FCC Workshop on Network Resiliency 2013
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Lessons learned by "measuring" the Internet during/after the Sandy storm

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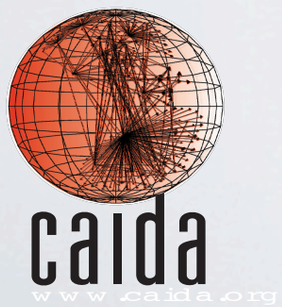


ANALYSIS OF INTERNET OUTAGES

By combining different measurement sources

- BGP
  - BGP updates from route collectors of ***RIPE-NCC RIS*** and ***RouteViews***
- Active Traceroute Probing
  - Archipelago Measurement Infrastructure (***ARK***)
  - ***RIPE-NCC Atlas***
- Internet Background Radiation (IBR)
  - Traffic reaching the ***UCSD Network Telescope***
- *more data sources to come...*

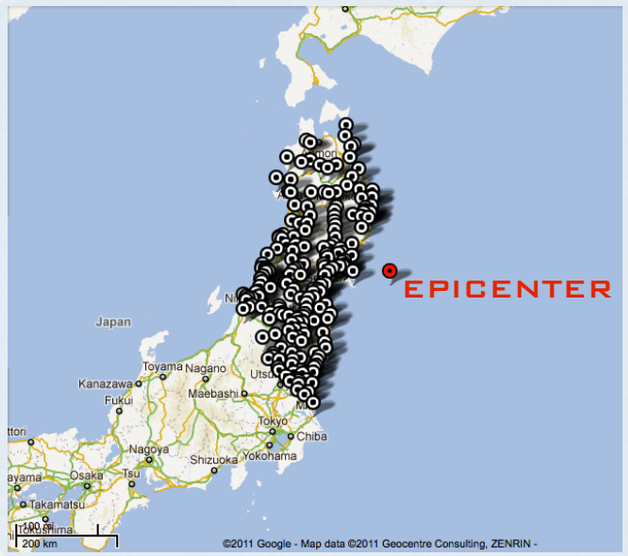
CASE STUDIES

Different for causes/tech implications/impact

- Country-level Internet Blackouts (*BGP withdrawals, packet-filtering, satellite-signal jamming, ...*)

Egypt, Jan 2011
Government orders to shut down the Internet

- Natural disasters affecting the infrastructure/population



Japan, Mar 2011
Earthquake of Magnitude 9.0

SANDY: IS IT DIFFERENT?

(compared to our previous case studies)

- Movement over a large area
  - with no fixed epicenter like an earthquake has

- High level of Internet penetration in the affected region, including major hubs for international Internet connectivity

- Disruption was limited to only a subset of networks/hubs in the affected region, making it harder to identify geographic areas of massive impact

- For the 1st time we tried to measure in realtime

ACTIVE MEASUREMENTS

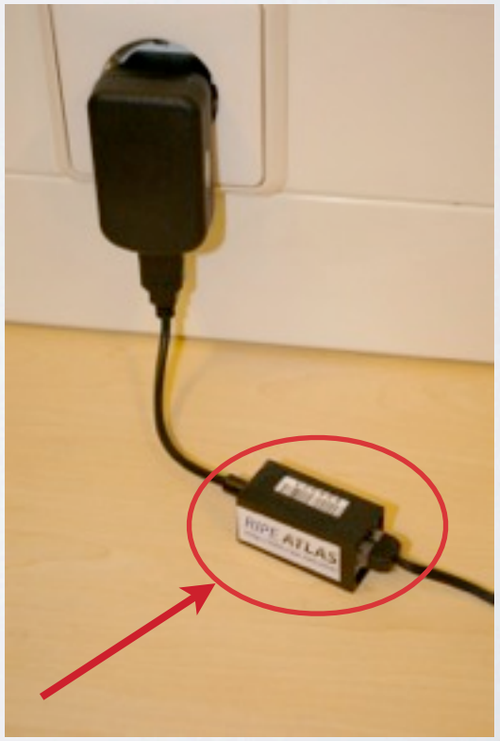
ARK + ATLAS

- CAIDA ARCHIPELAGO (*ARK*)
  - Coordinate traceroute-based topology measurement probing the full routed IPv4 address space

