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RoutingWatch

Visual Exploration and Analysis of Routing Events

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RoutingWatch

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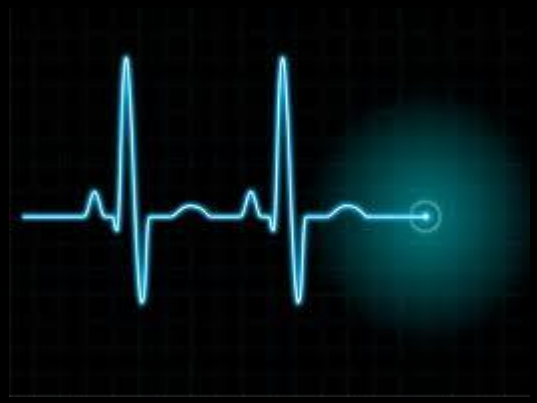

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State of the Art

Management & Monitoring Tools	Inference Algorithms	Visualization Systems

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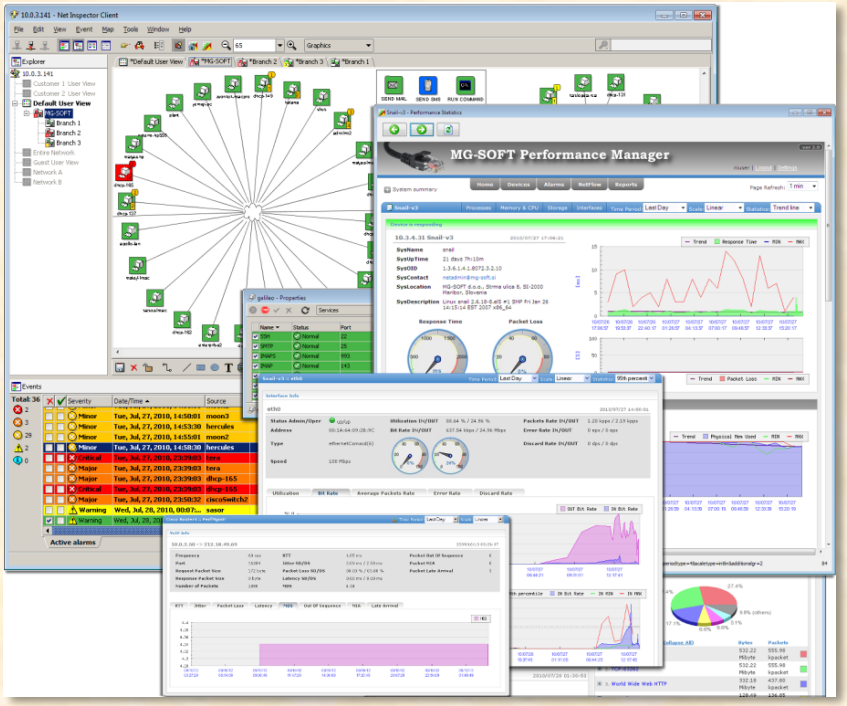
State of the Art

Management & Monitoring Tools | Inference Algorithms | Visualization Systems

Net Inspector



