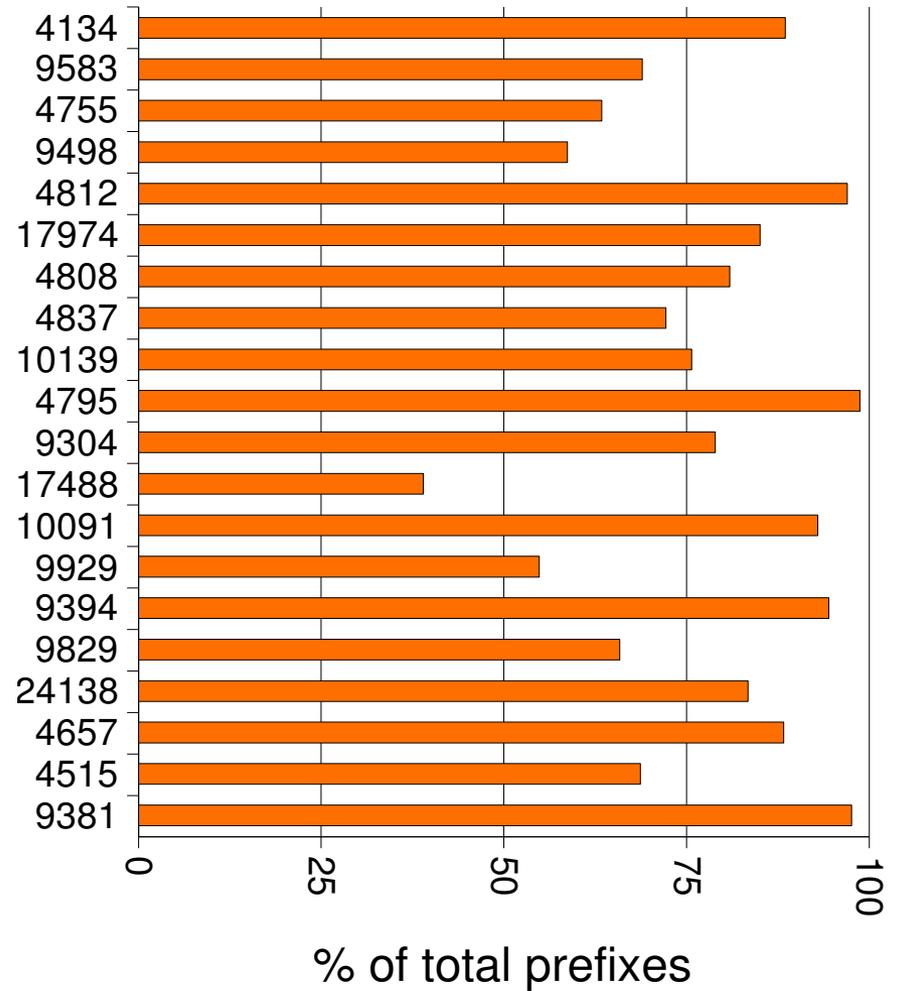
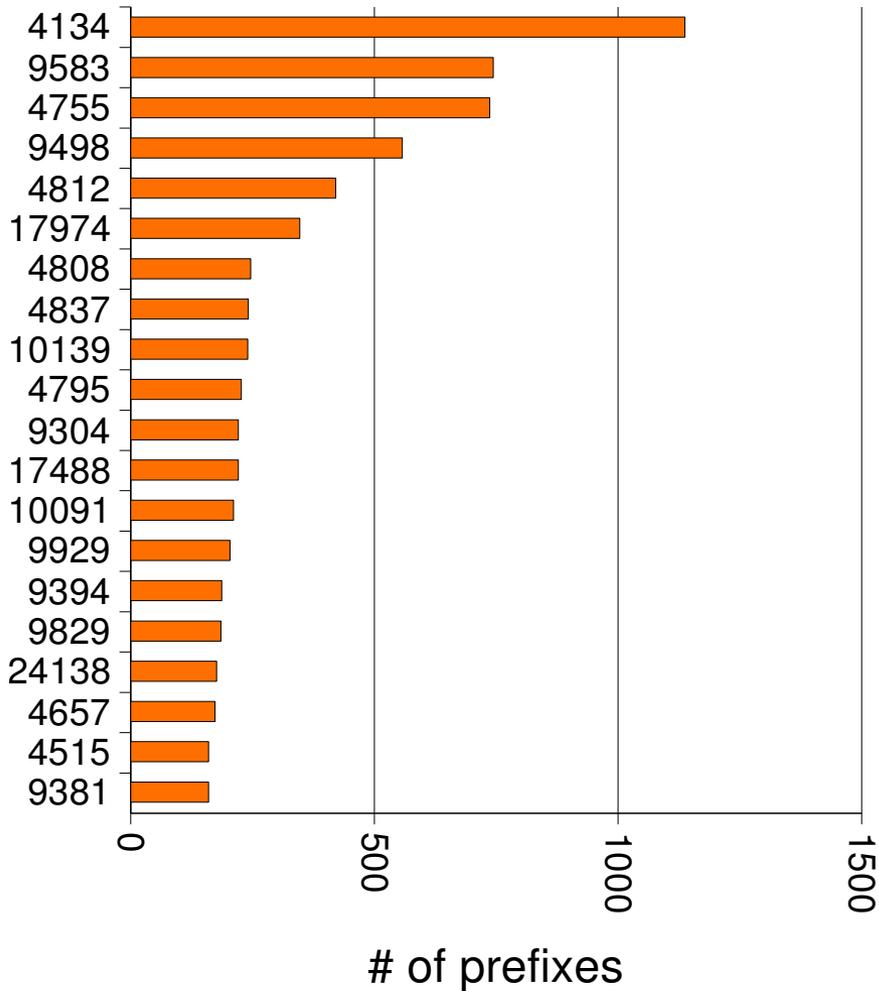
## Max/Median Unstables by Country



# Impacted ASNs

- Examined Asian prefixes outaged and/or unstable by origin AS – 1667 ASNs impacted:
  - China Telecom: AS4134, AS4812 (CN)
  - Sify: AS9583 (IN)
  - VSNL: AS4755 (IN)
  - Bharti BT Internet: AS9498 (IN)
  - PT Telekomunikasi: AS17974 (ID)
  - CNC Group (AS4808, AS4837) (CN)
  - Smart Broadband: AS10139 (PH)
  - INDOSAT: AS4795 (ID)

# •Winners & Losers by ASN (cont'd)



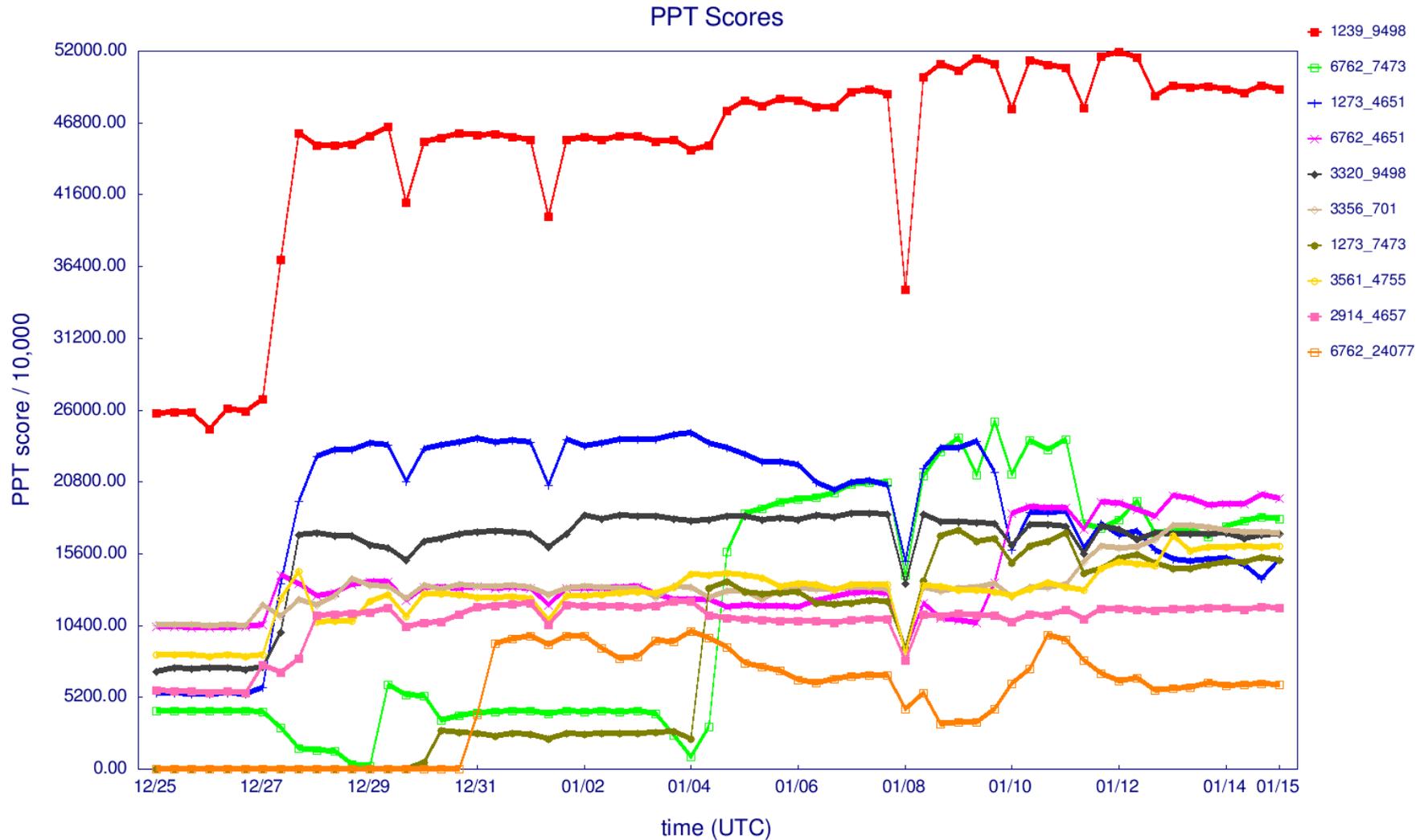
# Edge Analysis

- PPT (Prefix, Peer, Time) score for each edge: for each prefix, for each peer, sum the amount of time the peer saw the prefix routed on the edge during a time interval
- Caveats:
  - All prefixes have the same weight
  - Cannot distinguish **between** an edge with a lot of prefixes seen by only few peers, **and** an edge with few prefixes seen by a lot of peers