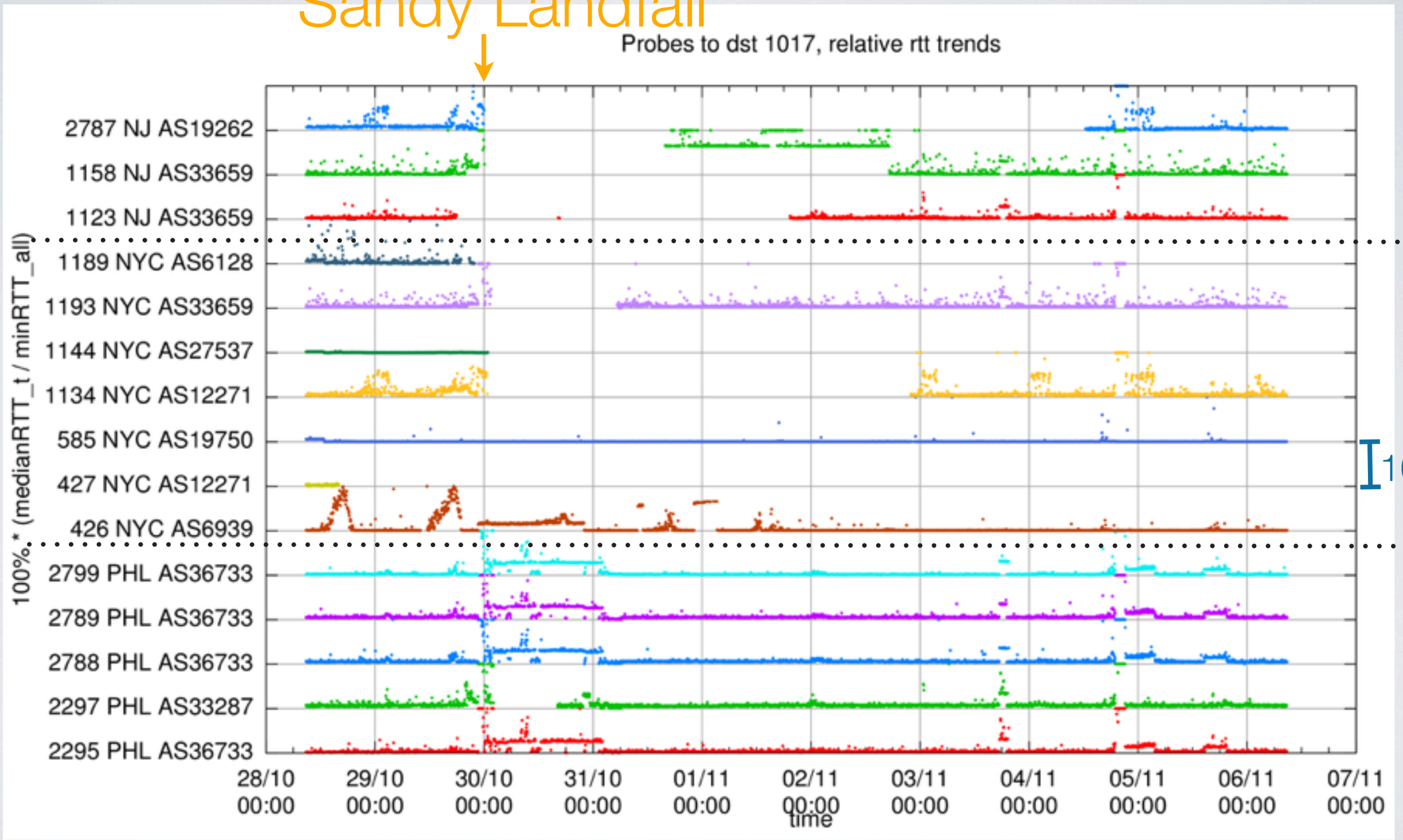
  http://www.caida.org/projects/ark/

- RIPE ATLAS
  - traceroutes/pings to fixed destinations
  - user-defined measurements (a community-oriented tool)

  https://atlas.ripe.net/



ATLAS: RTT


Sandy Landfall
Probes to dst 1017, relative rtt trends
2787 NJ AS19262
1158 NJ AS33659
1123 NJ AS33659
1189 NYC AS6128
1193 NYC AS33659
1144 NYC AS27537
1134 NYC AS12271
585 NYC AS19750
427 NYC AS12271
426 NYC AS6939
2799 PHL AS36733
2789 PHL AS36733
2788 PHL AS36733
2297 PHL AS33287
2295 PHL AS36733
100%.* (medianRTT_t / minRTT_all)
100%
28/10 00:00
29/10 00:00
30/10 00:00
31/10 00:00
01/11 00:00
02/11 00:00
03/11 00:00
04/11 00:00
05/11 00:00
06/11 00:00
07/11 00:00
time