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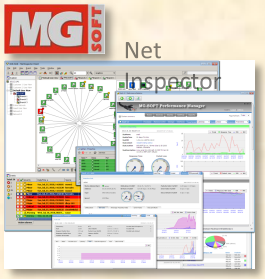

CISCO™ Embedded Event Manager

```
event manager applet interface_Shutdown
event syslog pattern "Interface FastEthernet1/0, changed
      state to administratively down"
action 1.0 cli command "enable"
action 1.5 cli command "config t"
action 2.0 cli command "interface fa1/0"
action 2.5 cli command "no shutdown"
action 3.0 cli command "end"
action 3.5 cli command "who"
action 4.0 mail server "192.168.1.1" to
      ".engineer@cisco.com." from ".EEM@cisco.com."
      subject ".ISP1_Interface_fa1/0_SHUT." body "Current
      users $_cli_result"
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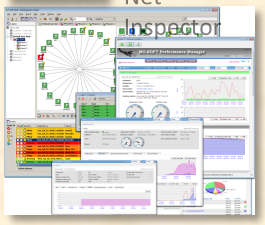
MG SOFT Net Inspector



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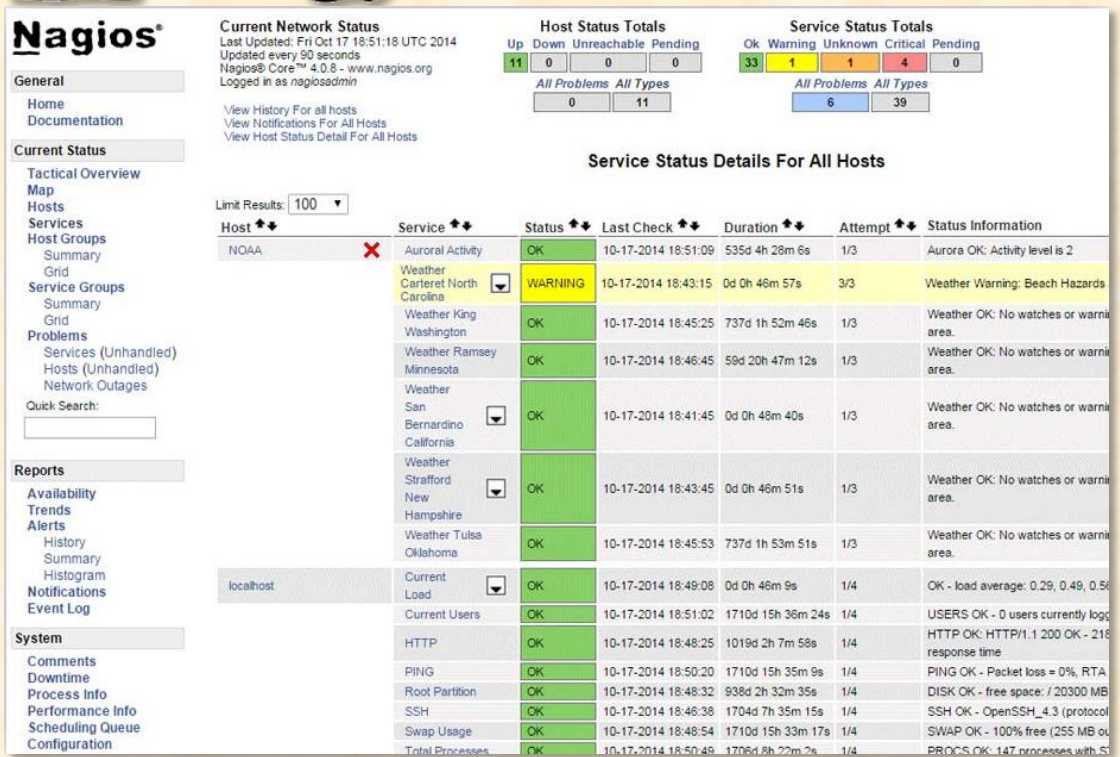
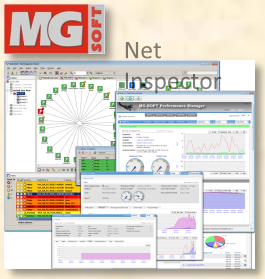
Nagios® Monitoring System



State of the Art

Management & Monitoring Tools | Inference Algorithms | Visualization Systems



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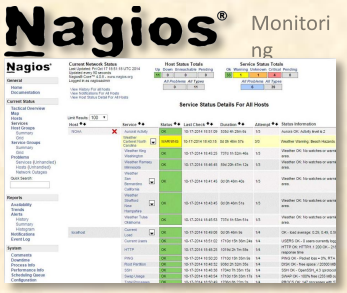
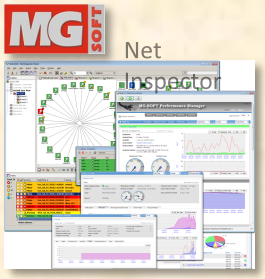


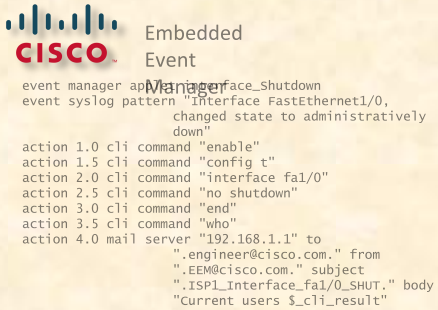
Monitoring

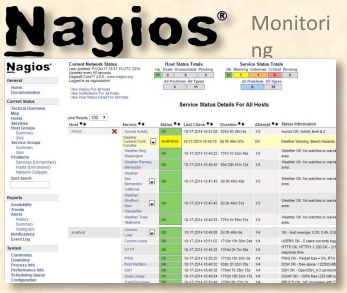
- Raise alarms based on unexpected changes in:
  - performance levels (bandwidth)
  - health flags (interface status)
  - configurations