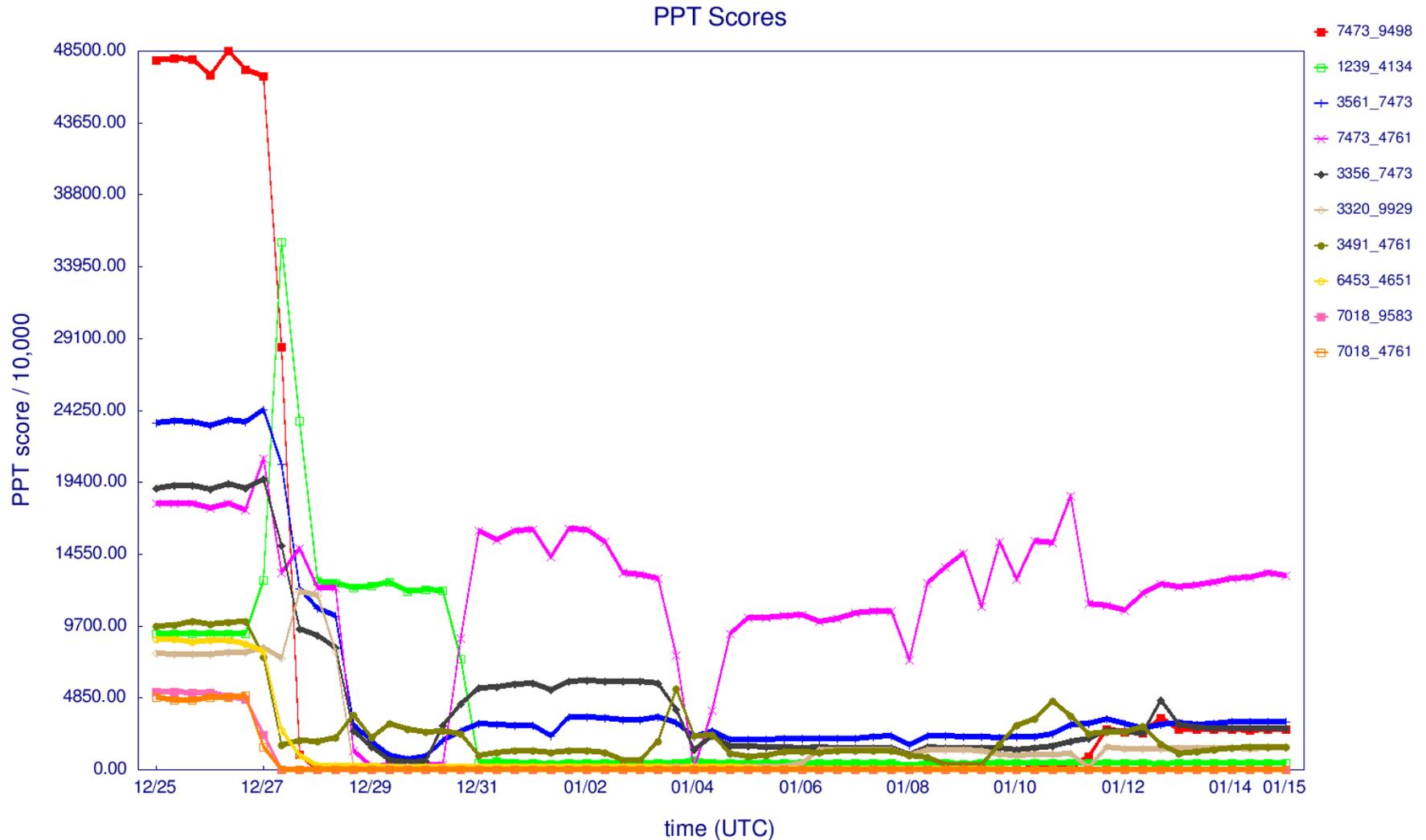
# Edge Analysis (cont'd)

- For each edge, generate time series with range 25 Dec 2006 to 15 Jan 2007 and 8 hours resolution
- Considered only prefixes from South-East Asia and the Indian subcontinent
- Filter out edges seen by less than 20 peers
- Evaluate the time series using the 2-day median difference between end and beginning

