Analysis of Periodic Behaviours in Network Measurements

Massimo Candela
NTT
massimo@ntt.net
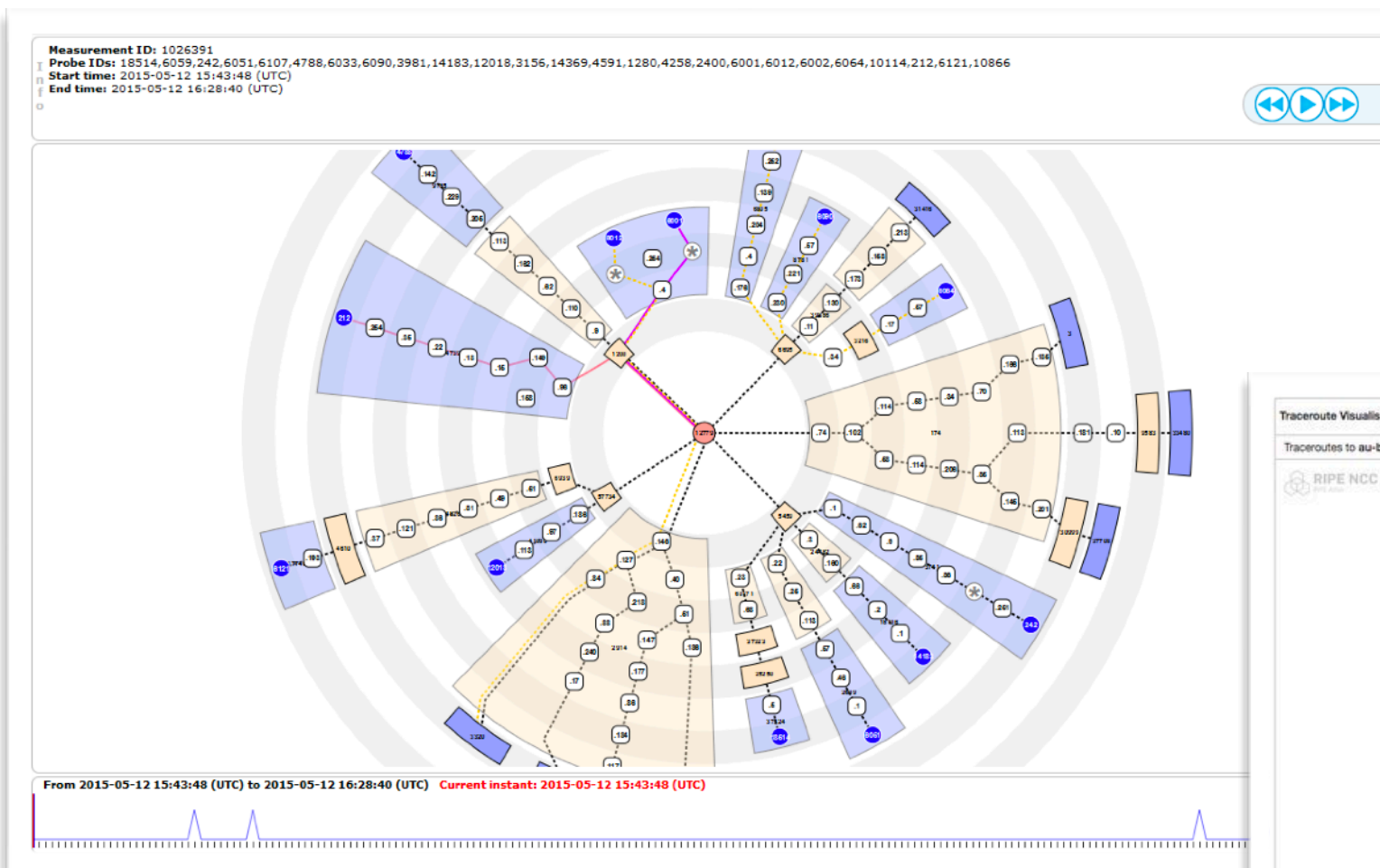
Periodicity