State of the Art

Management & Monitoring Tools | Inference Algorithms | Visualization Systems







- Raise alarms based on unexpected changes in:
  - performance levels (bandwidth)
  - health flags (interface status)
  - configurations
- Require polling and/or agents
- Must support many technologies

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- J. Wu, Z. M. Mao, J. Rexford, and J. Wang, “Finding a Needle in a Haystack: Pinpointing Significant BGP Routing Changes in an IP Network”. Proc. NSDI, 2005
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- Focus on BGP
- Long-term Internet evolution studies
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  - Future work envisions combined investigation of **space and time**, assessment of the **type of routing change**, **event inference**
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- M. Di Bartolomeo, V. Di Donato, M. Pizzonia, C. Squarcella, and M. Rimondini, “Mining Network Events using Traceroute Empathy”. Tech. Rep., 2015 http://arxiv.org/abs/1412.4074v2.pdf
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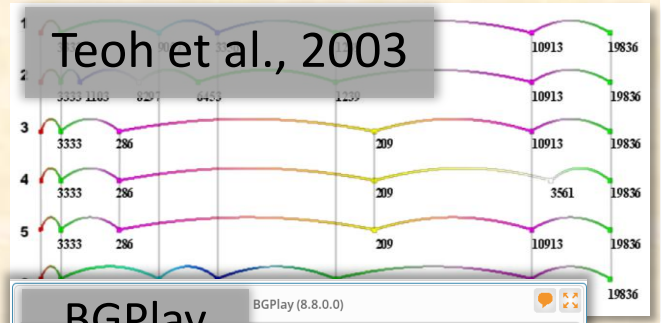
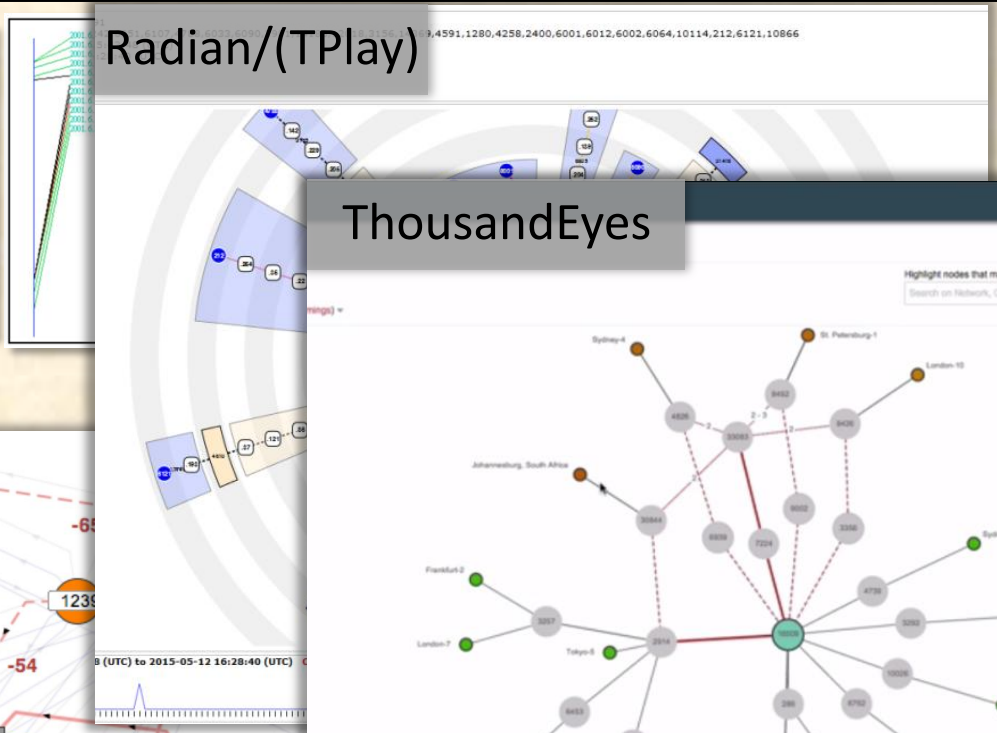
Teoh et al., 2003

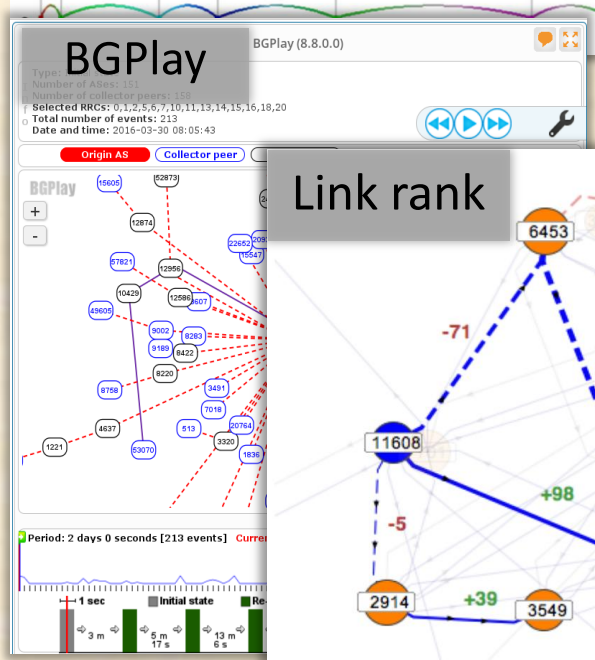


Radian/(TPlay)

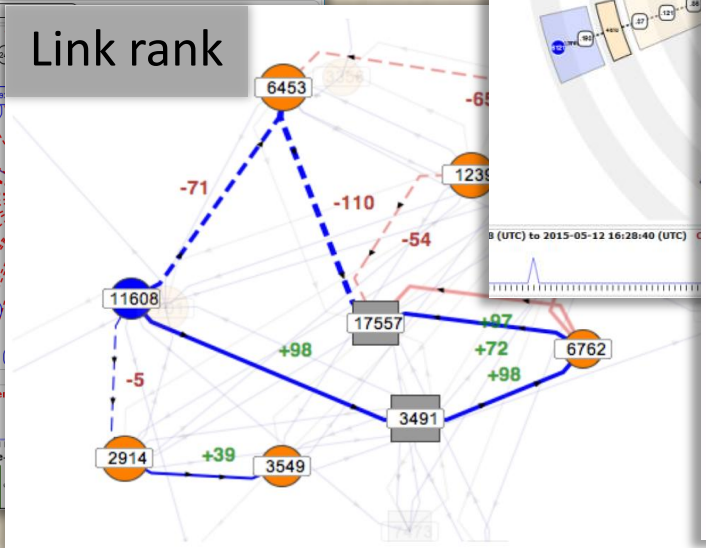


ThousandEyes

BGPlay