# Top 10 Edge Winners

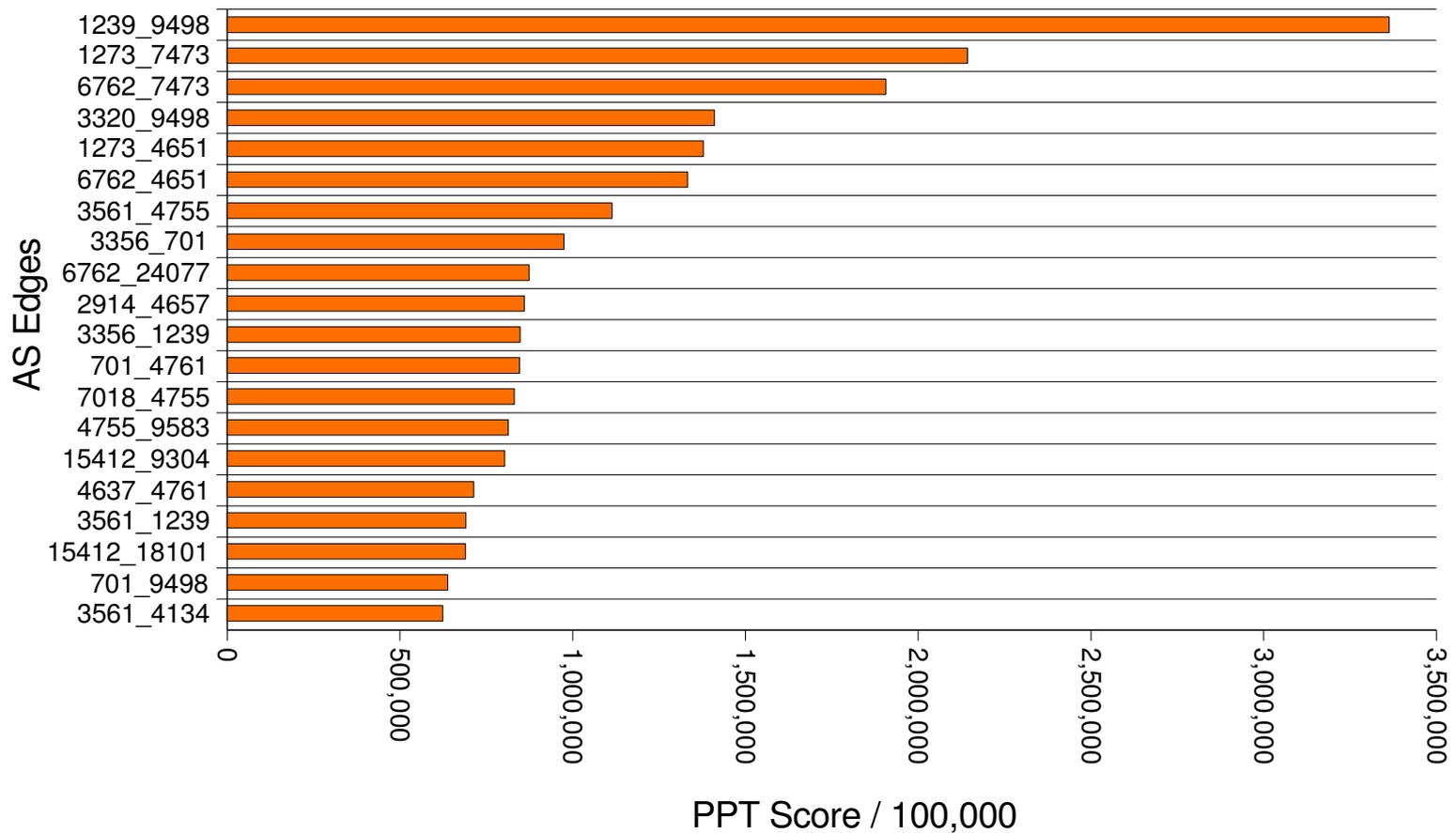


# Top 10 Edge Losers



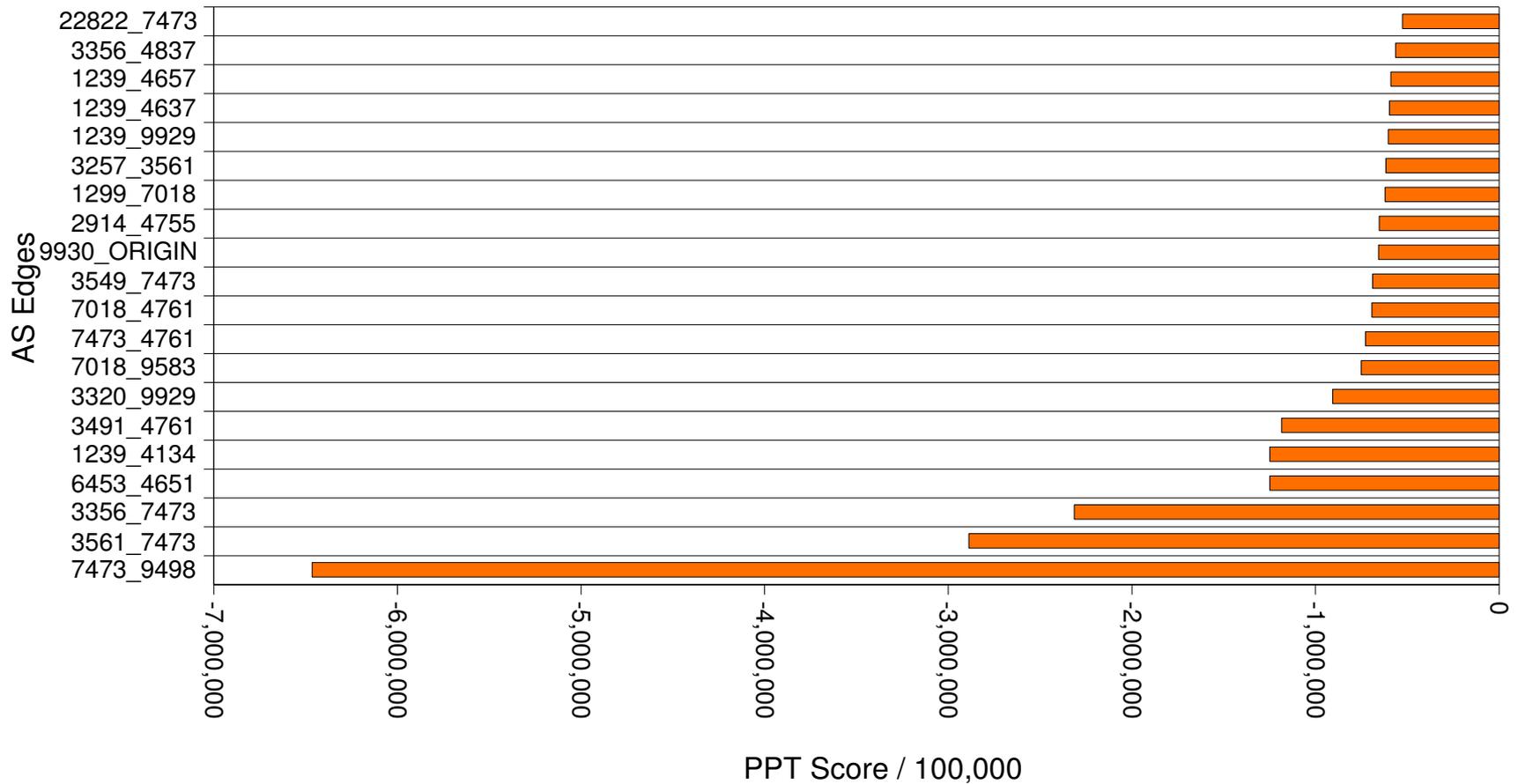
# Winning Edges

## Top 20 Winners



# Losing Edges

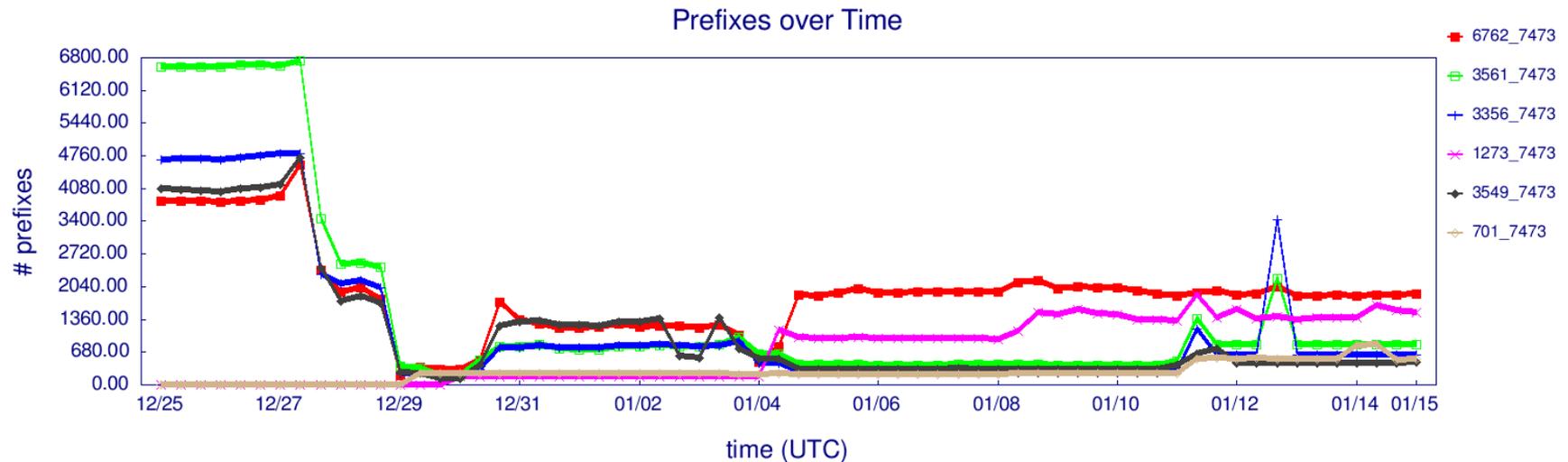
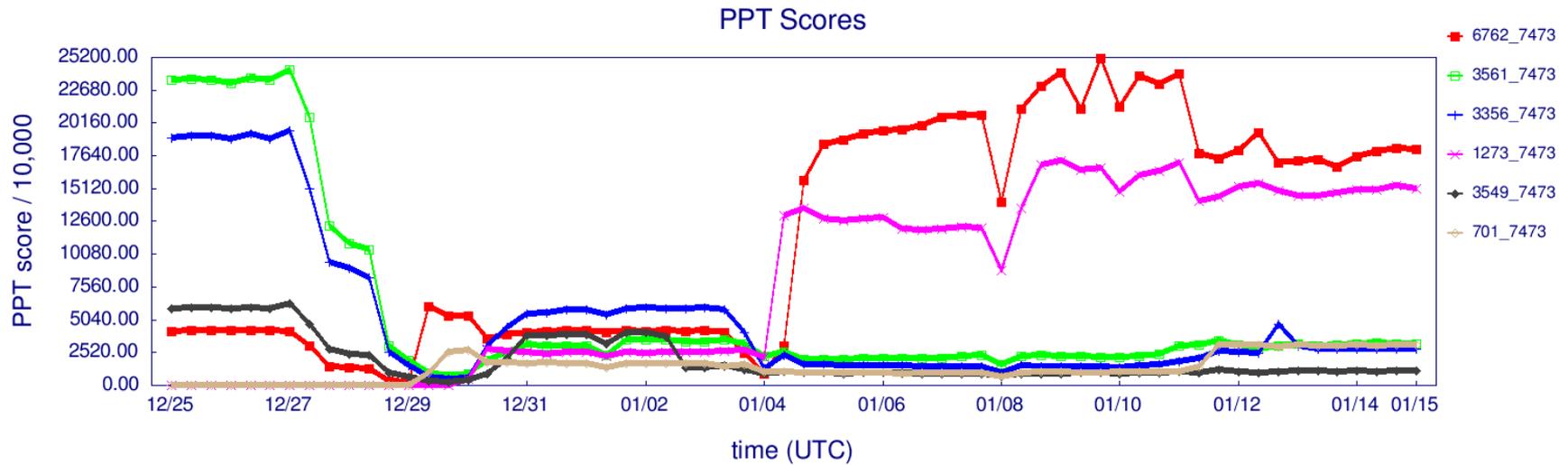
## Top 20 Losers