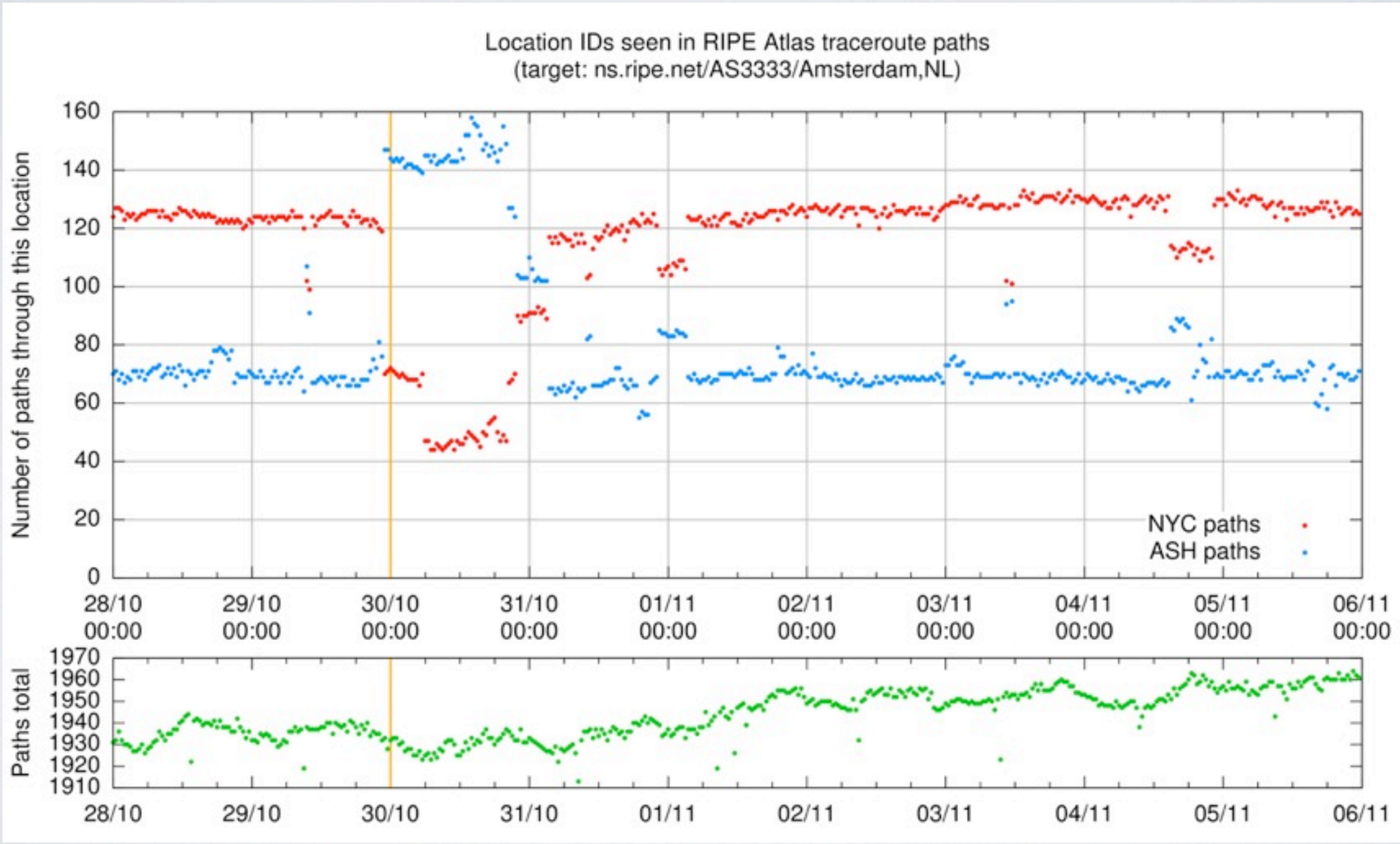
ATLAS: PATH CHANGES

Looking at two major hubs

- New York City (NYC) is a major Internet connectivity hub
- Ashburn/Washington DC (ASH) is the other for US-Europe traffic

