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

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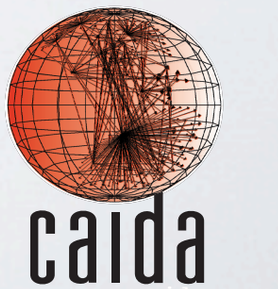
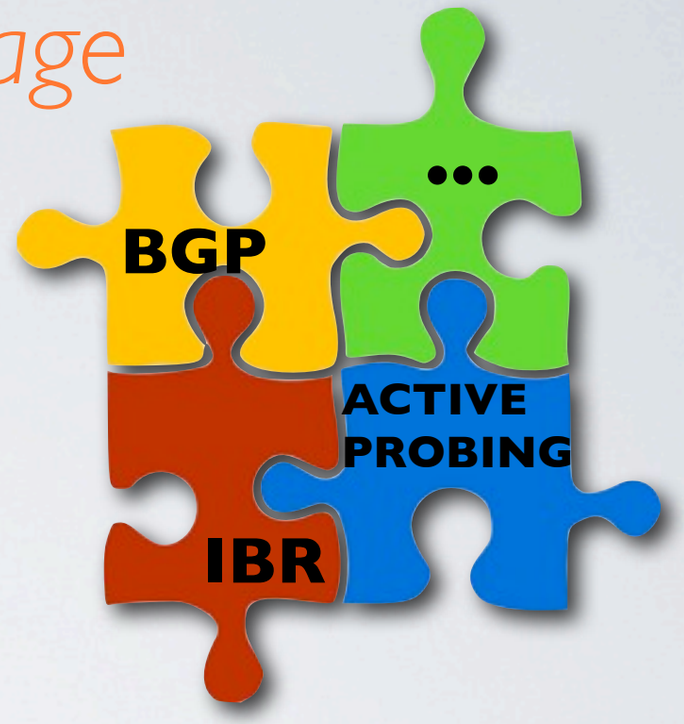


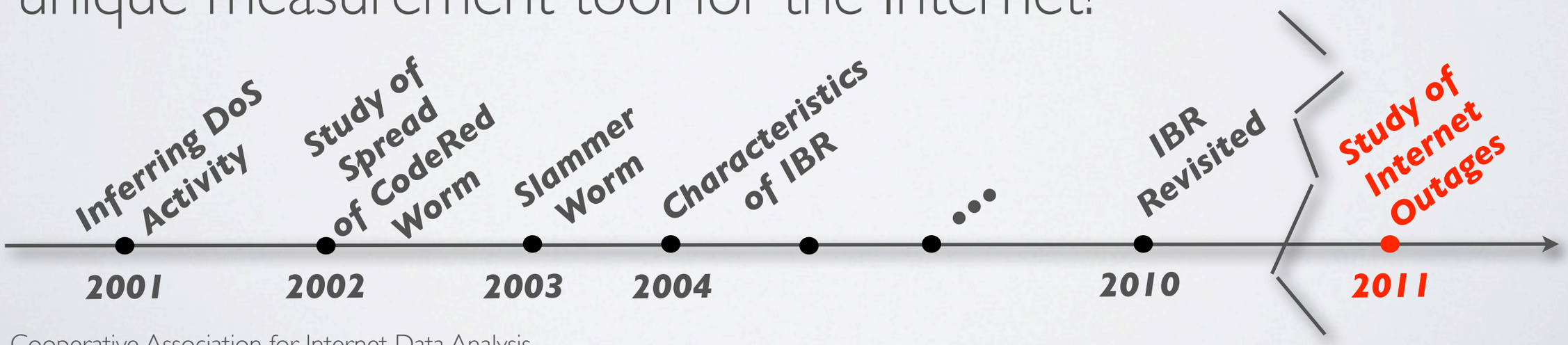
CONTEXT

Project goal & main message

- Analysis of **macroscopic Internet events** using multiple large-scale data sources



- Revival of Network Telescopes: ***Internet Background Radiation*** can be used as a unique measurement tool for the Internet!

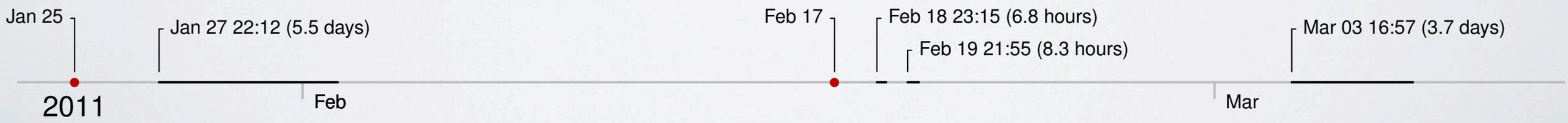


THE EVENTS (1/2)

Internet Disruptions in North Africa

- Egypt
  - *January 25th, 2011*: protests start in the country
  - The government orders service providers to "shut down" the Internet
  - ***January 27th, around 22:34 UTC***: several sources report the withdrawal in the Internet's global routing table of almost all routes to Egyptian networks
  - The disruption lasts ***5.5 days***

- Libya
  - *February 17th, 2011*: protests start in the country
  - The government controls most of the country's communication infrastructure
  - ***February 18th (6.8 hrs), 19th (8.3 hrs), March 3rd (3.7 days):*** three different connectivity disruptions:

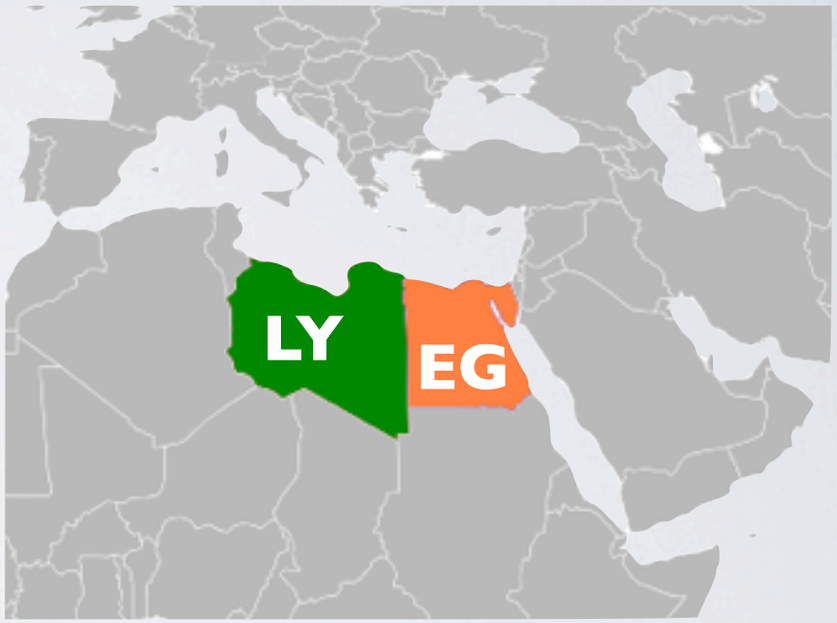


NETWORK INFO

Prefixes, ASes, Filtering

- Egypt
  - **3165 *IPv4*** and 6 *IPv6* **prefixes** are delegated to Egypt by AfriNIC
  - They are managed by **51 Autonomous Systems**

  - **Filtering** type: **BGP only**
  - Filtering dynamic: synchronized; progressive

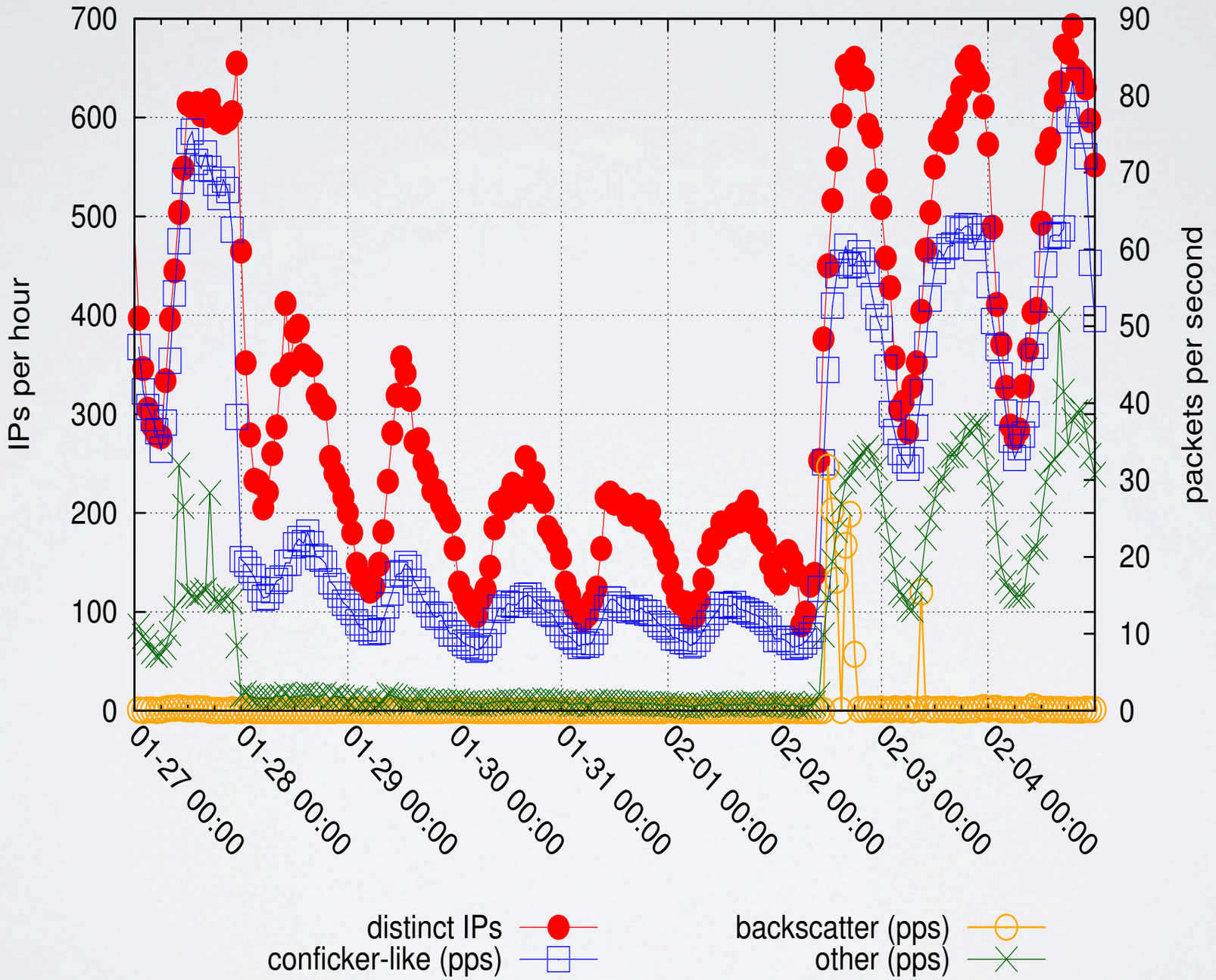


- Libya
  - **13 *IPv4* prefixes**, no *IPv6* prefixes
  - **3 Autonomous Systems** operate in the country

  - **Filtering** type: mix of **BGP, packet filtering, satellite signal jamming**
  - Filtering dynamic: testing different techniques; somehow synchronized