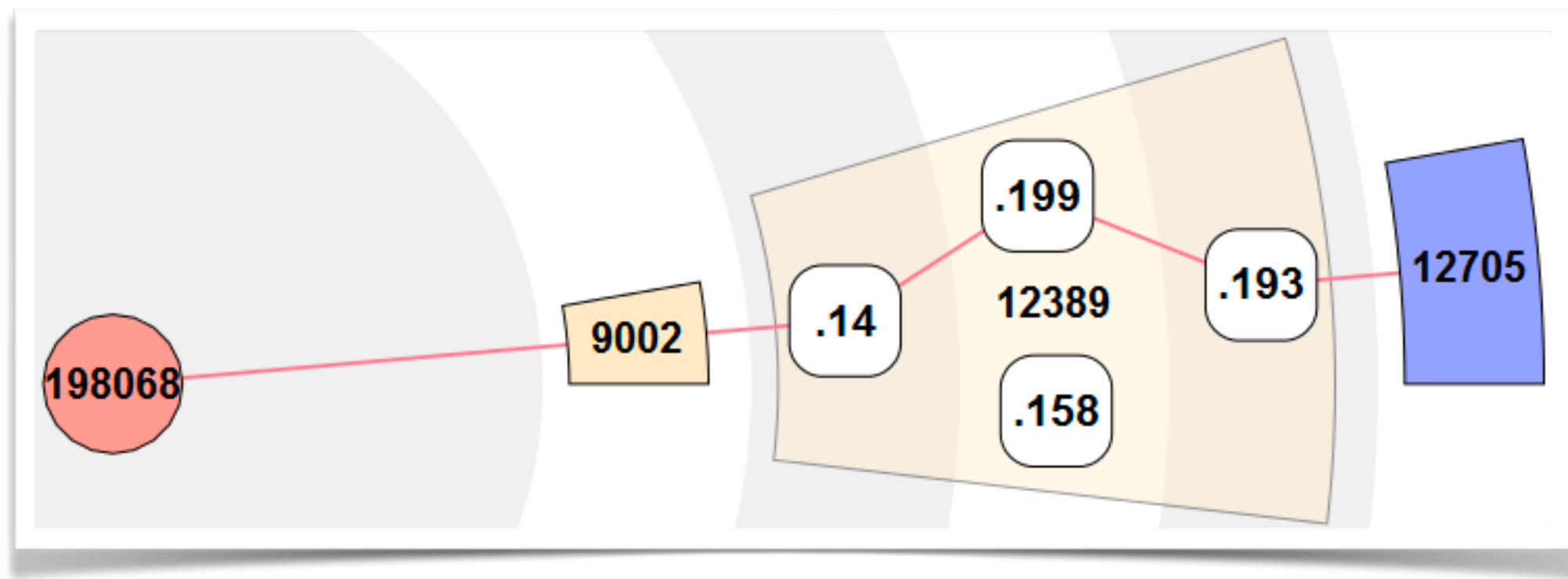
*"In mathematics, a periodic function is a function that repeats its values in **regular intervals** or periods."*