ATLAS: PATH CHANGES

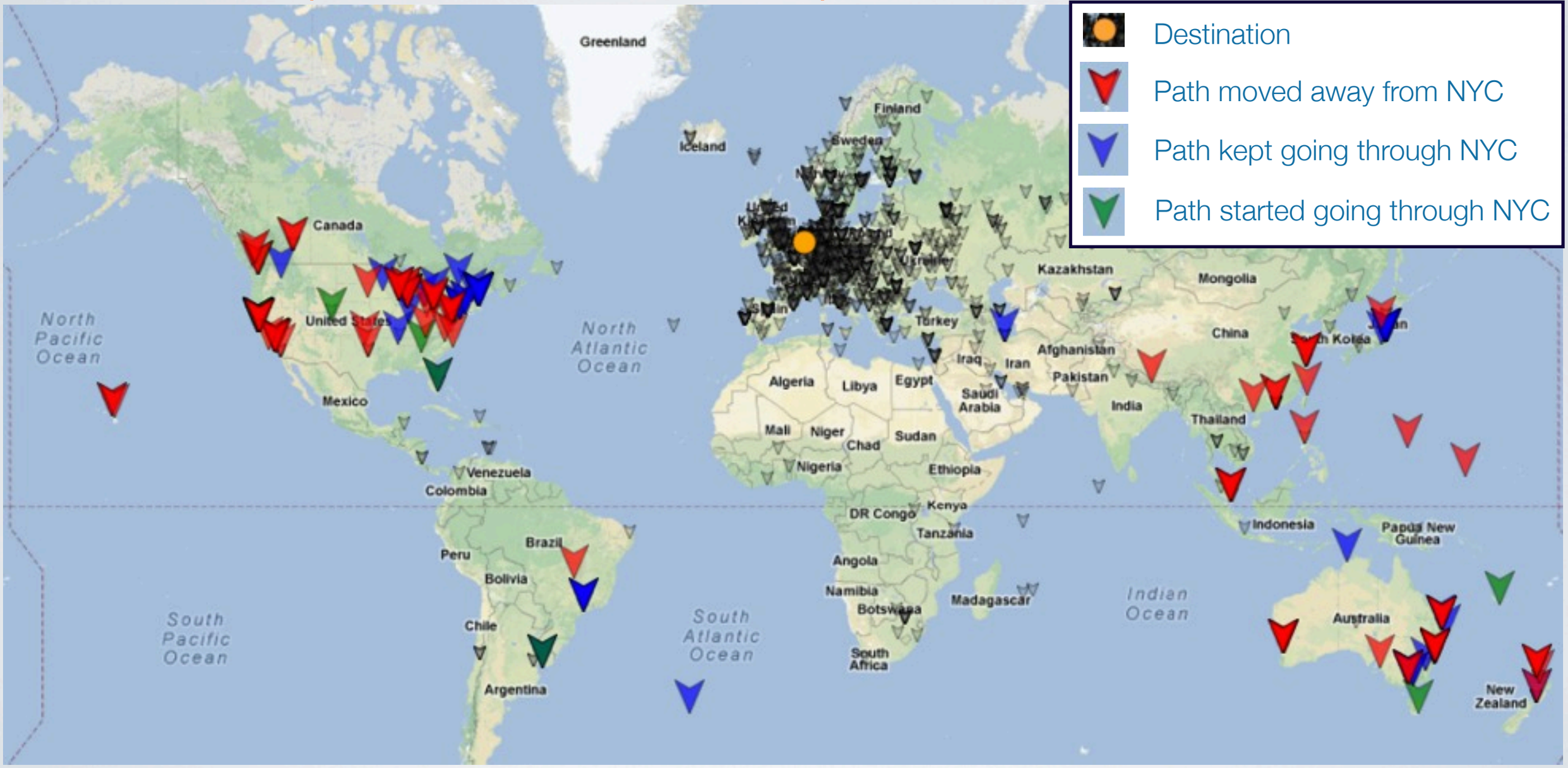
dst: ns.ripe.net / AS3333 / NL



ATLAS: NYC PATH CHANGES

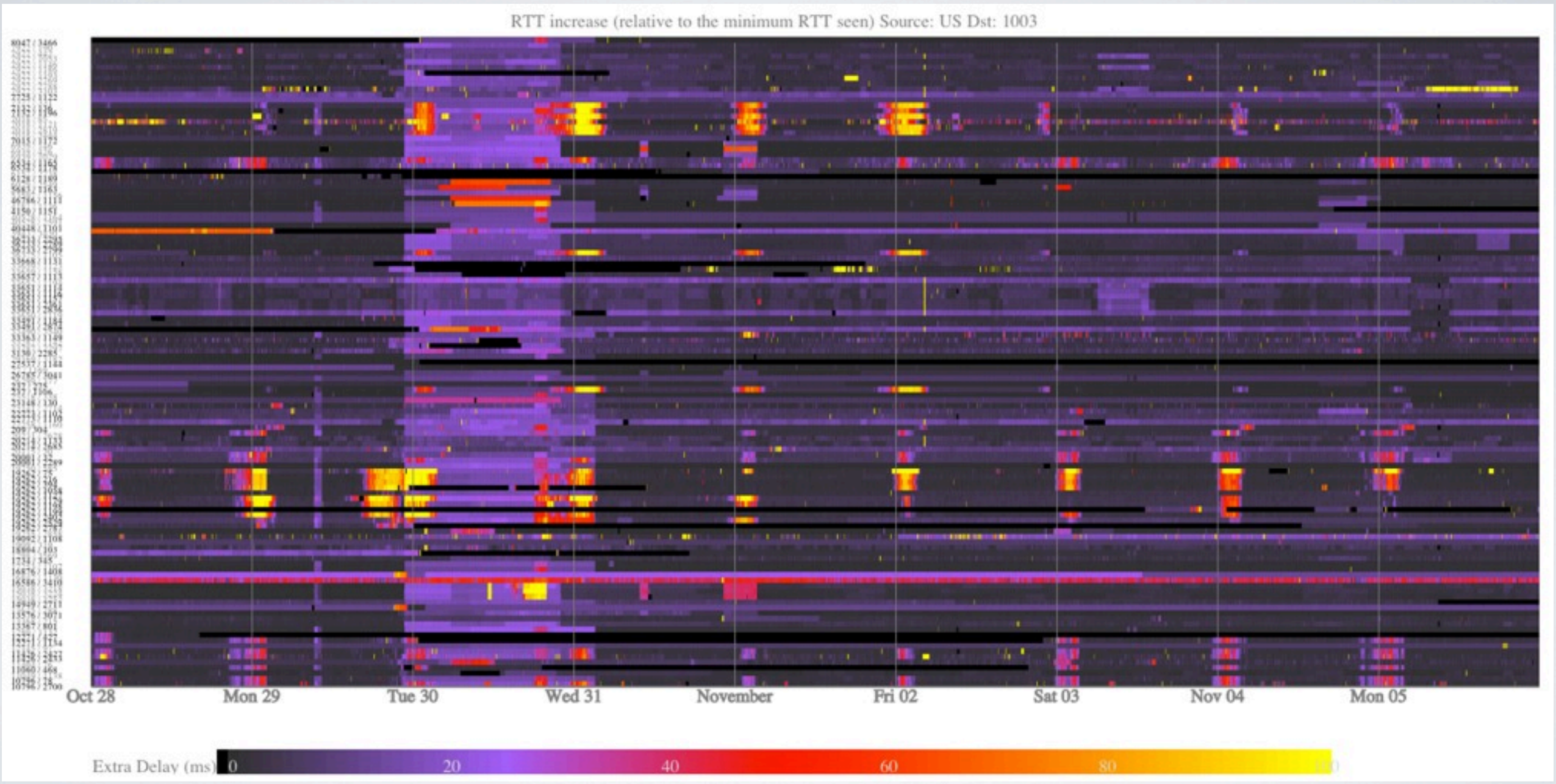