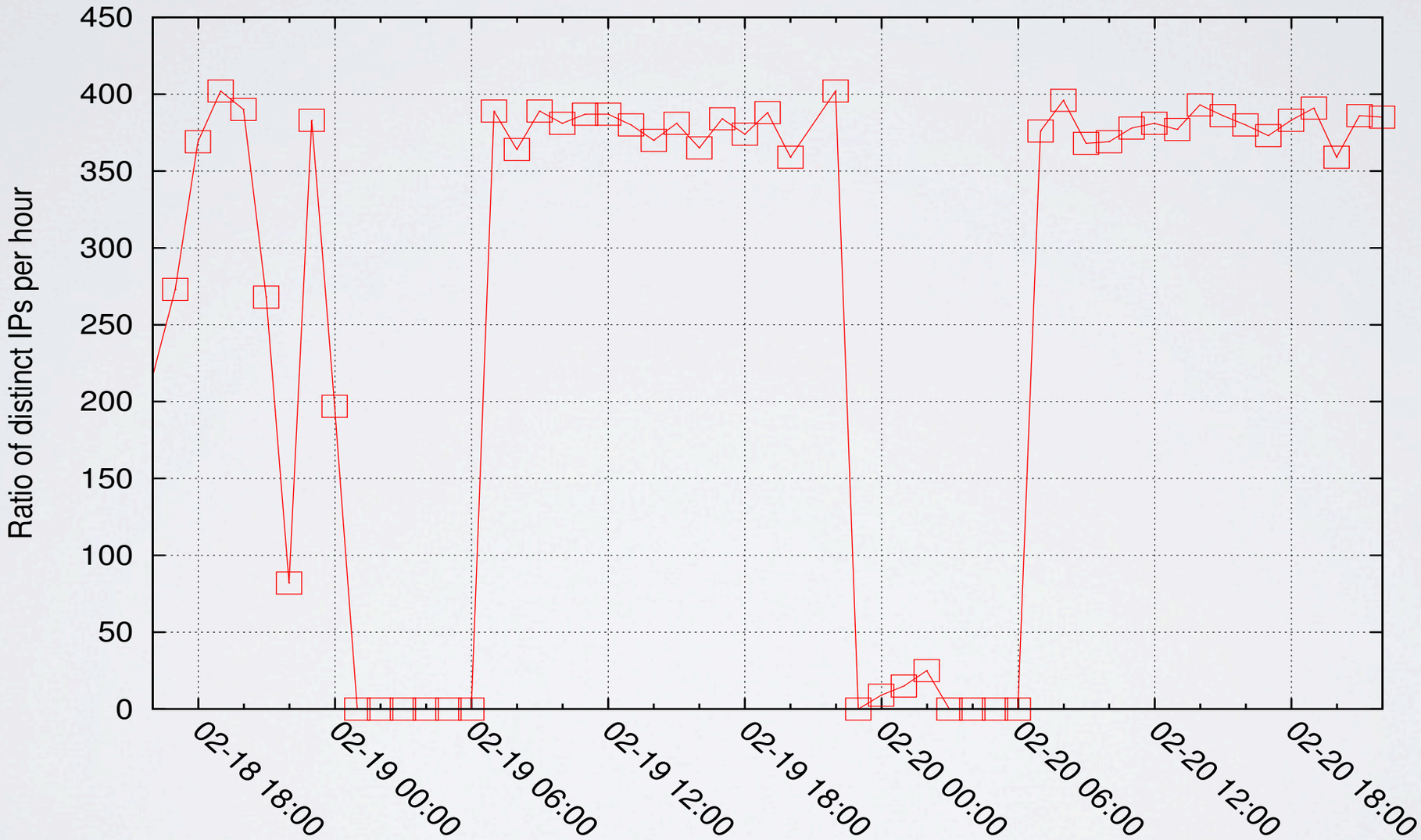
EGYPT

rate of distinct src IPs vs packet rate



LIBYA

the first two outages



THE EVENTS (2/2)

Earthquakes

- Christchurch - NZ
  - *February 21st, 2011* 23:51:42 UTC
  - Local time 22nd, 12:51:42 PM
  - Magnitude: 6.1

- Tohoku - JP
  - *March 11th, 2011* 05:46:23 UTC
  - Local time 02:46:23 PM
  - Magnitude: 9.0

	Christchurch - NZ		Tohoku - JP	
Distance (Km)	Networks	IP Addresses	Networks	IP Addresses
< 5	1	255	0	0
< 10	283	662,665	0	0
< 20	292	732,032	0	0
< 40	299	734,488	0	0
< 80	309	738,062	5	91
< 100	310	738,317	58	42,734
< 200	348	769,936	1,352	1,691,560
< 300	425	828,315	3,953	4,266,264
< 400	1,531	3,918,964	16,182	63,637,753
< 500	1,721	4,171,527	41,522	155,093,650

We use MaxMind GeoLite City DB to compute distance from a given network to the epicenters