Link rank



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RoutingWatch

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Traceroutes → Events

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Traceroutes → Events

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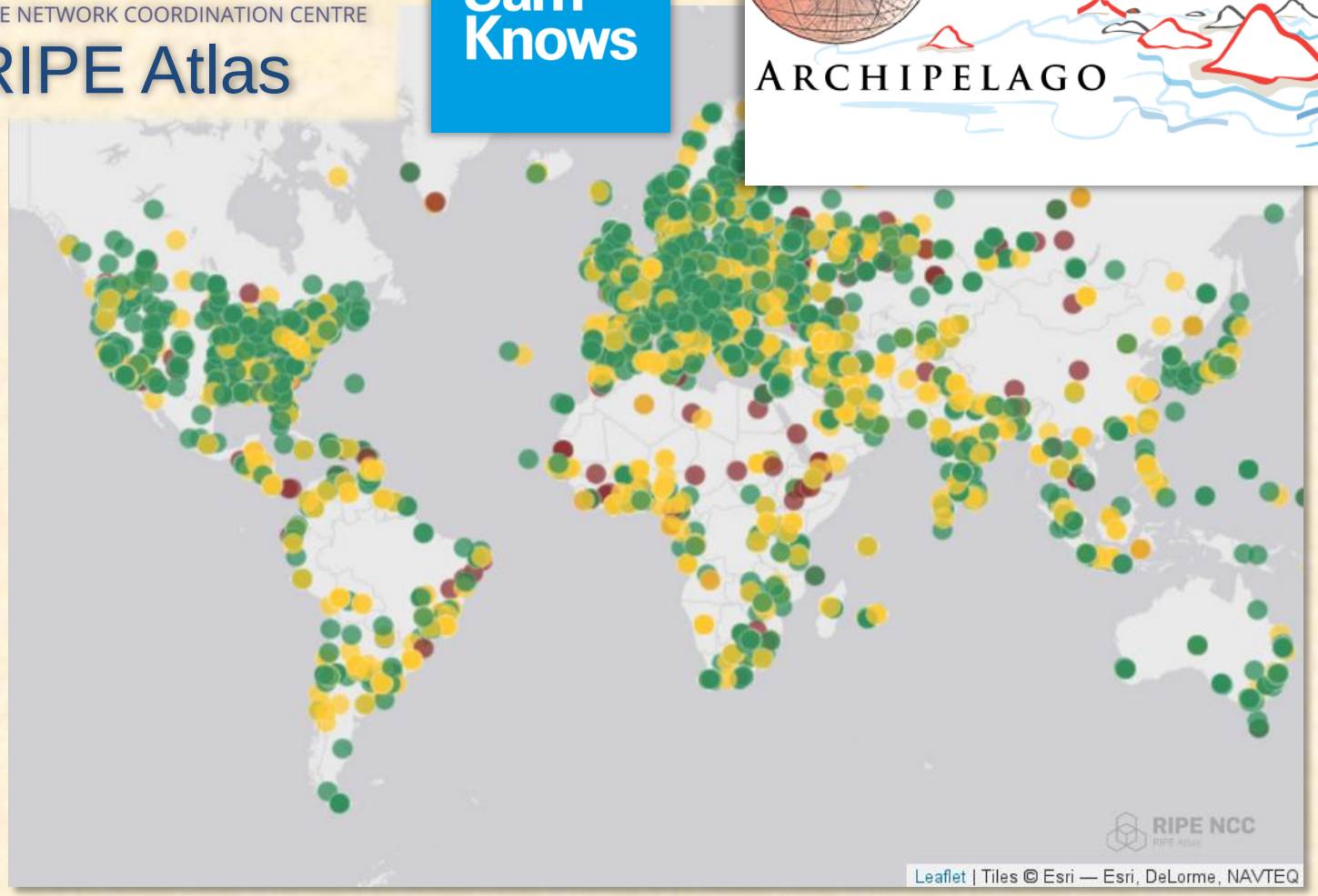
Traceroutes → Events

RIPE NCC
RIPE NETWORK COORDINATION CENTRE
RIPE Atlas

Sam Knows

caida
ARCHIPELAGO



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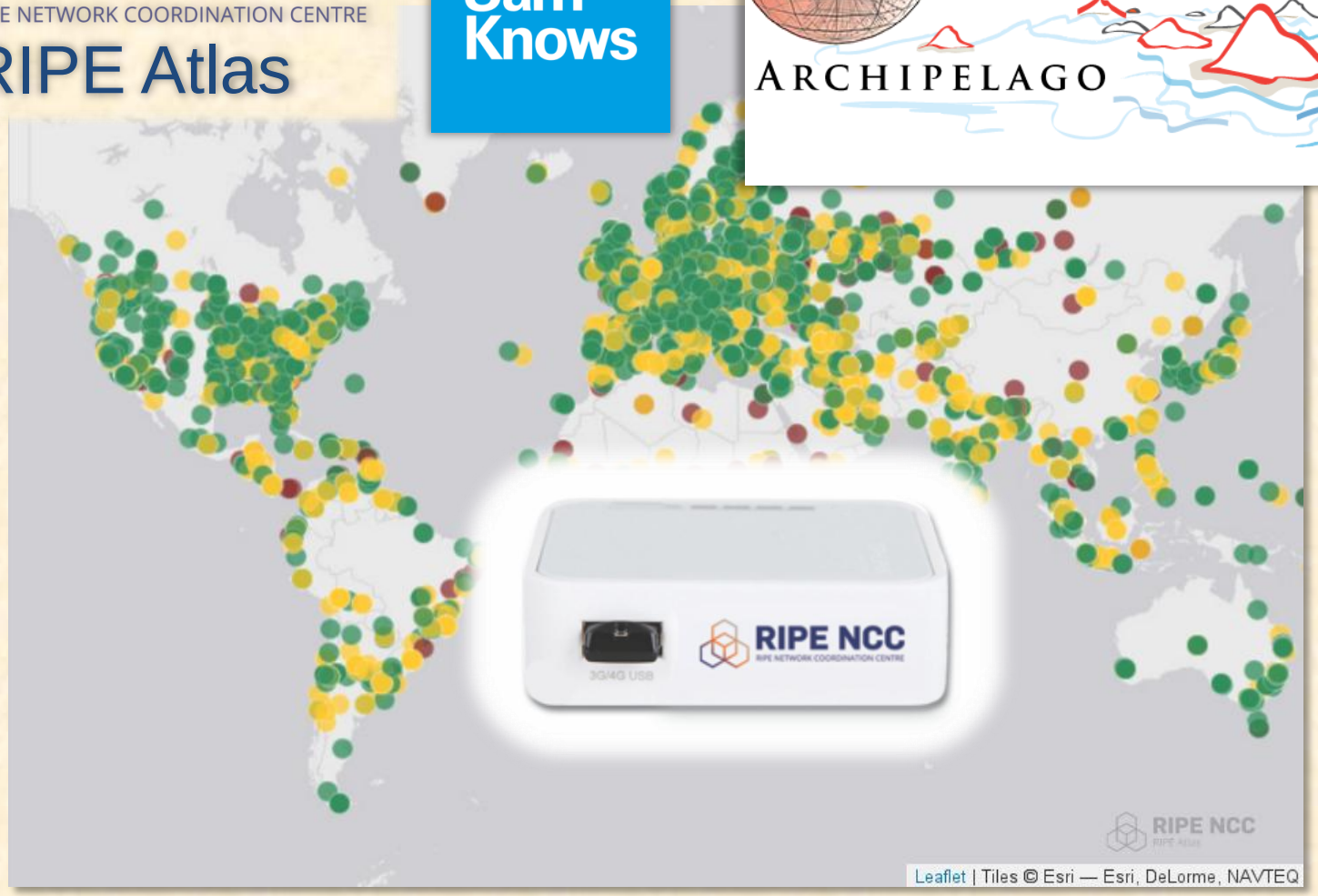


Traceroutes → Events

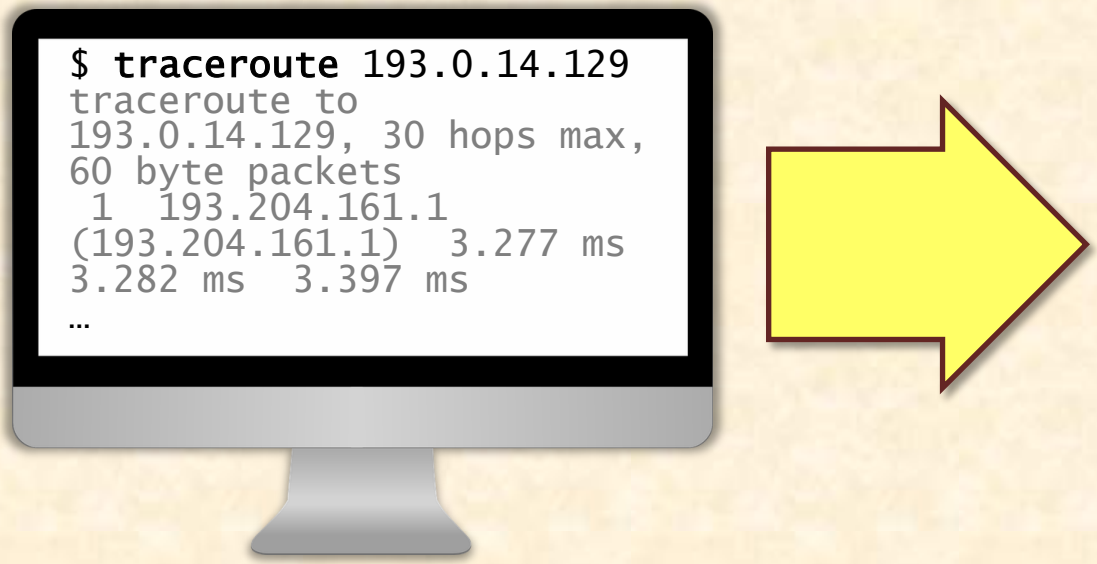
RIPE NCC
RIPE NETWORK COORDINATION CENTRE

Sam Knows

caida
ARCHIPELAGO

```