dst: ns.ripe.net / AS3333 / NL

pre: 22:00 UTC vs. post: 09:00 UTC



ATLAS: LATENCY

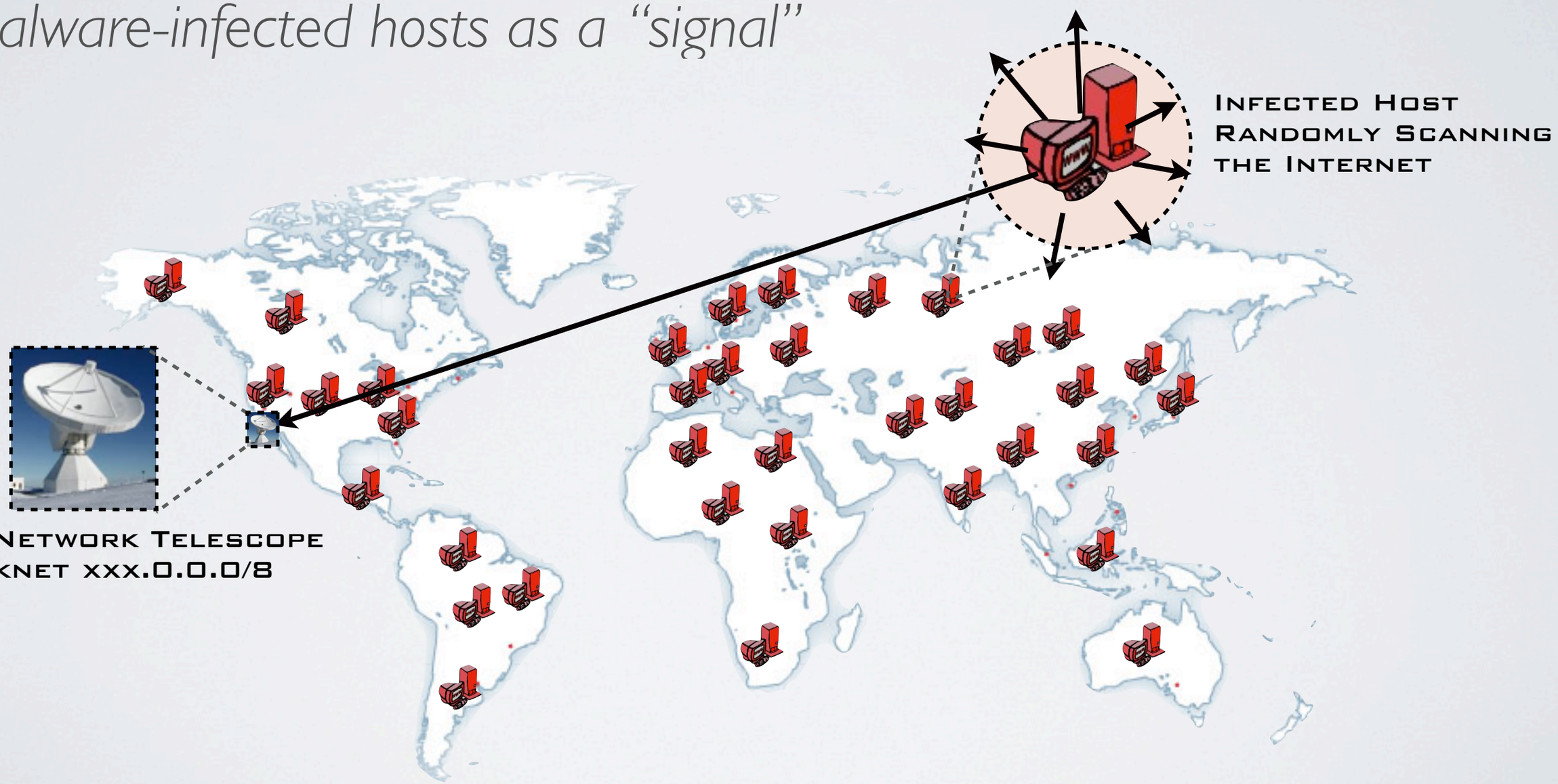
RTT US -> AS3333/NL (+20 ms)