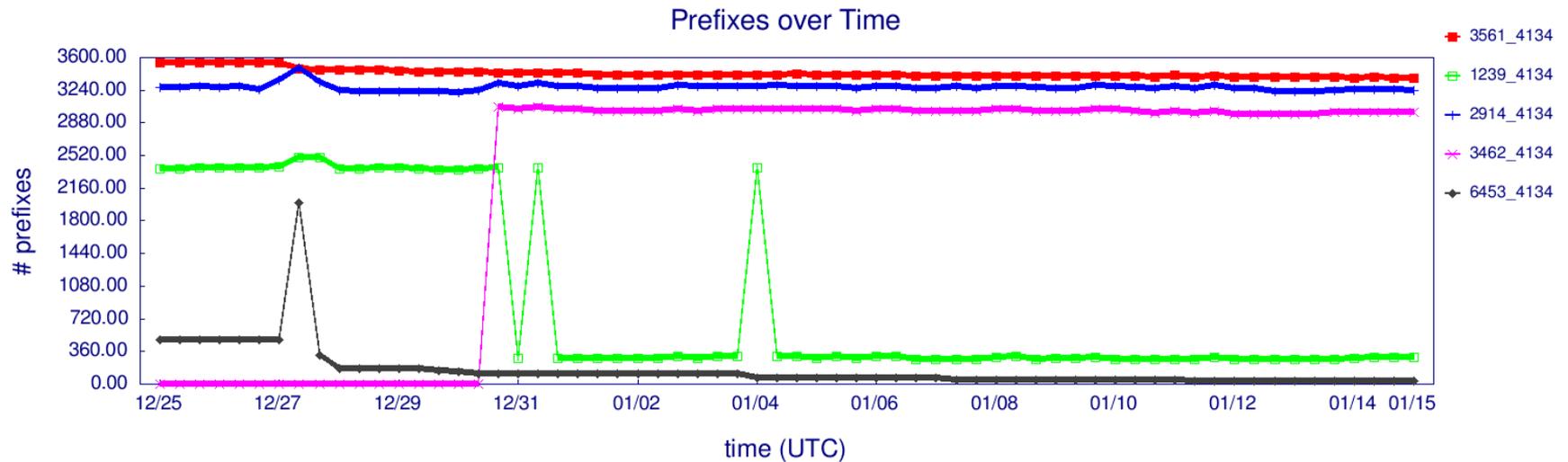
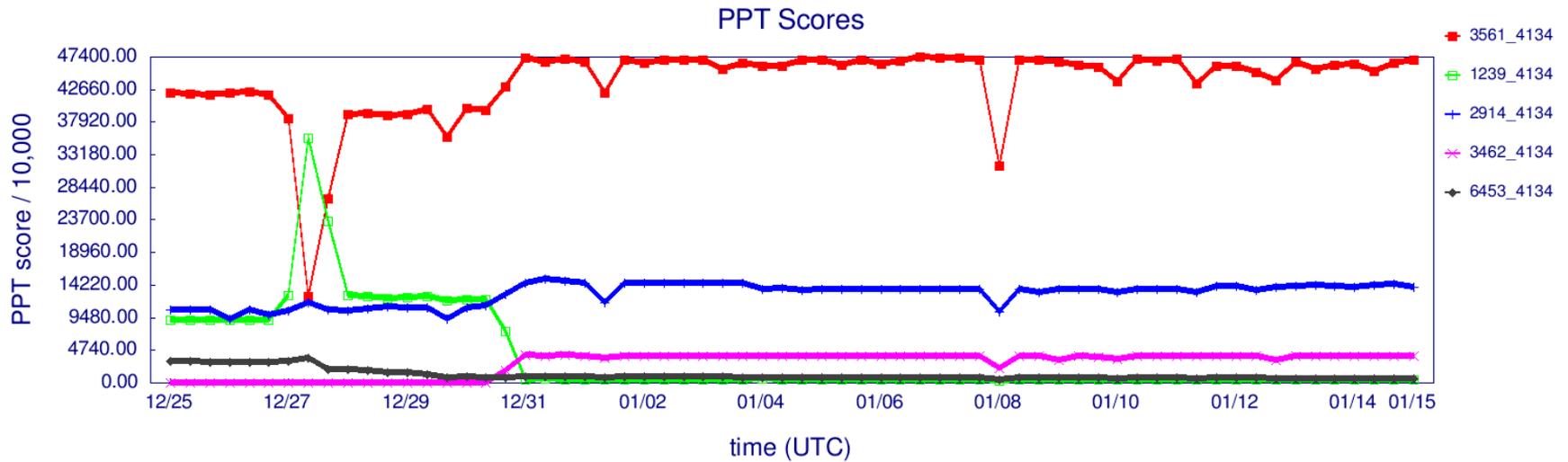
# Regional Stories

- AS7473 Singapore Telecom (SG)
- AS4134 China Telecom (CN)
- AS9498 Bharti BT Internet (IN)
- AS4761 INDOSAT (ID)
- AS4651 Communication Authority of Thailand (TH)
- AS24077 TMHK Global Transit (HK)