$ traceroute 193.0.14.129
traceroute to
193.0.14.129, 30 hops max,
60 byte packets
 1  193.204.161.1
(193.204.161.1)  3.277 ms
3.282 ms  3.397 ms
…
```

Traceroutes → Events



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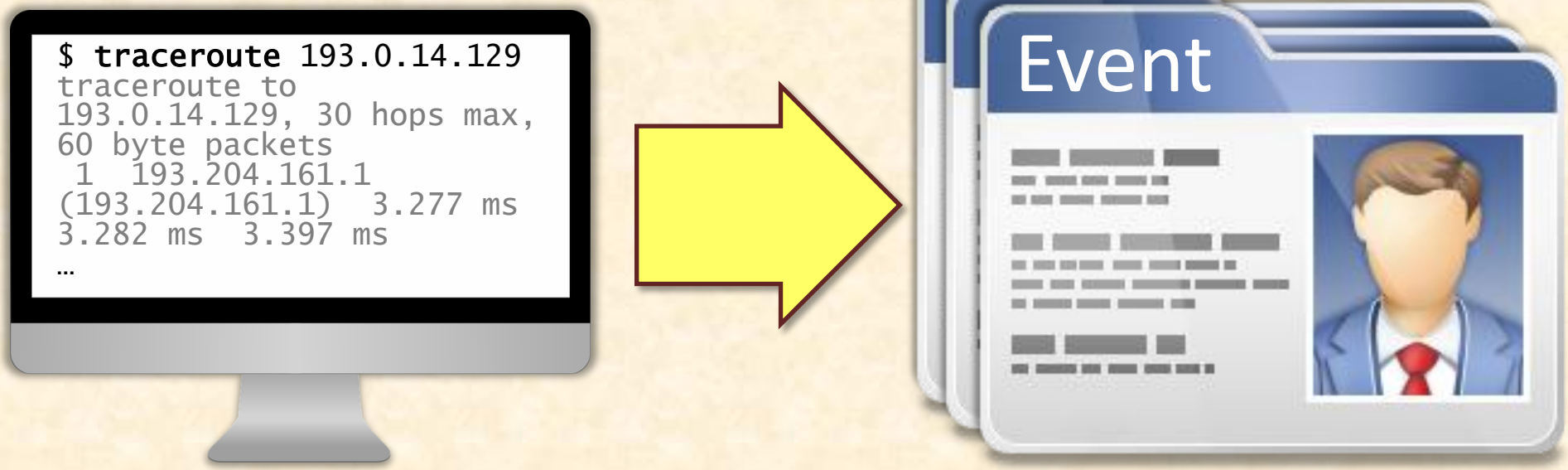

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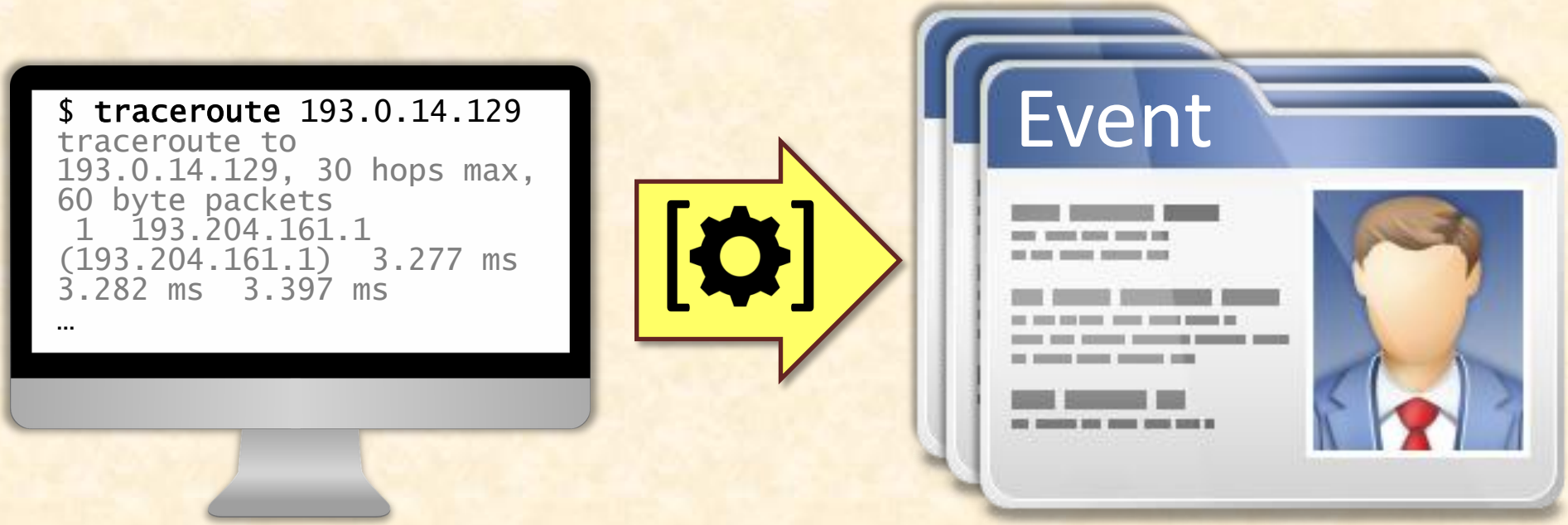

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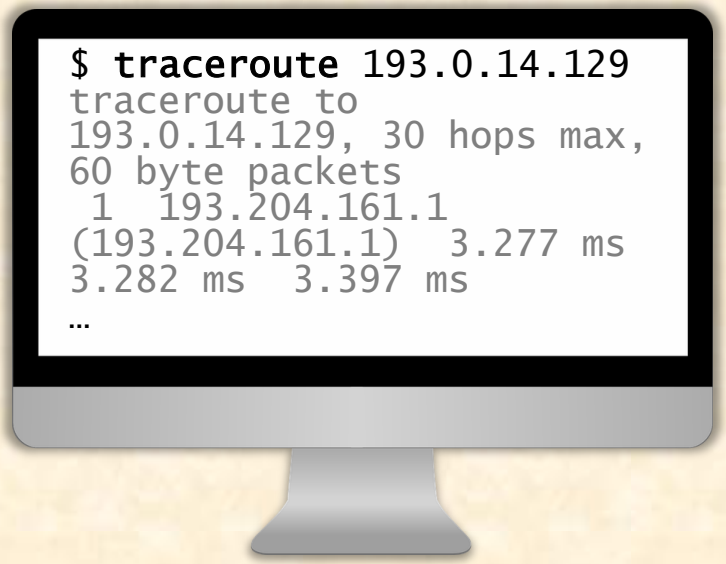

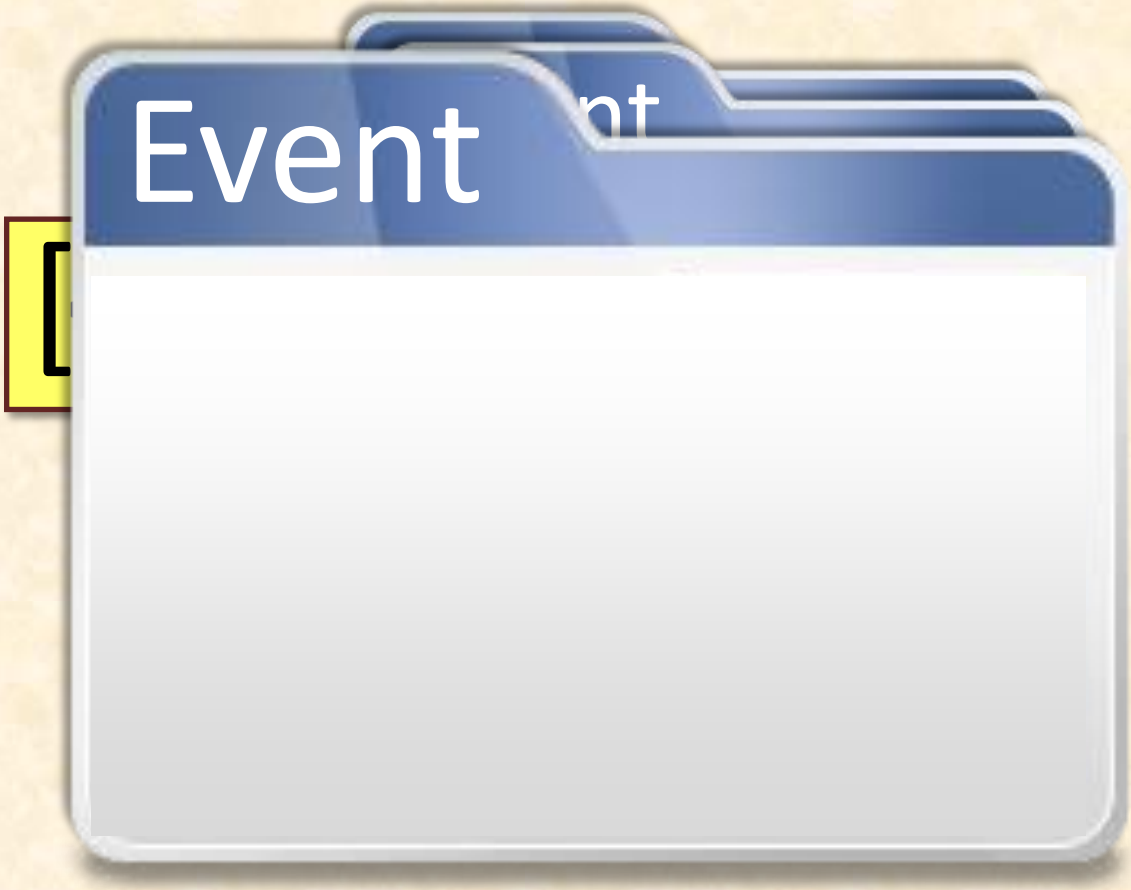

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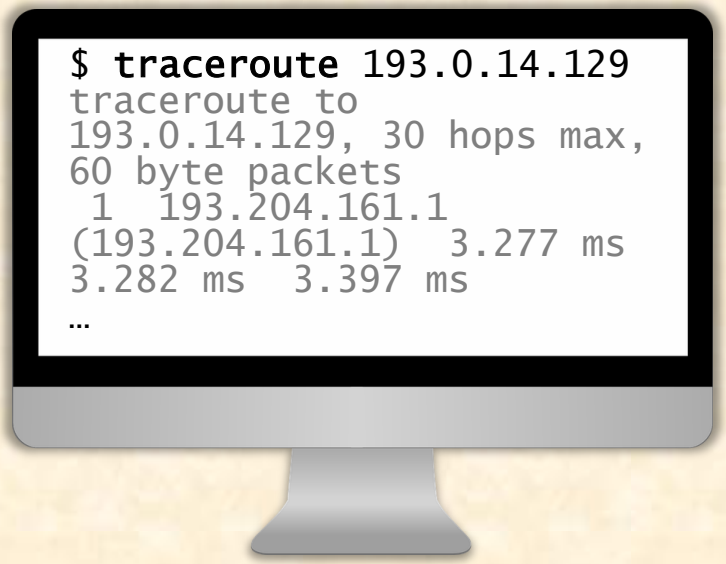

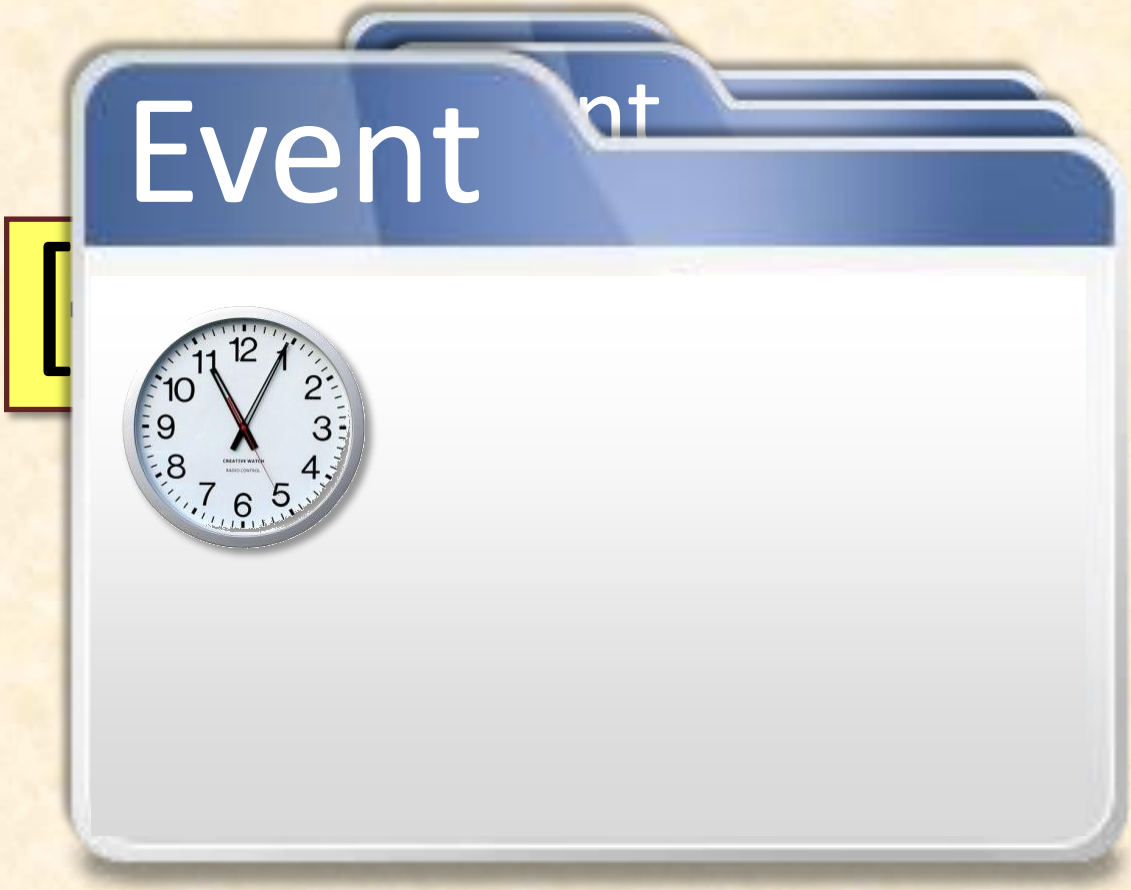