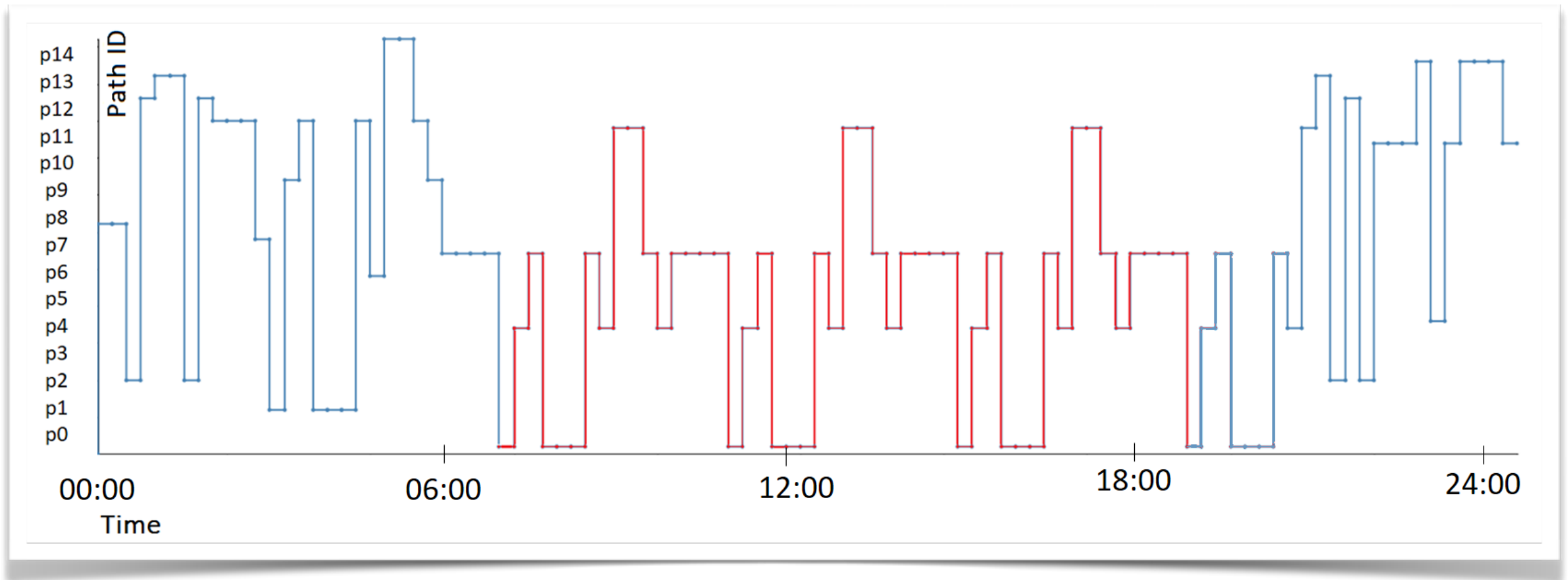-wikipedia

Periodicity in Traceroutes
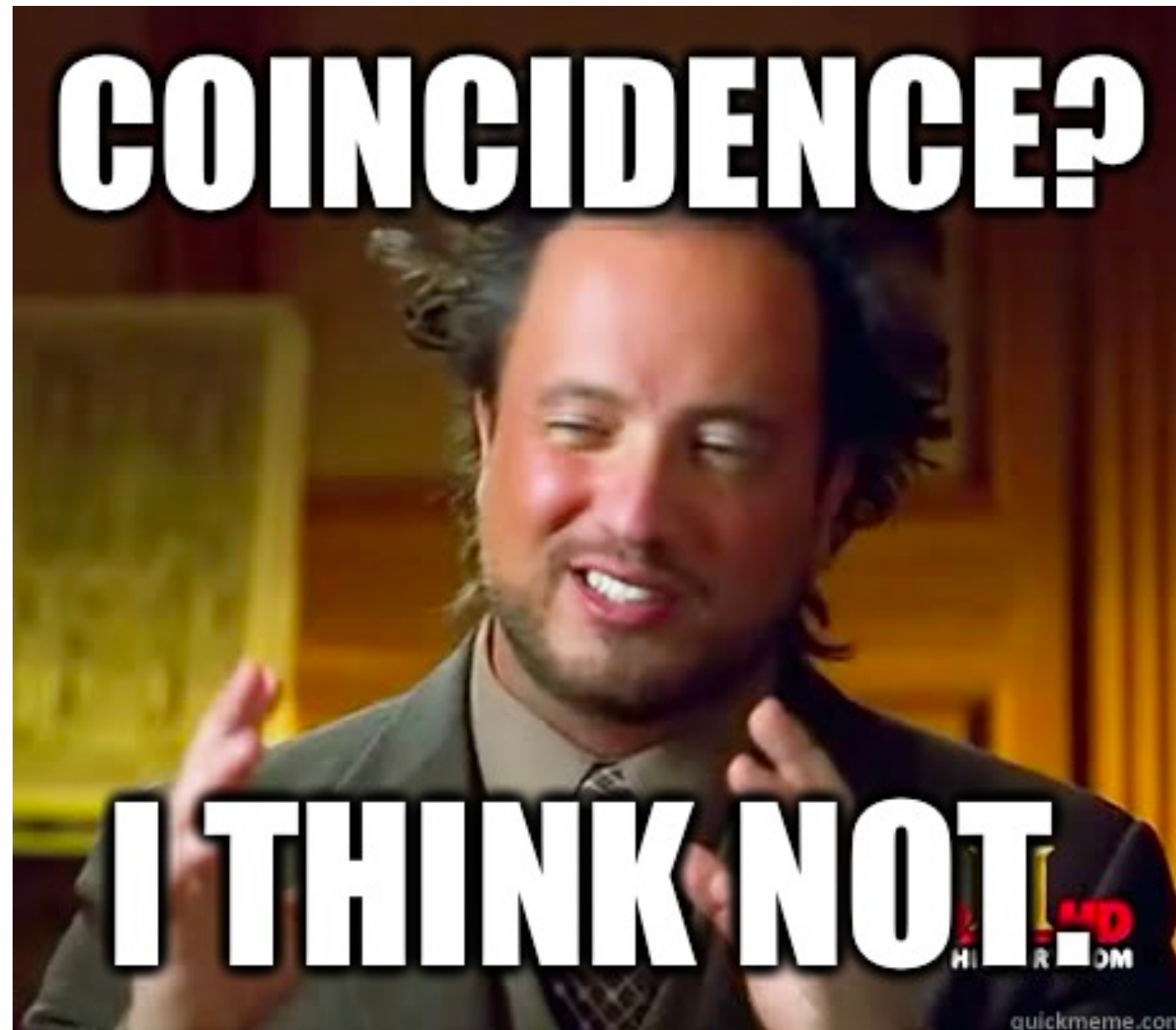
Periodicity in Traceroutes