# Singapore Telecom (AS7473)

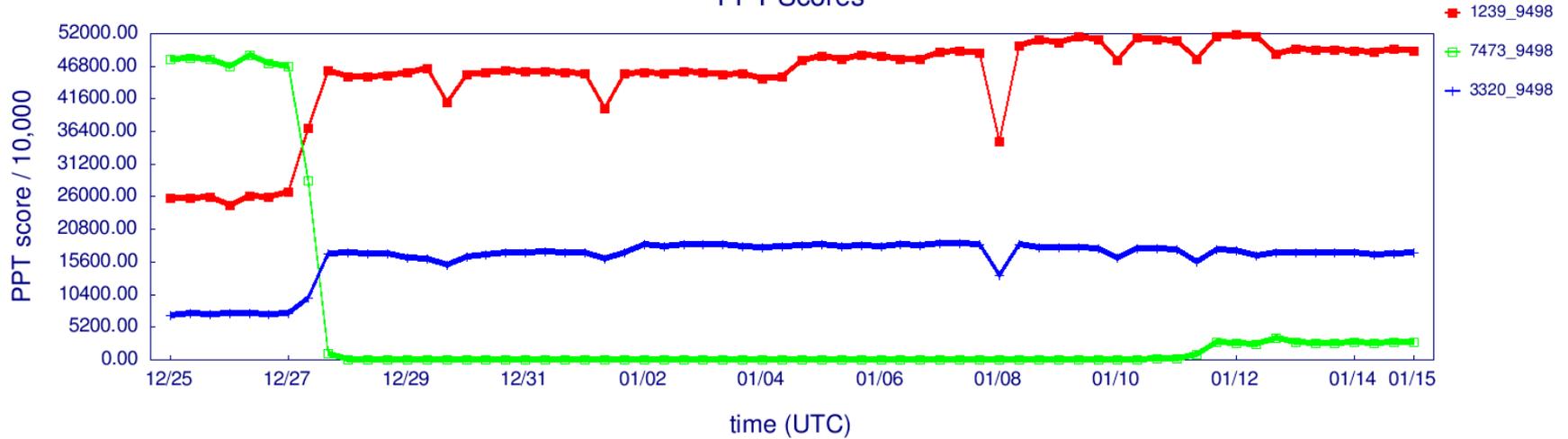


# China Telecom (AS4134)

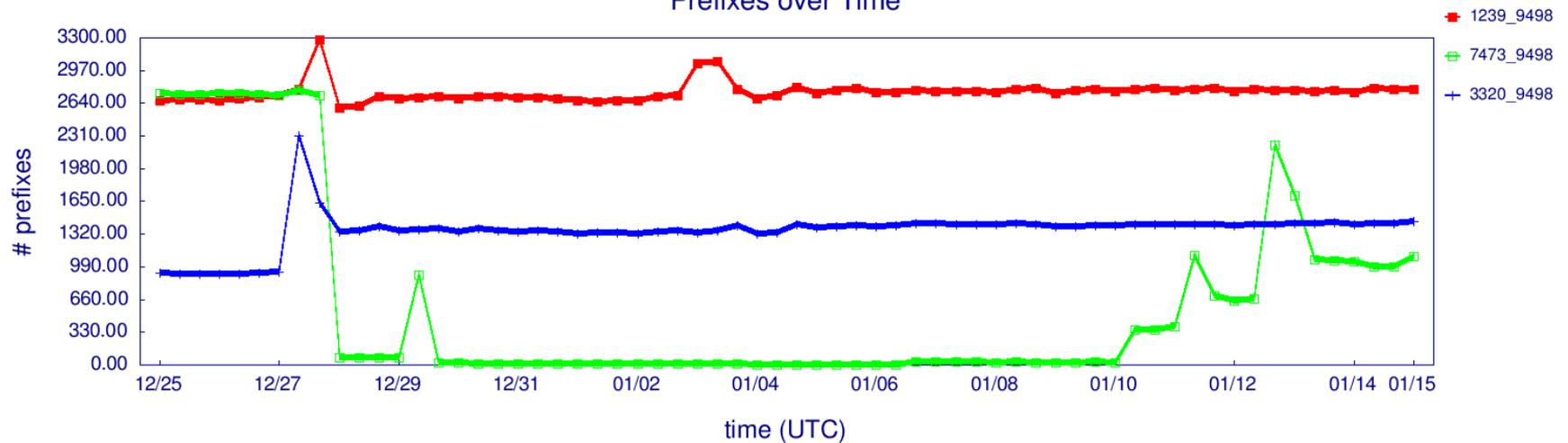


# Bharti BT Internet (AS9498)

PPT Scores

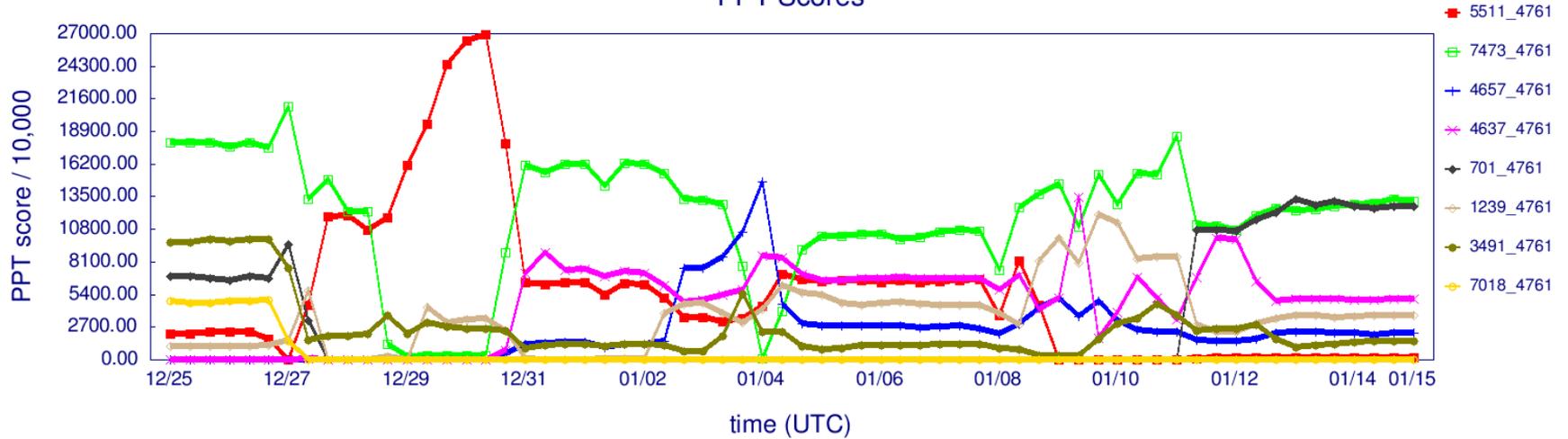


Prefixes over Time

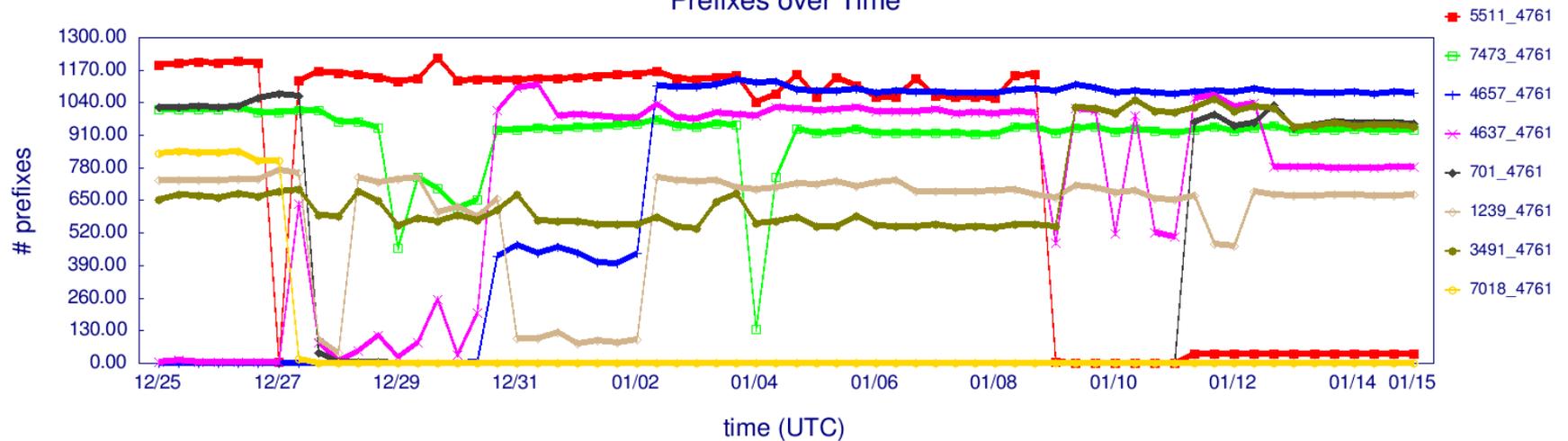


# INDOSAT (AS4761)

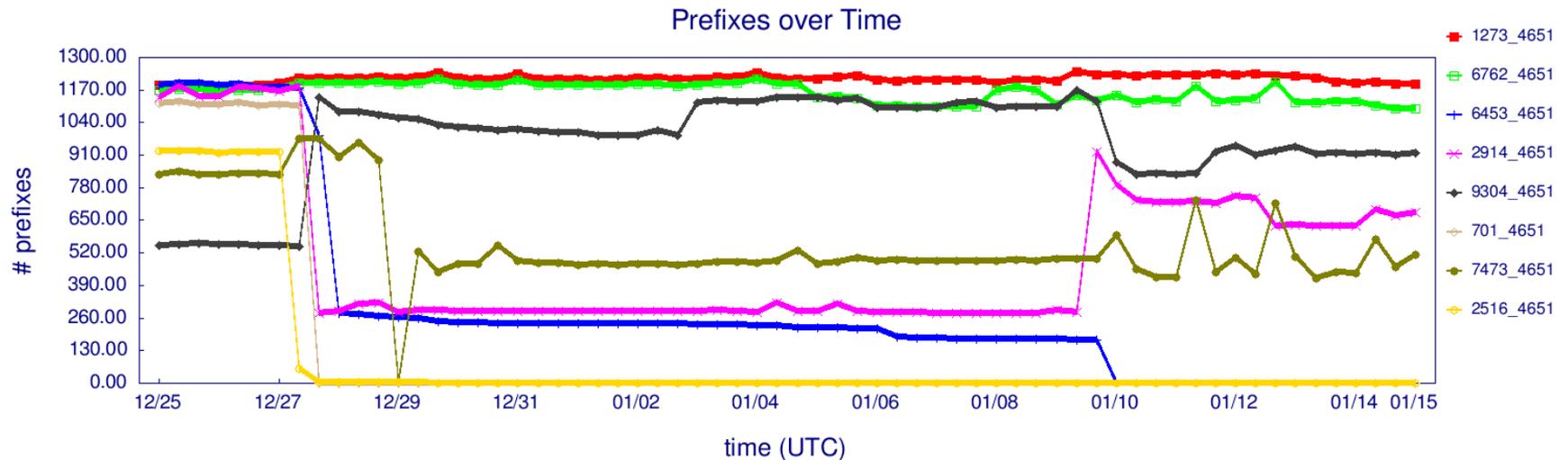
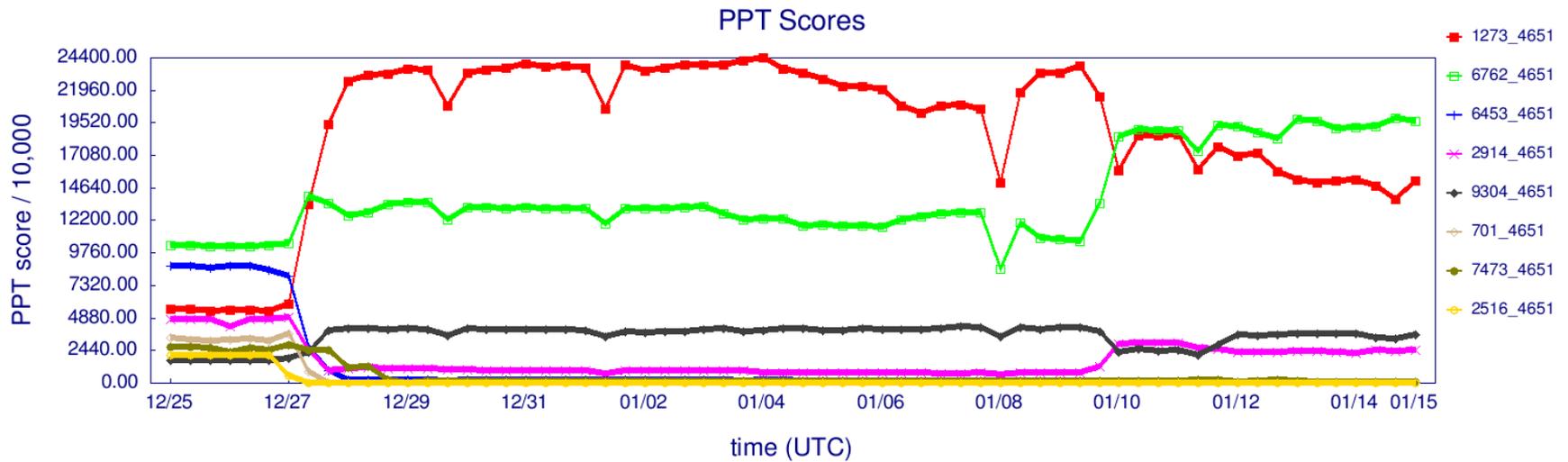
## PPT Scores