IBR

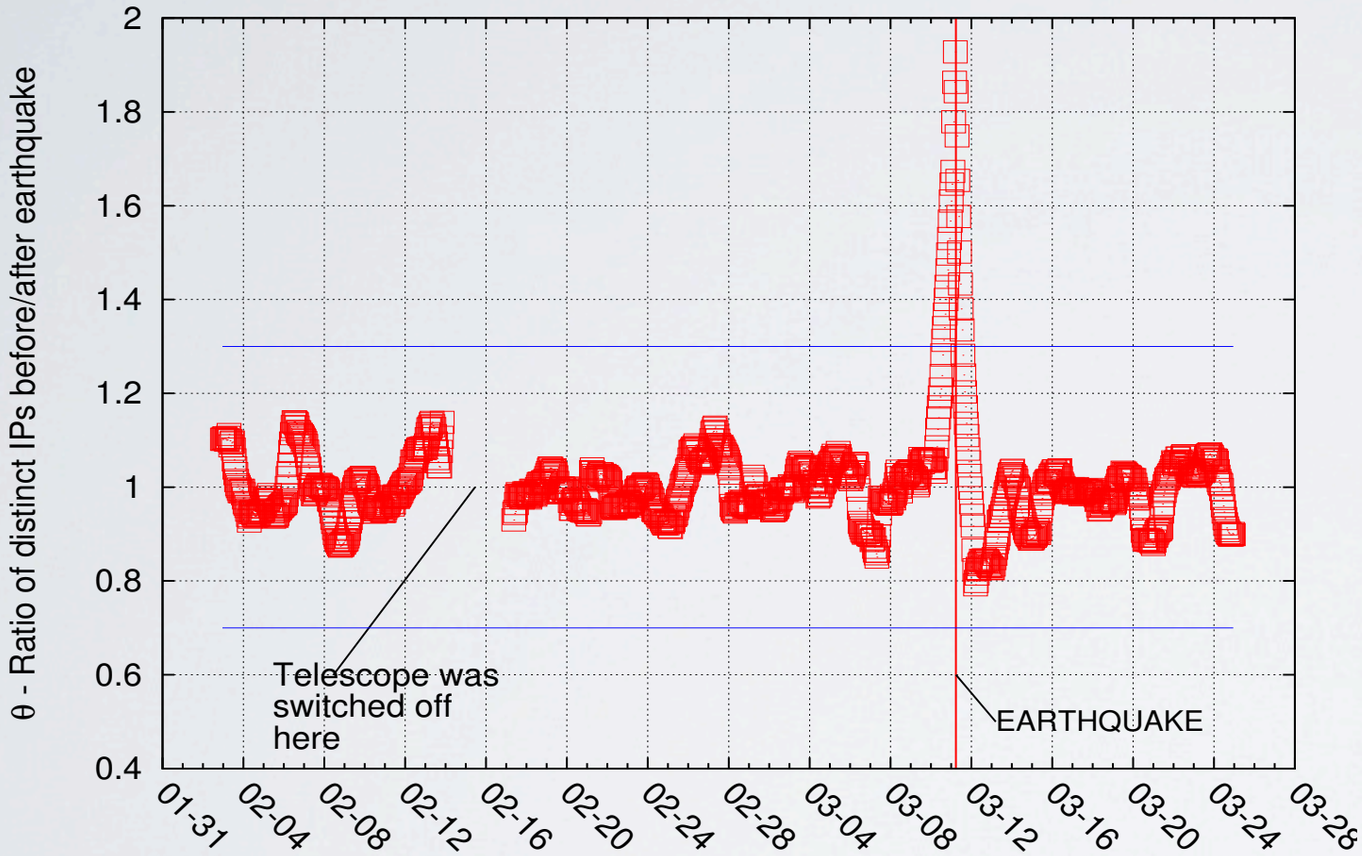
"Extracting benefit from harm.."