A SIMPLE METRIC

to evaluate impact and extension

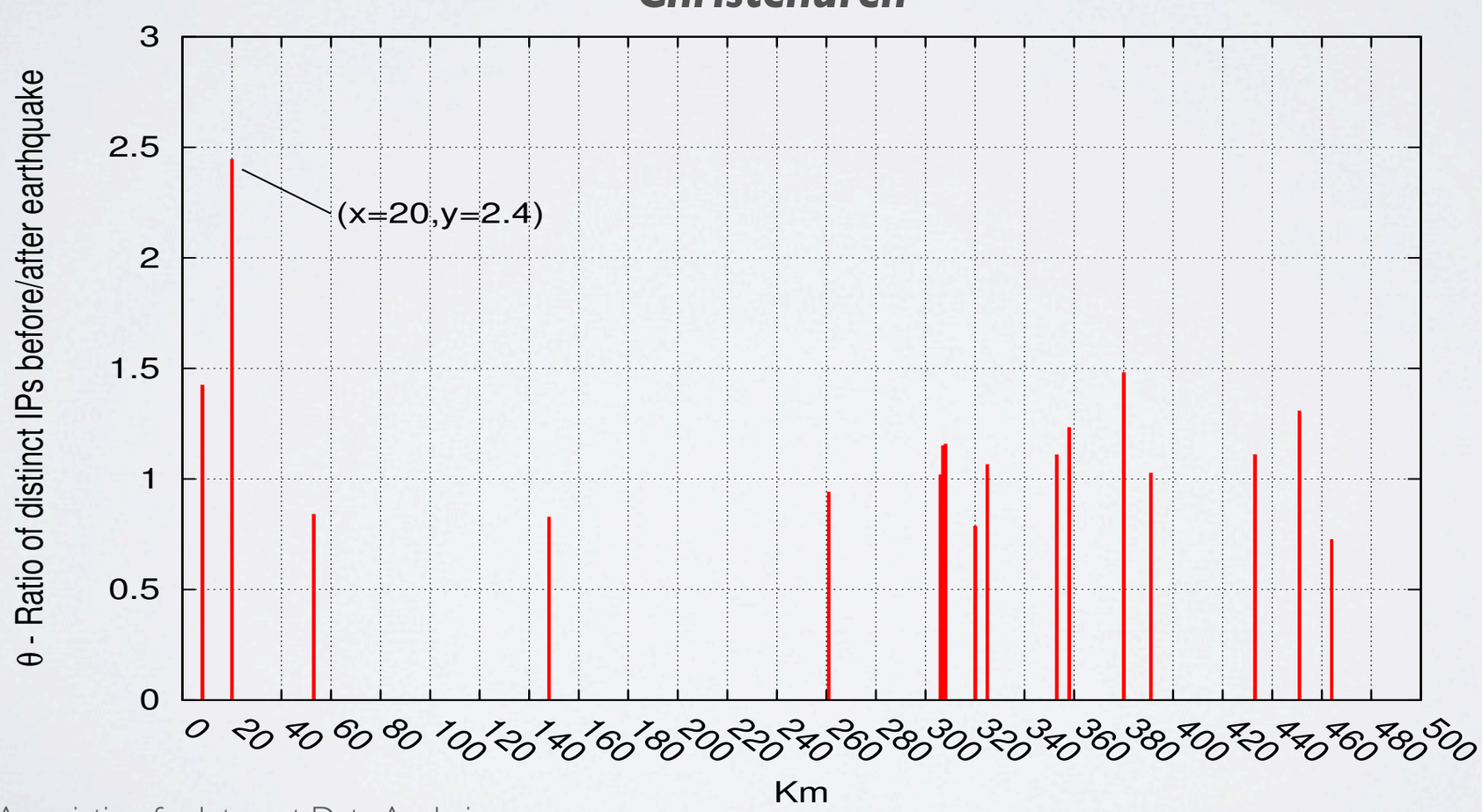
- $I_{\Delta t_i}$ number of distinct source IP addresses seen by the telescope over the interval Δti,
- $\Delta t_1, ..., \Delta t_n$ 1-hour time slots ***following*** the event
- $\Delta t_{-1}, ..., \Delta t_{-n}$ 1-hour time slots ***preceding*** the event

$$\theta = \frac{\sum_{i=-1}^{-24} I_{\Delta t_i}}{\sum_{j=1}^{24} I_{\Delta t_j}}$$

RADIUS OF IMPACT

rough estimate based on θ

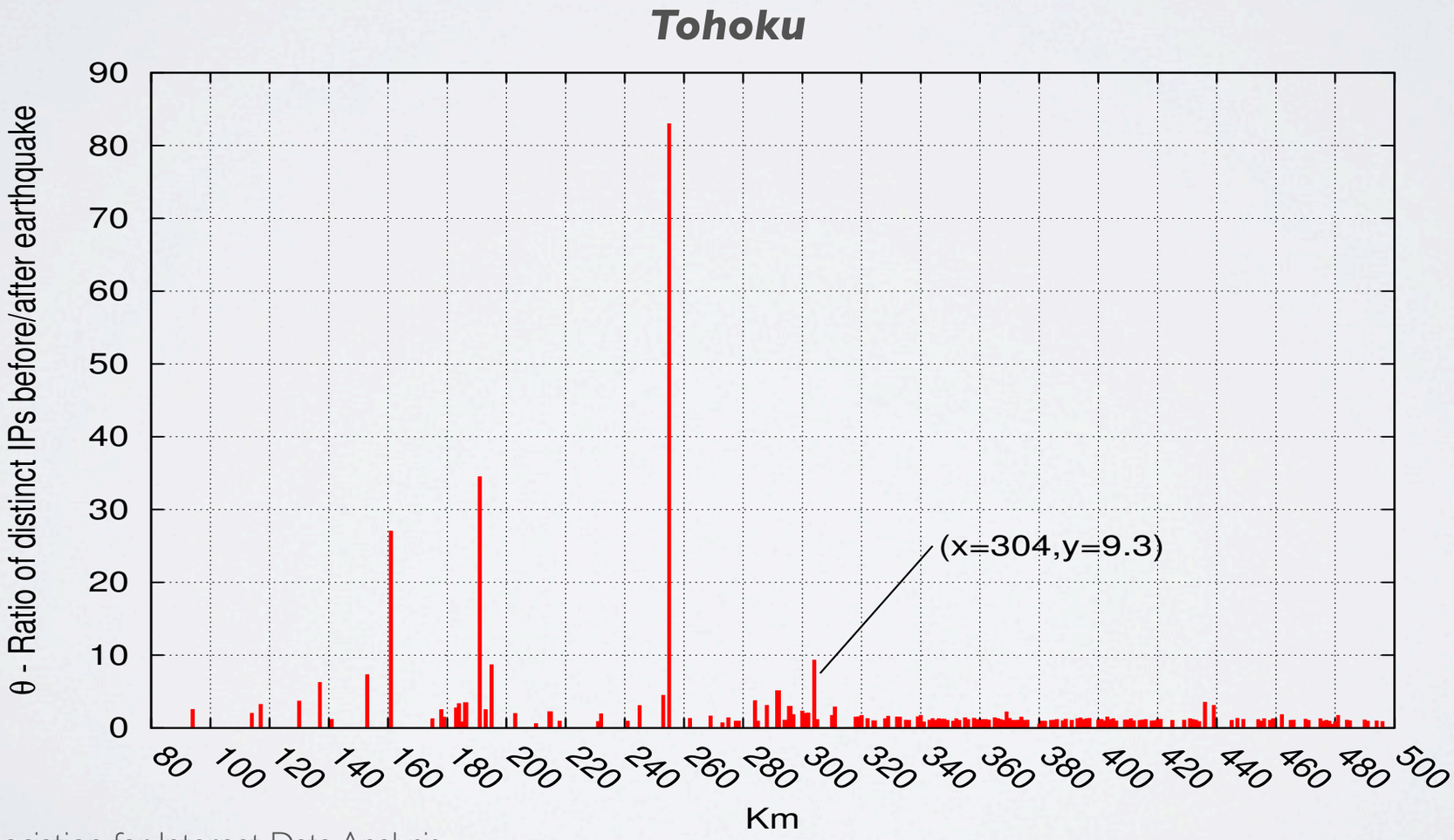
- We compute θ for address ranges geolocated at different distances from the epicenter of the earthquake *(0 to 500km in bins of 1km each)*
- θ around 1 indicates no substantial change in the number of unique IP addresses observed in IBR before and after the event.