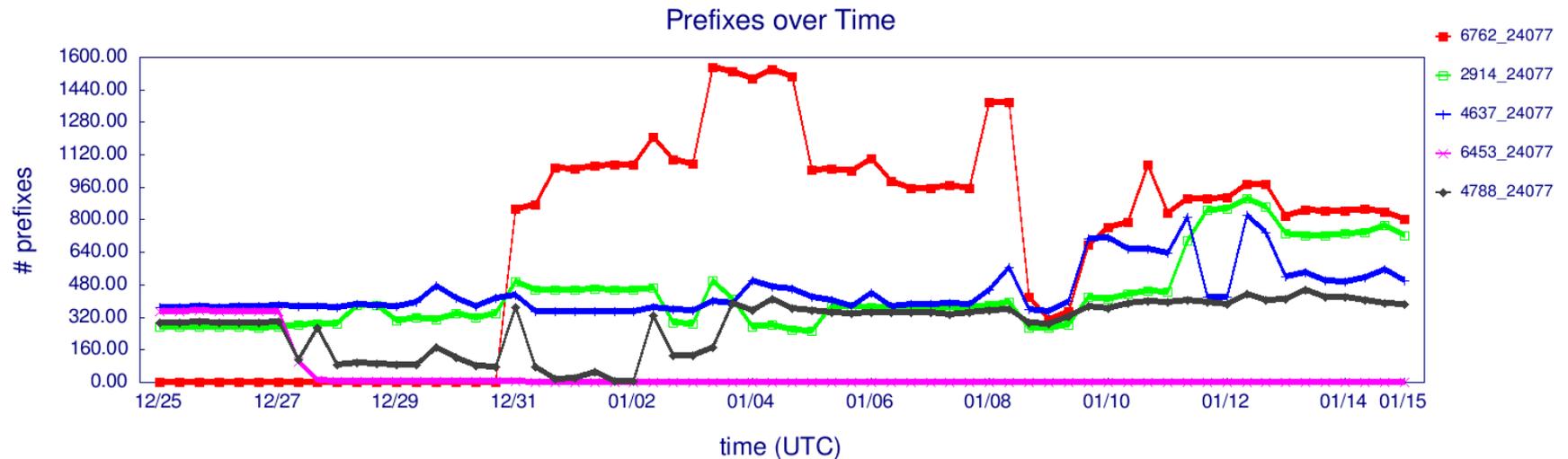
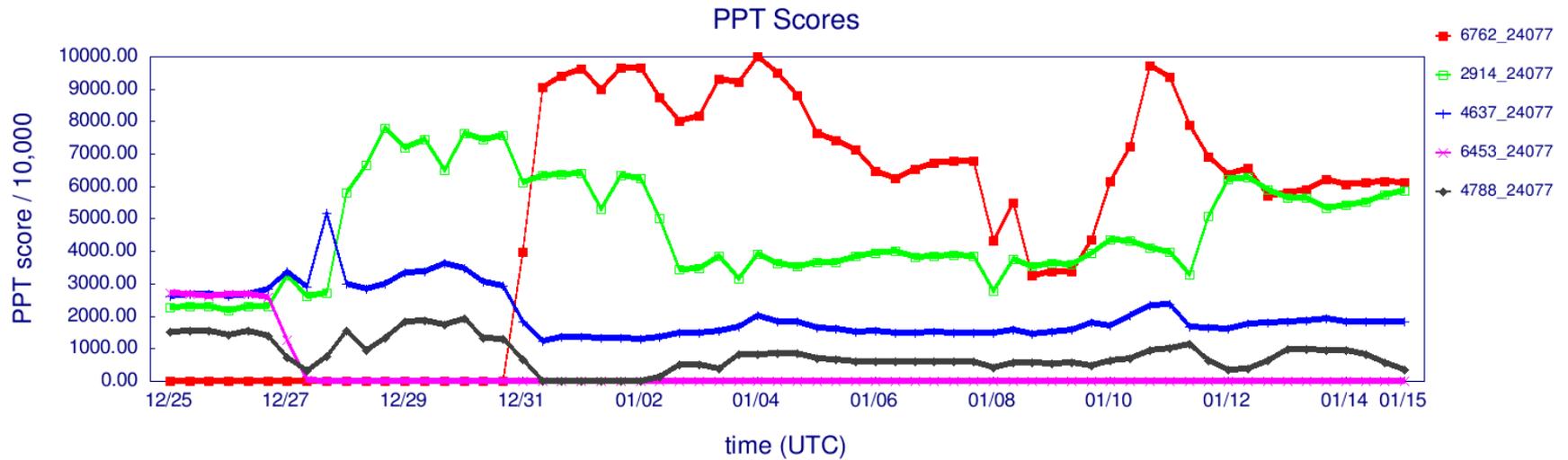
## Prefixes over Time



# Communication Authority of Thailand (AS4651)



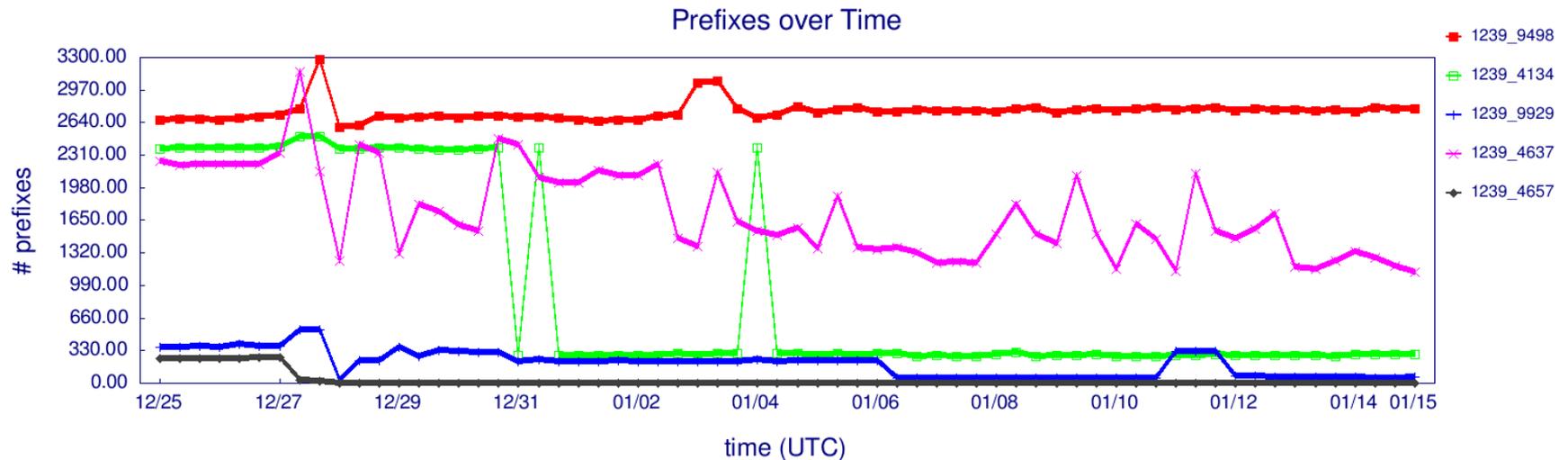
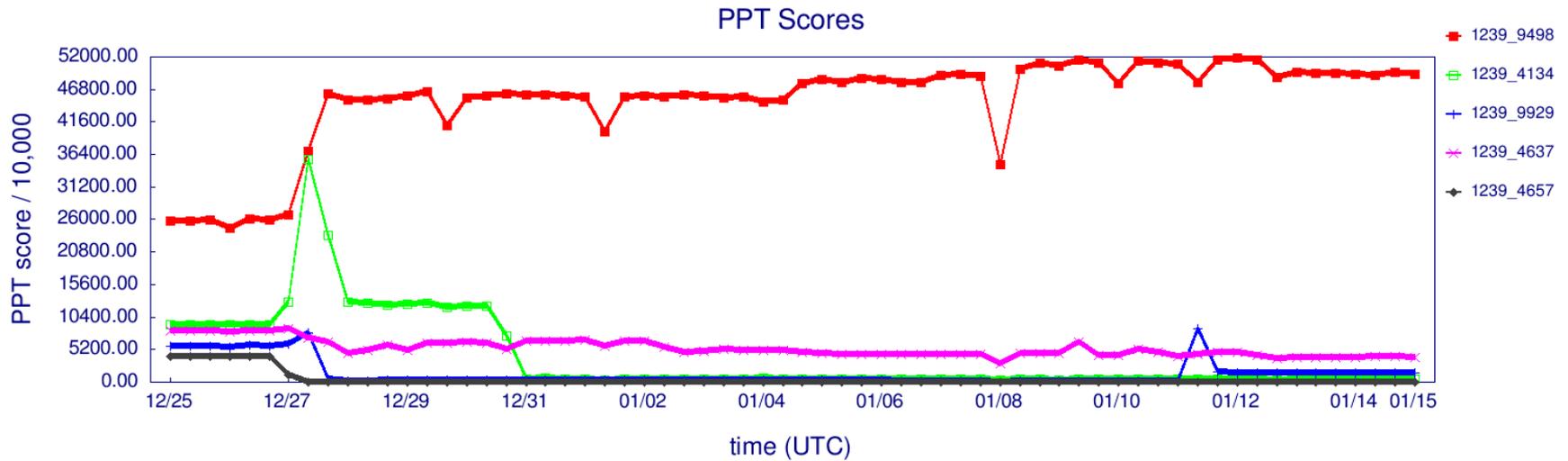
# TMHK Global Transit (AS24077)