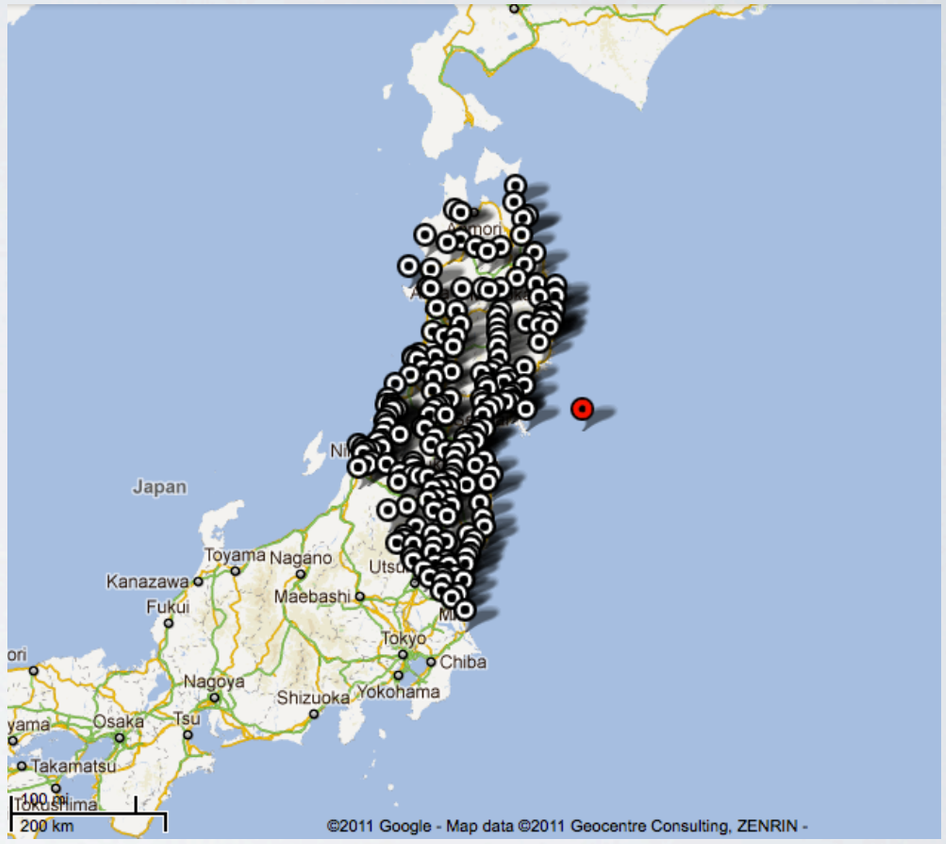
- Use *Internet Background Radiation (IBR) generated by malware-infected hosts as a "signal"*



IBR: TOHOKU'S EARTHQUAKE

the effect of the 2011 earthquake/tsunami in Japan





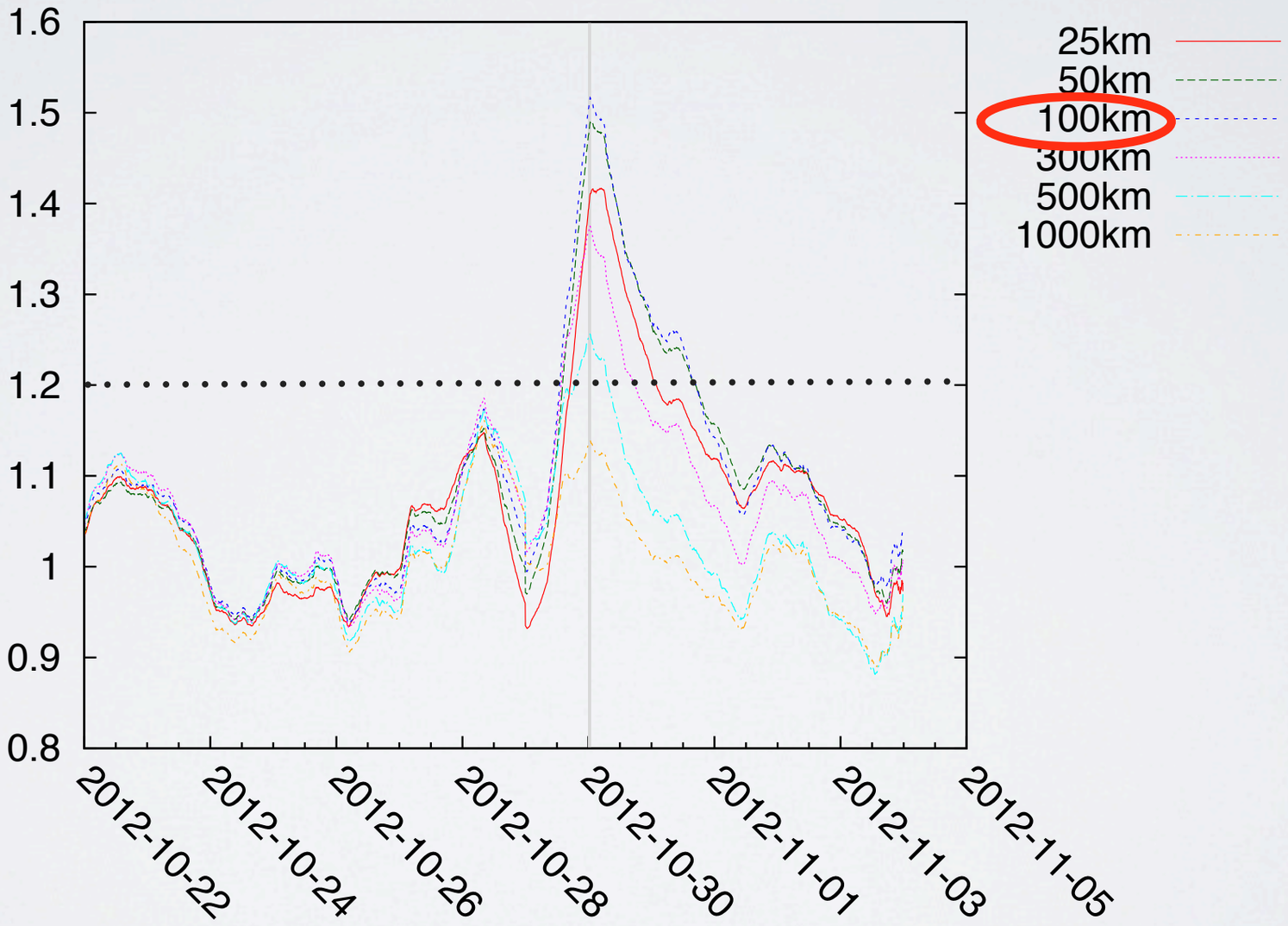
Extracting Benefit from Harm: Using Malware Pollution to Analyze the Impact of Political and Geophysical Events on the Internet