RADIUS OF IMPACT

rough estimate based on θ

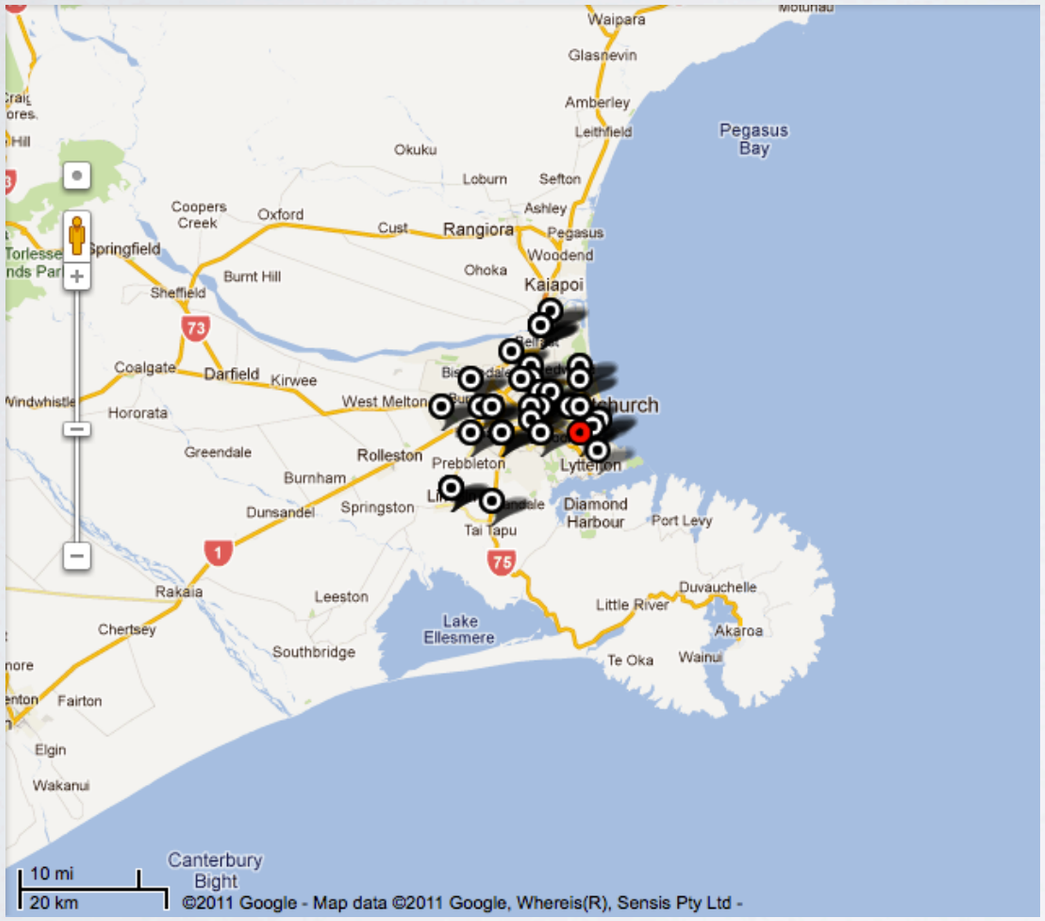
We call ρ_{max} the maximum distance at which we observe a value of θ significantly > 1