- We are not talking about path diversity… we are talking about path changing ("somehow") with **a specific period**!

Periodicity in Traceroutes

- The traceroutes are issued from probe 18326 to anchor br-sao-as22548

- A periodic interval is present from 7:00 to 19:00.

- The period lasts 4 hours.

- The periodic pattern is [p0, p4, p7, p0, p0, p0, p7, p4, p12, p12, p7, p4, p7, p7, p7, p7] x 3

Periodicity in Traceroutes

We want to…

- Understand better the dynamics of large-scale of Internet topology measurements datasets

- Quantify periodic behaviours in traceroutes

- Determine if they depend on artefacts of the used data set or on real topology changes of the network

The Dataset

- Anchoring Measurements, produced by RIPE Atlas

- The traceroutes are performed by 9738 probes towards 258 anchors, every 15 minutes

- We analysed **68 million** traceroutes (a week)

The Algorithm

- We created an algorithm able to find periodicity in the traceroute domain

- We tested/tuned the algorithm in a synthetic dataset of known characteristics (including insertion noise)

- We applied the algorithm to the real dataset

- Read more at https://ieeexplore.ieee.org/document/8718284 (open access)

We Found that…

36% of the source-destination pairs exhibit periodicities

- 79%, the period is repeated at most 10 times

- 88.5%, have at most 10 paths

  - But.. some more than 100 paths

- 70%, last less than 2 hours

  - Some last at least a week

- Only 0.15% are inter-AS

  - Lookups IP to AS are done with MAP-IT

  - Path diversity, just not periodic

ICMP Rate Limits

- 32% of the found periodicities present an alternation two paths where one IP is replaced by a *

  - Which is the results of a probe packet never coming back

  - Usually close to the source or the target (up to 61% in the first 3 hops)

- ICMP rate limiting can be the cause of it. However, it is hard to imagine a router that applies such limit periodically

  - Another explanation is that RIPE Atlas generates periodic bursts of ICMP traffic causing periodic discards

    - We determine the rate of ICMP packets injected into the network by each probe involved in such behaviour

    - The number of packets can variate from 0 to 800 per second, which is higher than average ICMP rate limiting thresholds