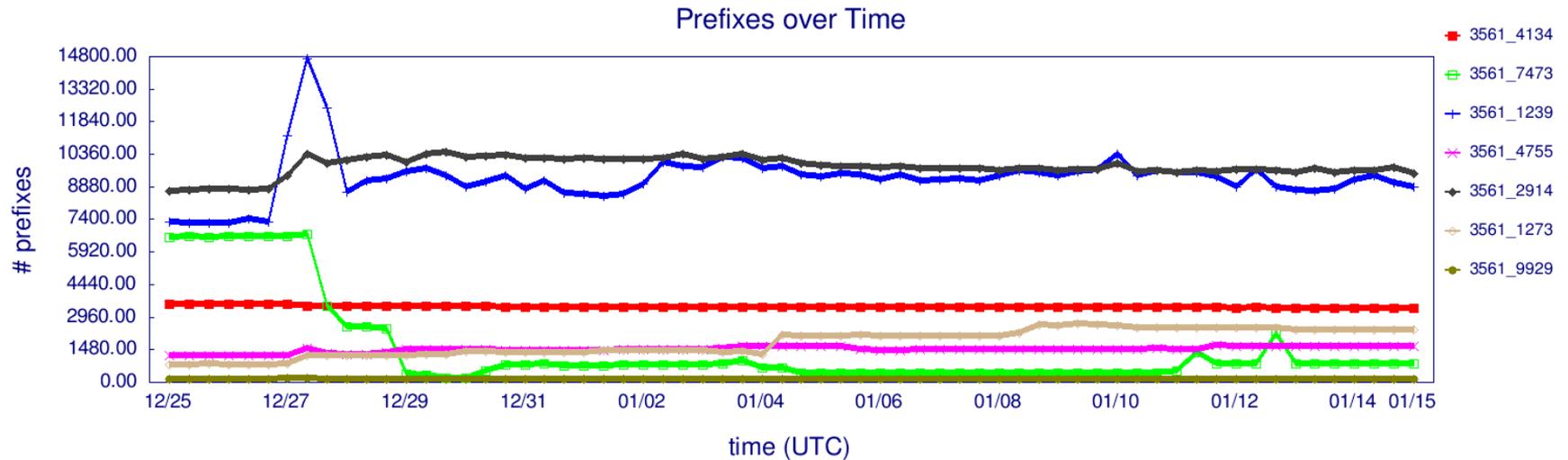
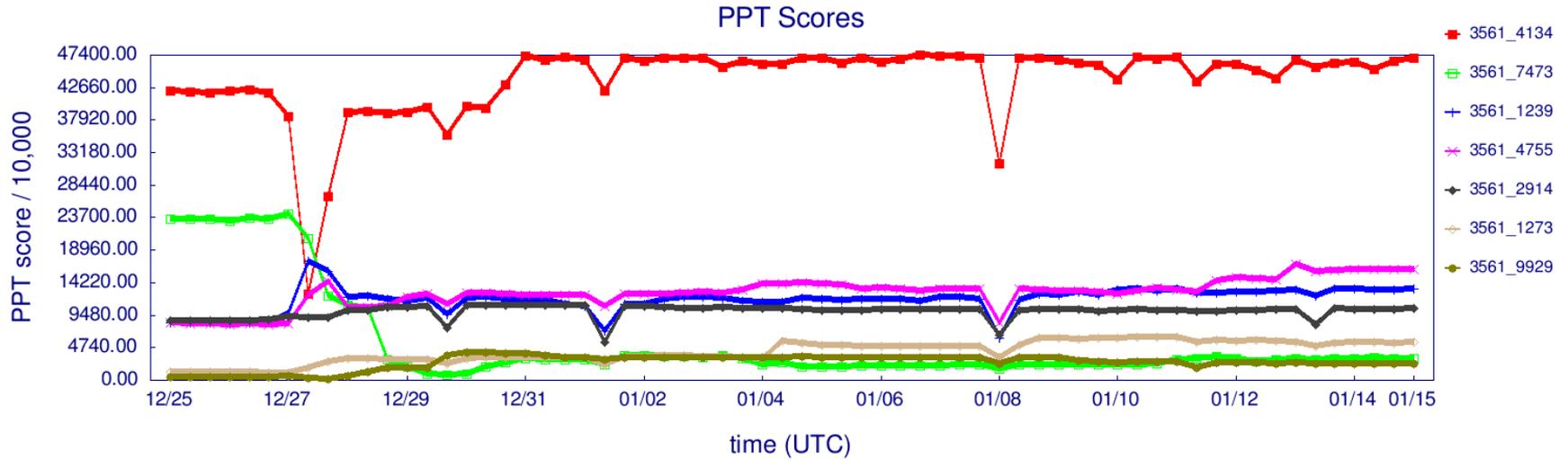
# Global Stories

- AS1239 Sprint
- AS3561 Savvis
- AS2914 NTT/Verio
- AS6762 Telecom Italia
- AS1273 Cable & Wireless