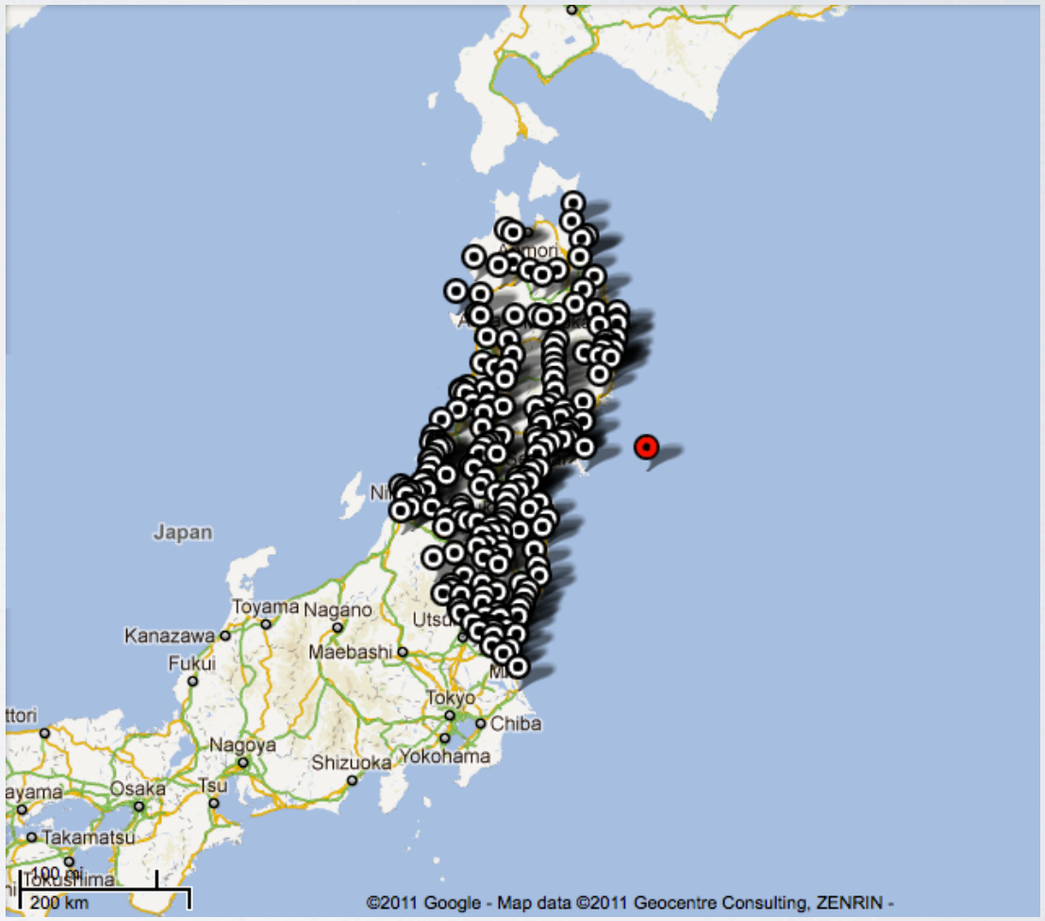
EXTENSION OF IMPACT

geo coordinates of most affected networks

Networks within each respective ρ_{max}



(a) Christchurch

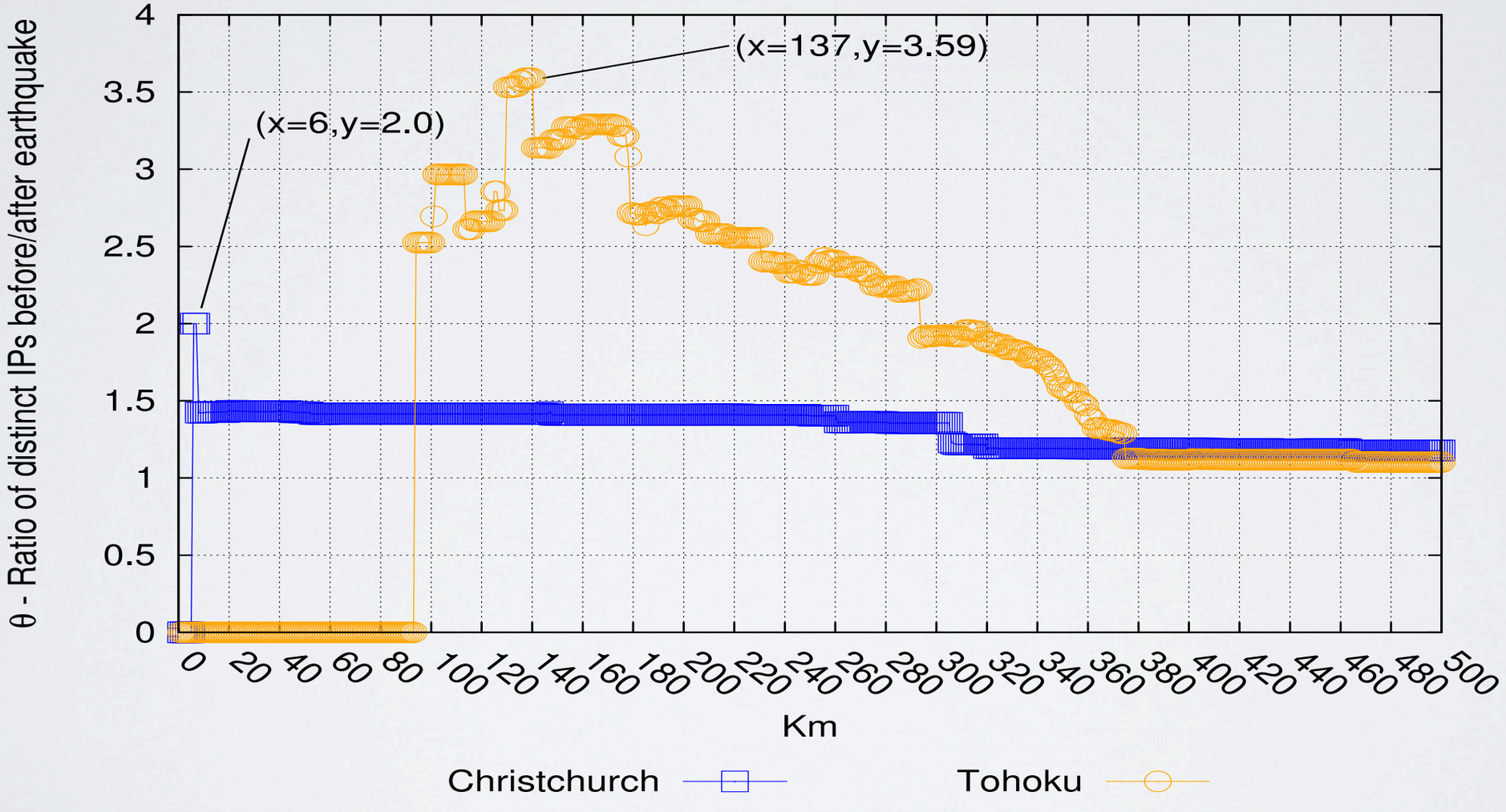


(b) Tohoku

"MAGNITUDE"

A measure of impact

- Varying the radius, we pick the highest value of θ calculated for *the whole set of* networks within the corresponding circle