ICMP Rate Limiting
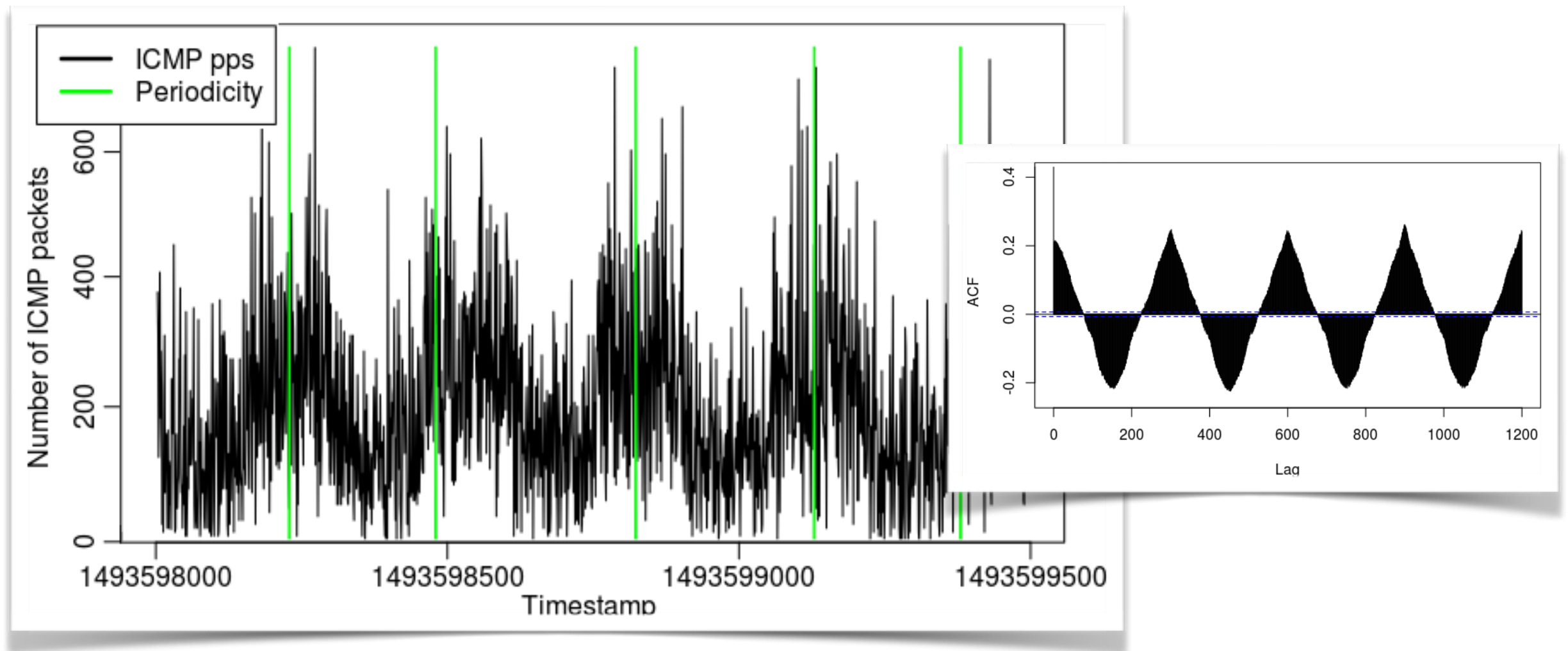
- Measurements in RIPE Atlas tend to synchronise

- 81% of periodicities happen during a burst

Load Balancers

- Anchoring Measurements use Paris traceroute

  - paris_ids are periodically cycled

- This may justify periodic rotation of paths

  - Only if the same path corresponds always to the same paris_id

- 25% of the periodicities are in this category

MPLS Tunnels

- Multi-Protocol Label Switching (MPLS) is a mechanism that enables operators to specify virtual paths through IP networks

  - Various studies show that MPLS generates path diversity because of its use in Traffic Engineering

- Two main router configurations that reveal hints about MPLS

  - RFC4950

  - ttl-propagate

- 8% of the periodicities involve a tunnel in the periodic portion of the path

  - 0.54% tunnel same as periodic portion

  - 7.34% starts inside and ends outside

  - 0.12% starts outside and ends inside

IP Aliases

- Converting a traceroute topology into a router topology requires identifying which addresses belong to the same router (IP alias resolution)

  - We used the Internet Topology Data Kit (by CAIDA)

- While 10.27% of the periodicities were including aliases, **only 0.27% disappear** after alias resolution

  - 0.5% have smaller set of alternating paths

  - 8.07% outside periodic path

  - 1.42% inside periodic path but not influential

In Loving Memory…

Mattia Iodice

- First author of this paper

- Introduced the topic of periodicities of Internet routing at RIPE 74 in Budapest.

- He passed away on April the 3rd, 2018, at the age of 25.

- He was not only a promising researcher but especially *a good friend*.

Questions?

massimo@ntt.net

@webrobotics

Thanks to my co-authors:
- Mattia Iodice
- Giuseppe Di Battista