A. Dainotti, R. Amman, E. Aben, K. C. Claffy

ACM SIGCOMM Computer Communication Review, January 2012

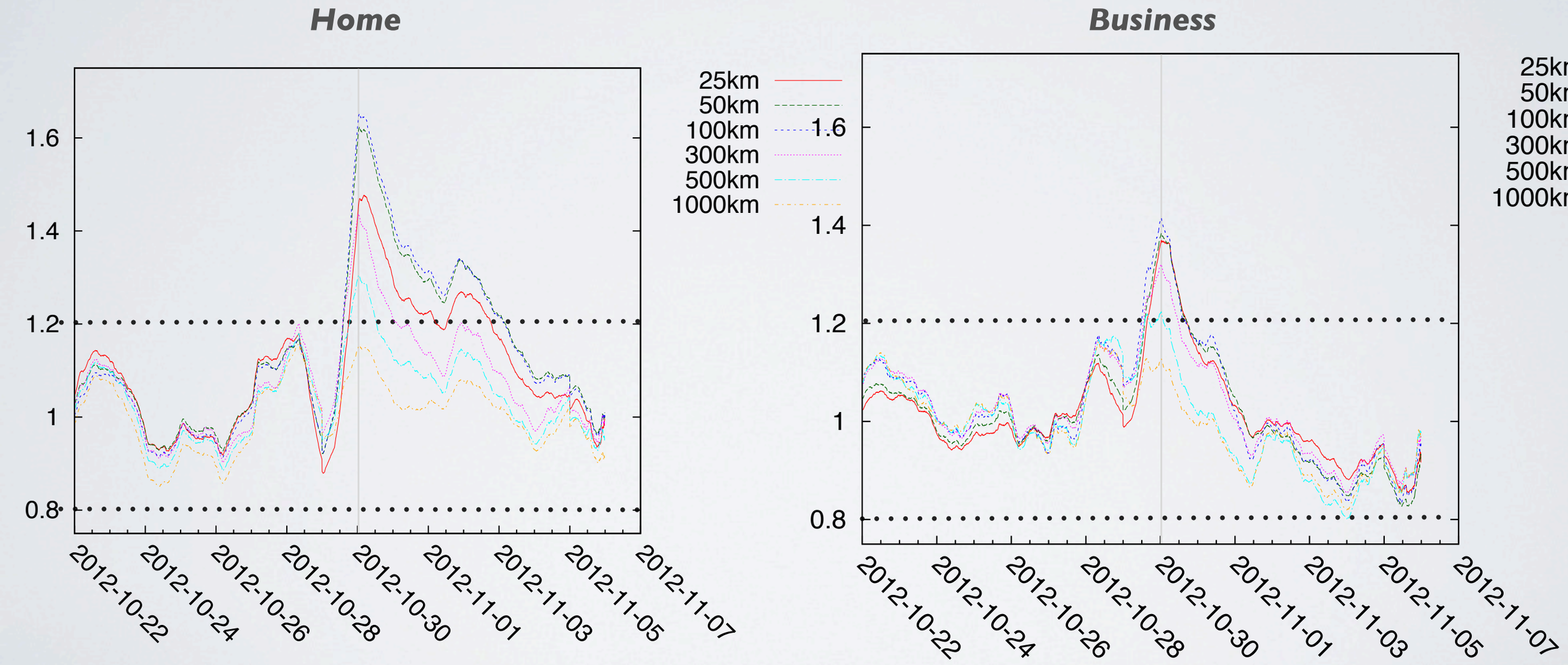
IBR: SANDY IN NYC

Reusing the same metric based on ratio of distinct source IPs



IBR: NY, HOME *vs* BUSINESS

*Different impact on home vs business users**



**** according to NetAcuity***
www.digitalelement.com/NetAcuity

WISHLIST / CURRENT WORK

(partial list)

- ARK
  - Increase (time + space) granularity
  - *wish*: IP Census data, to be used to improve on-demand probing
  - Geo-Ark on demand, for realtime measurements

- Improve tools for geography-based analysis of Internet data
  - which helps also with *realtime analysis* and *combining* different measurements
    - Geolocation of BGP-advertised prefixes
    - Fast/interactively-visual selection of network blocks/prefixes
    - Implement different cartography/geo-analysis techniques (e.g., for IBR)
    - Realtime/Interactive geographical visualization

THANKS