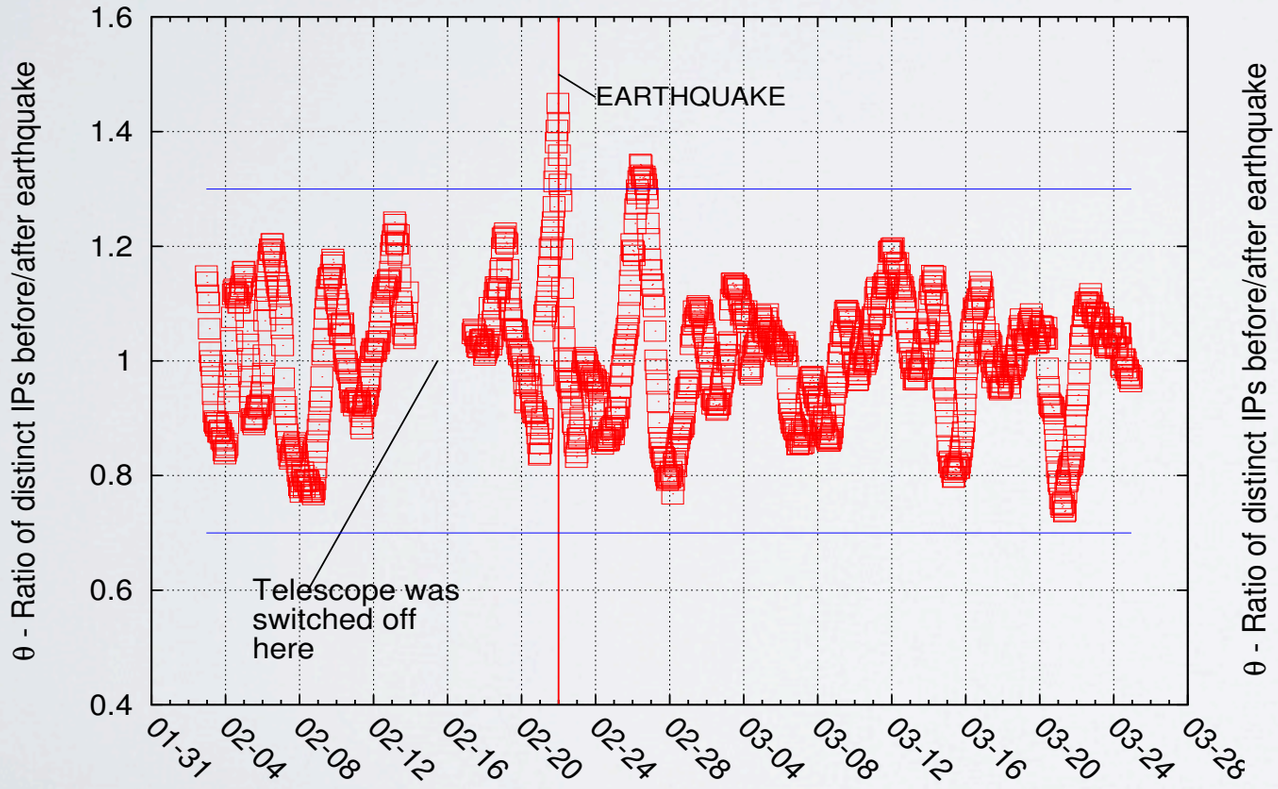
	Christchurch	Tohoku
Magnitude (θ_{max})	2 at $6km$	3.59 at $137km$
Radius (ρ_{max})	$20km$	$304km$

EVALUATING Θ

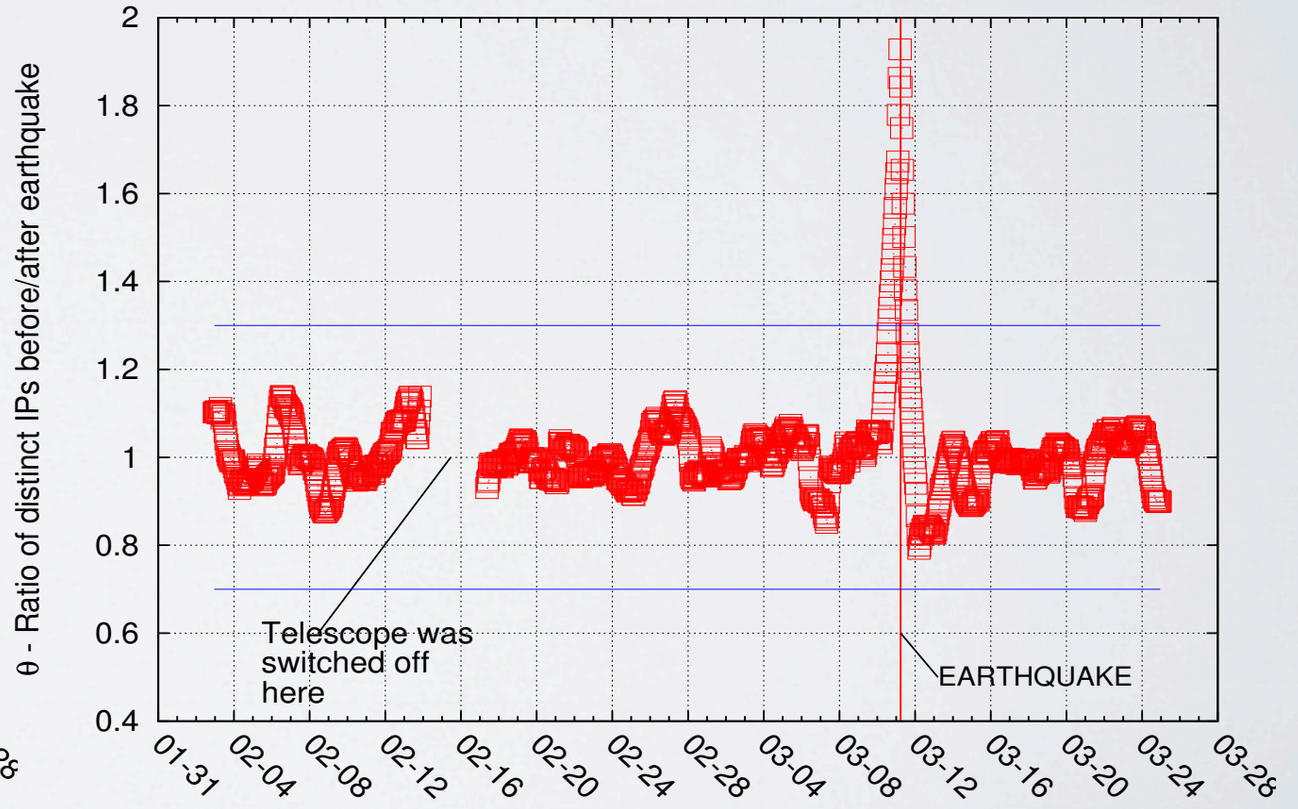
variations over a long time period

- 2 months period of observation
- θ normally stays within [0.7 - 1.3]