# Sprint (AS1239)

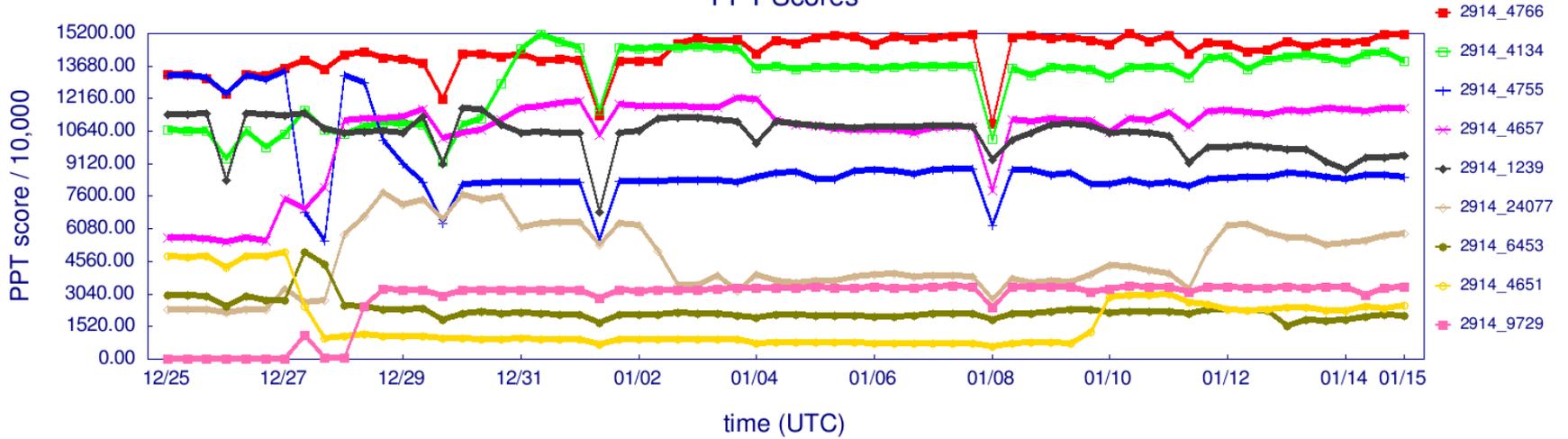


# Savvis (AS3561)

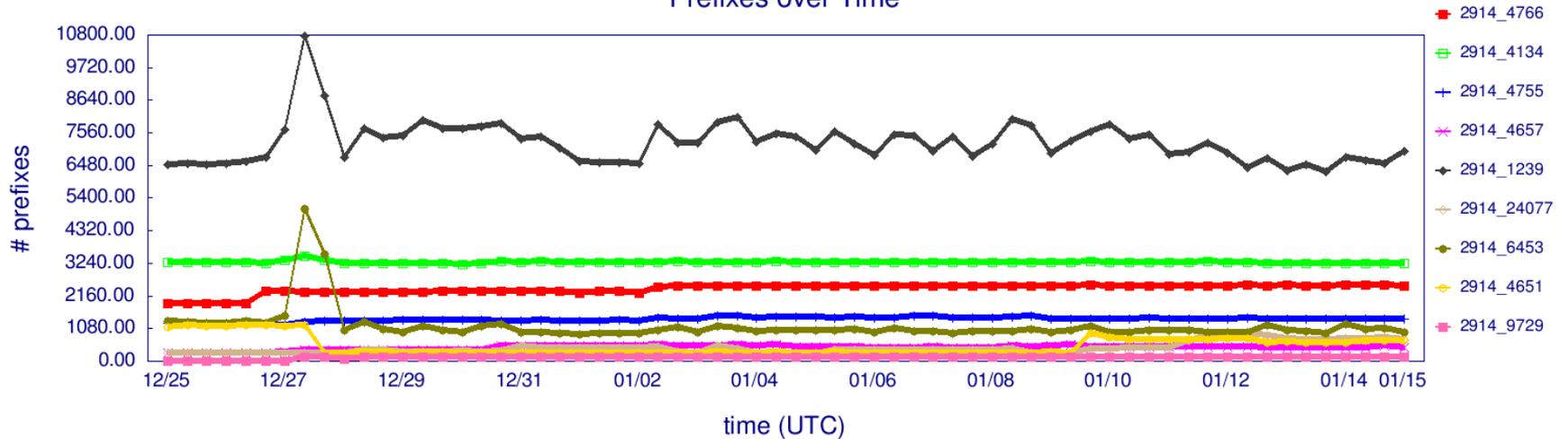


# NTT/Verio (AS2914)

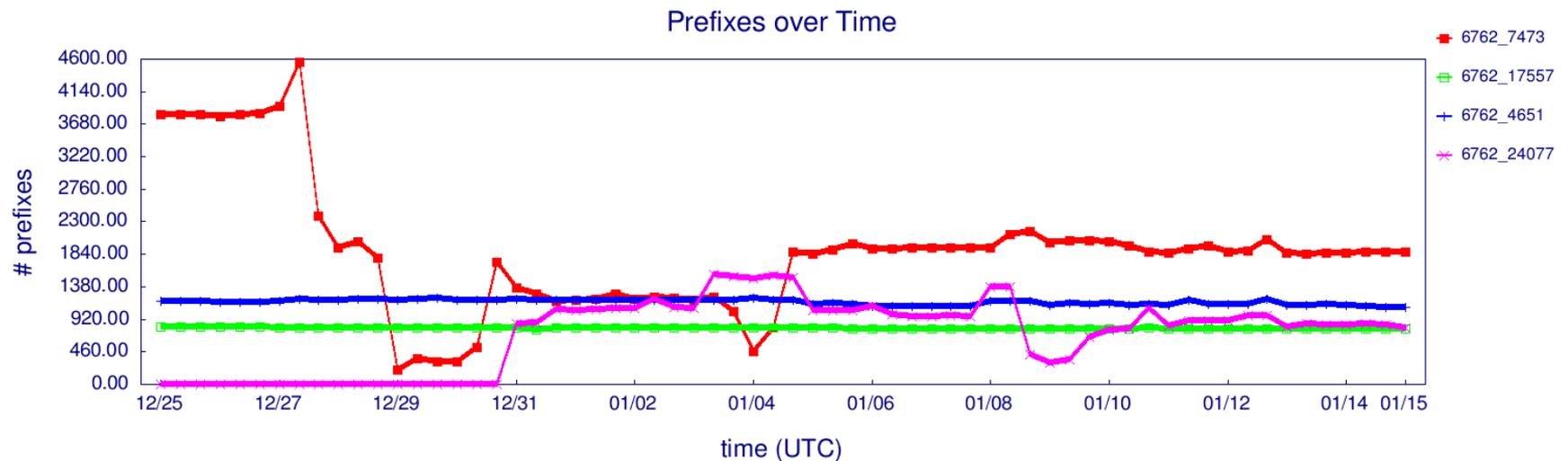
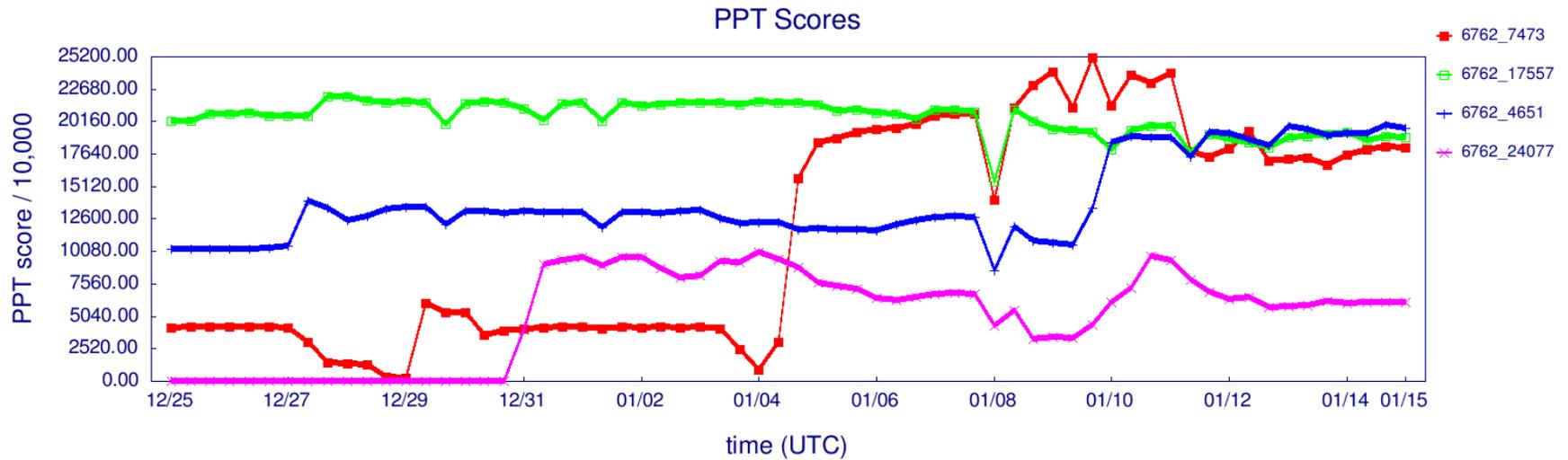
## PPT Scores



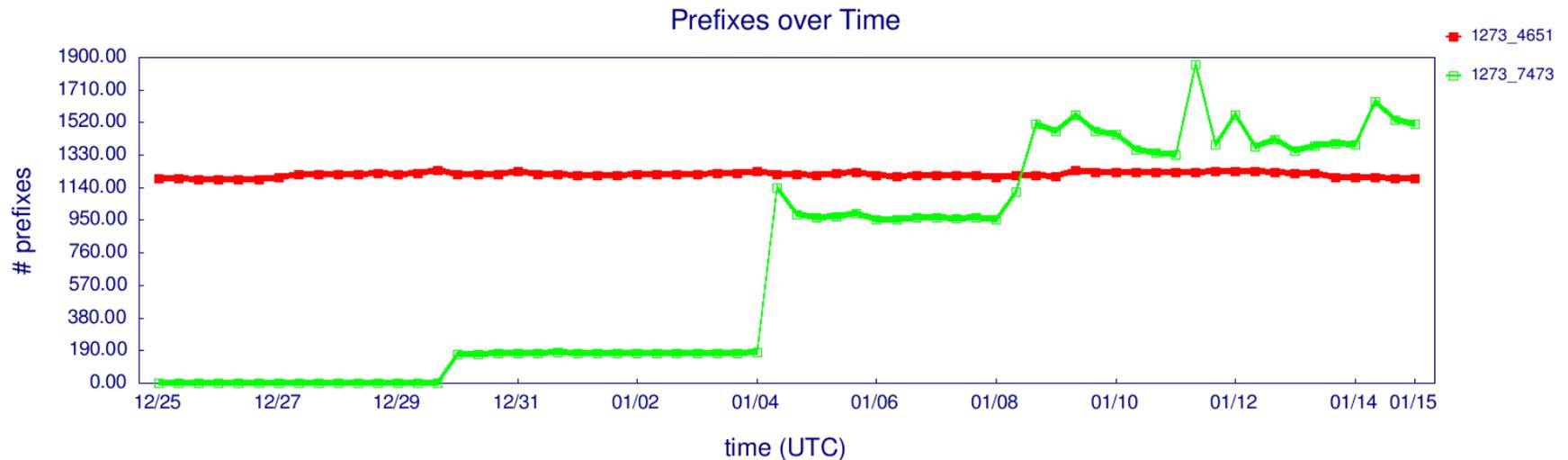
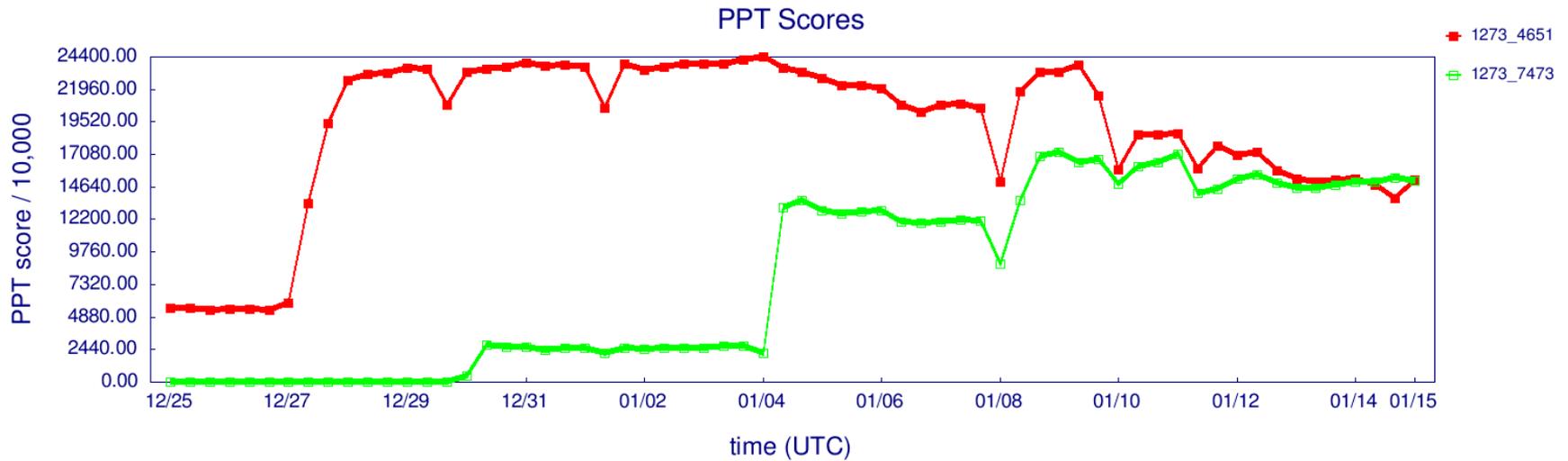
## Prefixes over Time



# Telecom Italia (AS6762) – Winner



# Cable & Wireless (AS1273) – Winner



# Interesting Stories During Quake

- France Telecom (AS5511) provided temporary transit to Bharti (AS9498) from Dec 27 to Jan 5
- Indonesian routes move to INDOSAT (AS4761, AS4795) with transit mostly from DTAG (AS3320)
- China Netcom (AS9929) uses temporarily Sprint (AS1239) and DTAG (AS3320) as transits then drops them in favour of UUNet (AS701) and Savvis (AS3561)
- China Telecom (AS4134) routes move temporarily from Savvis to Sprint on Dec. 27

# Interesting Stories After Quake

- Telecom Italia (AS6762) and Cable & Wireless (AS1273) are big winners adding Singapore Telecom (AS7473) and the Communication Authority of Thailand (AS4651) as customers
- Sprint (AS1239) gets to China Telecom (AS4134) through HiNet (AS9680) and Chunghwa Telecom (AS3462), i.e., 1239 9680 3462 4134

# Conclusions

- Quake illustrates fragility of the global Internet
  - “Local” events can have broad impact
  - Physical failures can be difficult to remedy
- Asia is particularly vulnerable
- Impact will be felt long after the repairs are complete
  - New business relationships
  - New cable systems
  - Renewed interest in redundancy

# Thank You

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