Christchurch



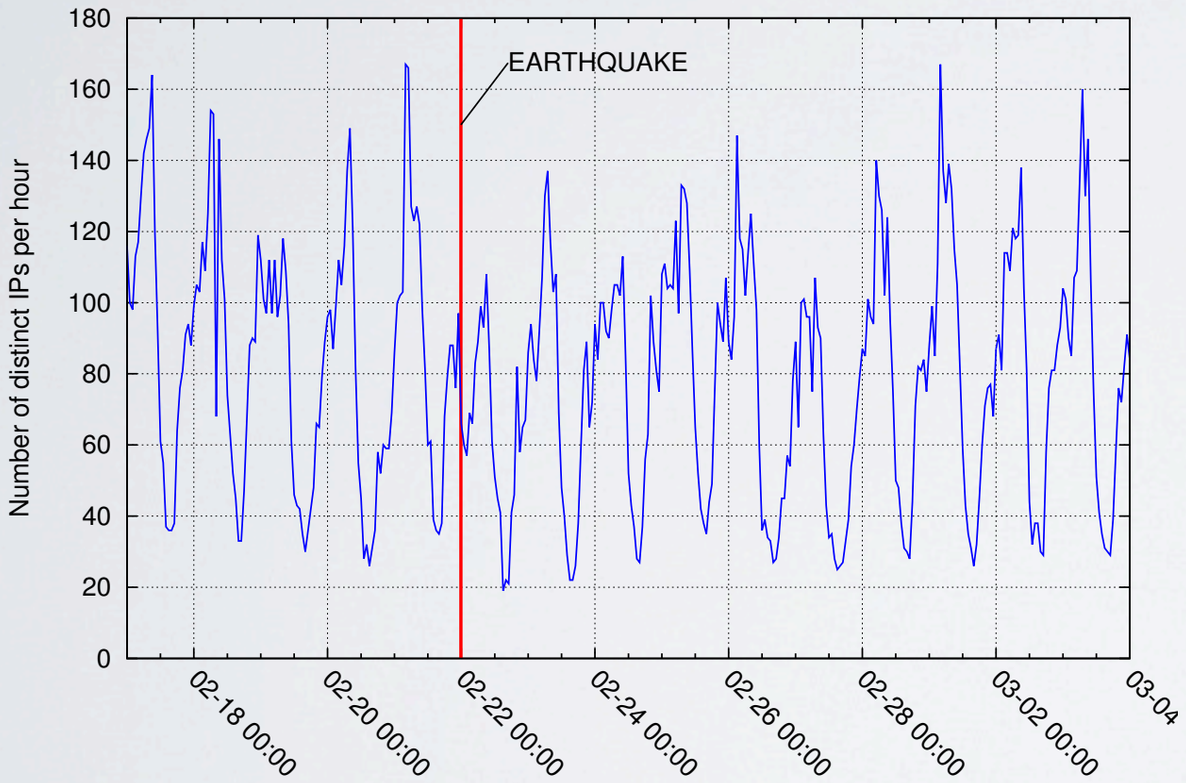
Tohoku



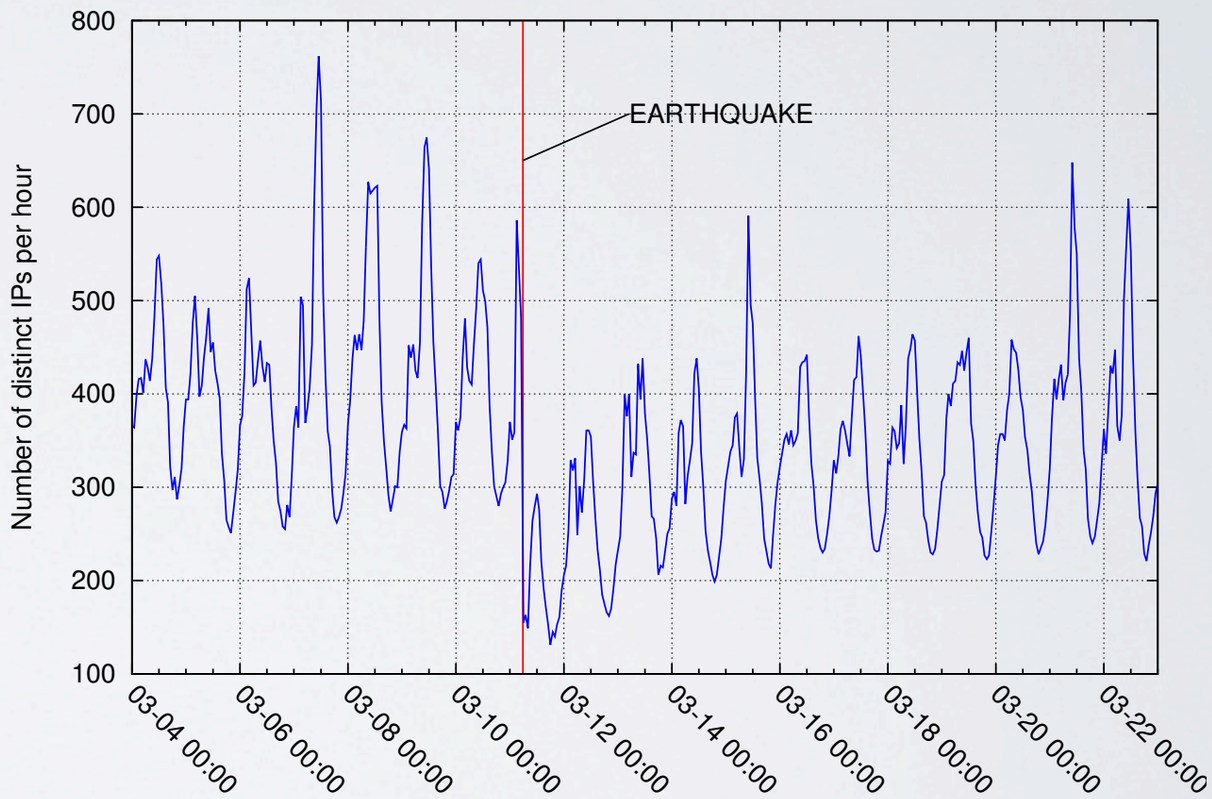
IP RATE IN TIME

reflects the dynamics of the event

Christchurch



Tohoku



CONCLUSION

ongoing work

- IBR is an effective source of data for the analysis of network outages caused by events of different typology

- Future work
  - Integrate and combine analysis of multiple data sources (BGP, IBR, active measurement, ...)
  - Analysis of AS/Link-level topology
  - Automated detection + triggered active measurements

THANKS

Cooperative Association for Internet Data Analysis
University of California San Diego