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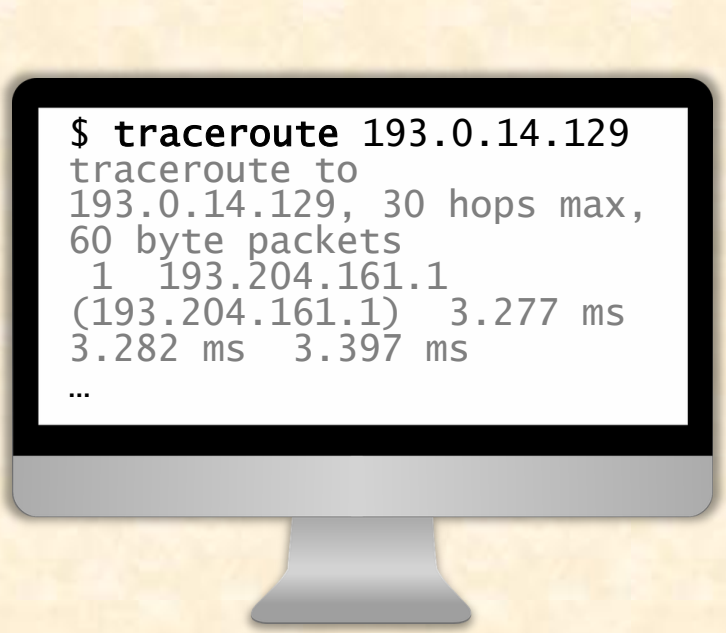

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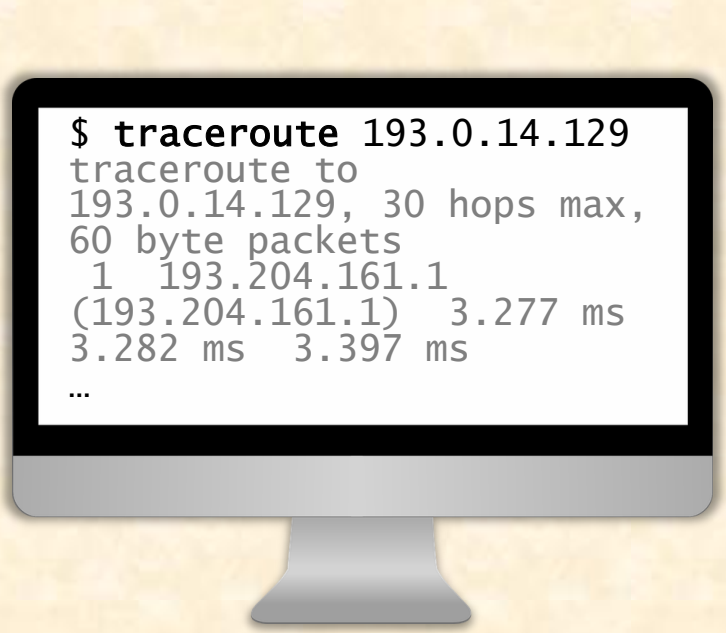

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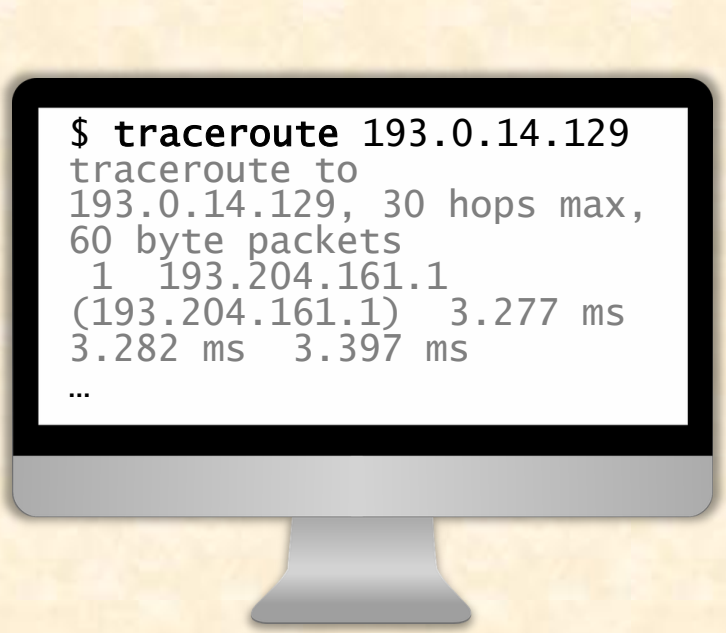

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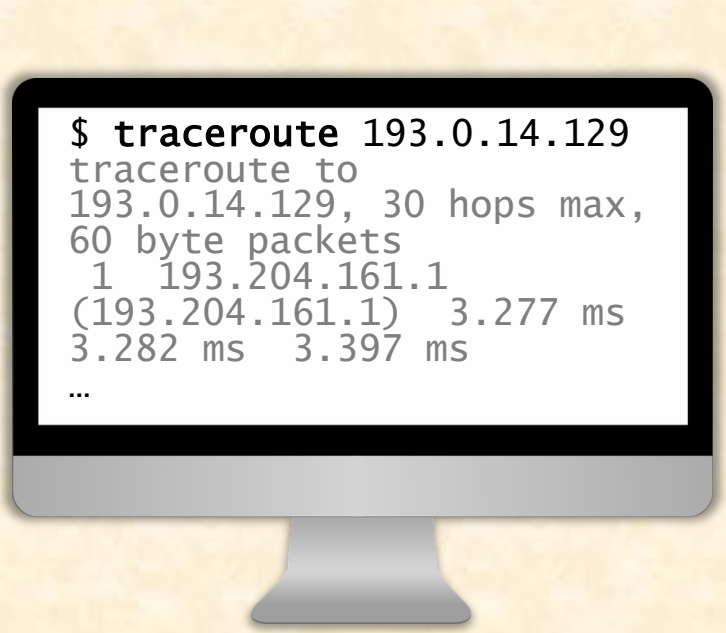

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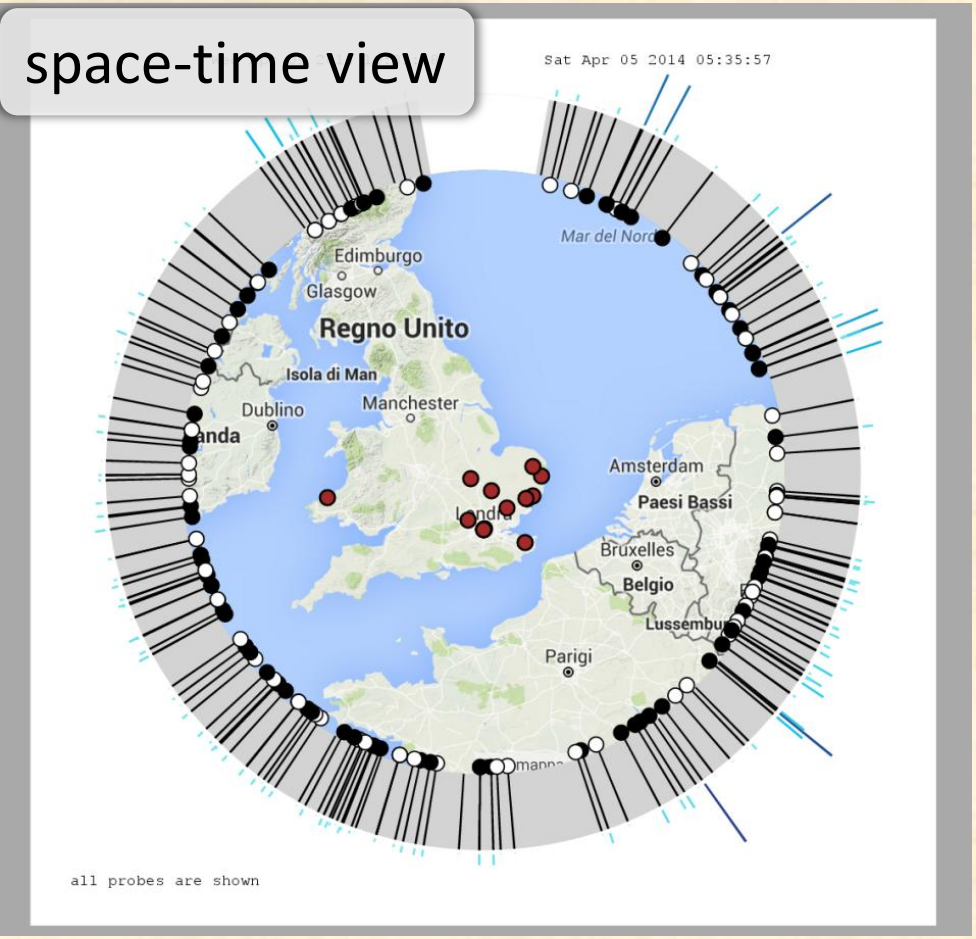
User interface

User interface

space-time view



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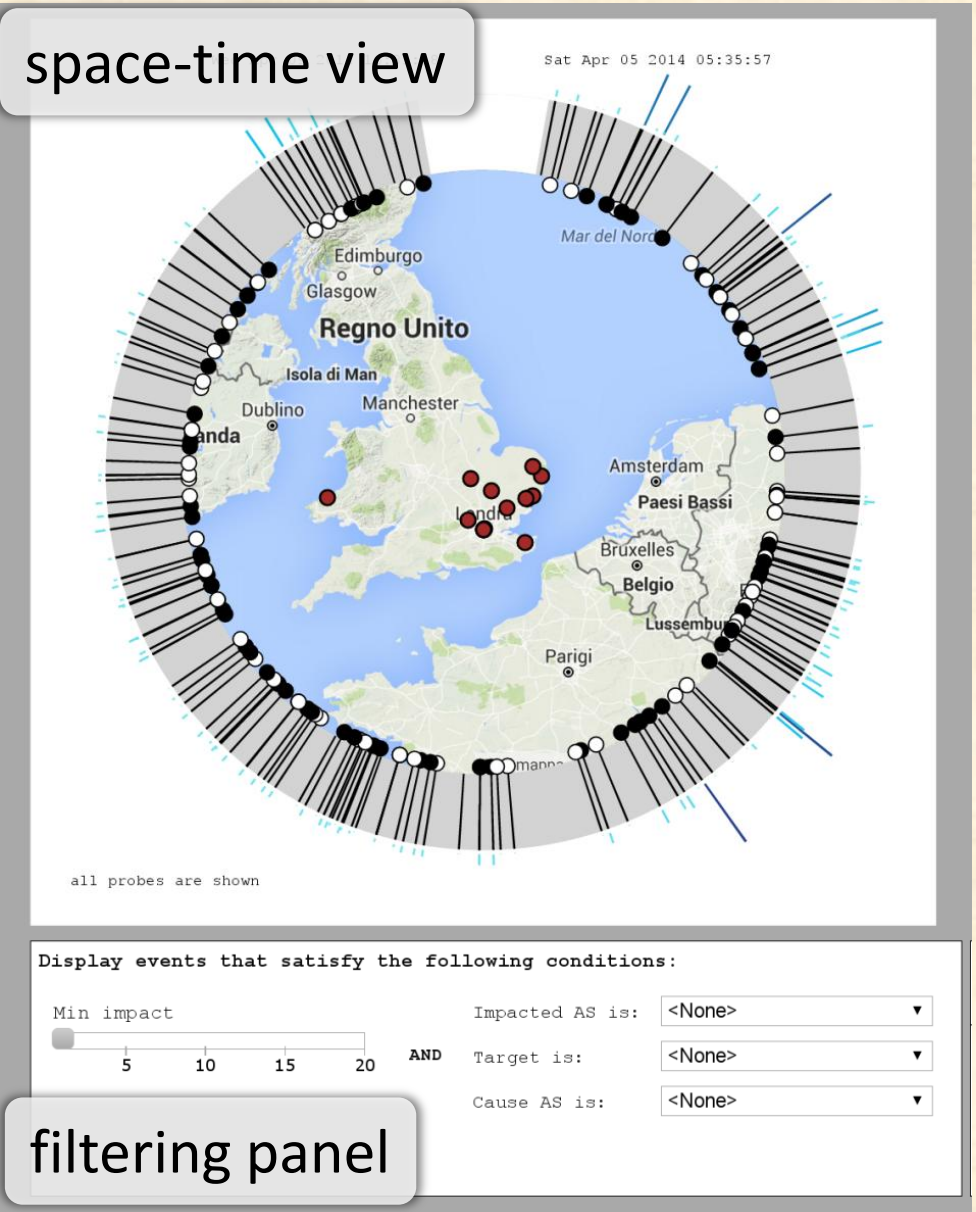

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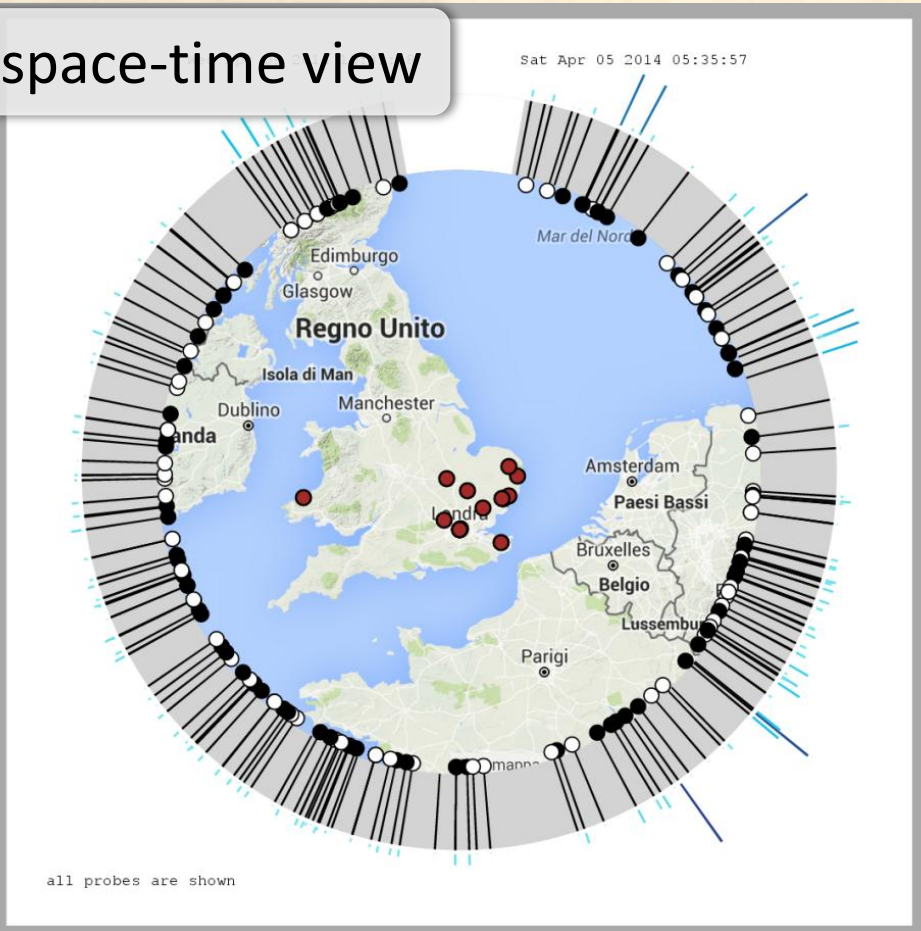
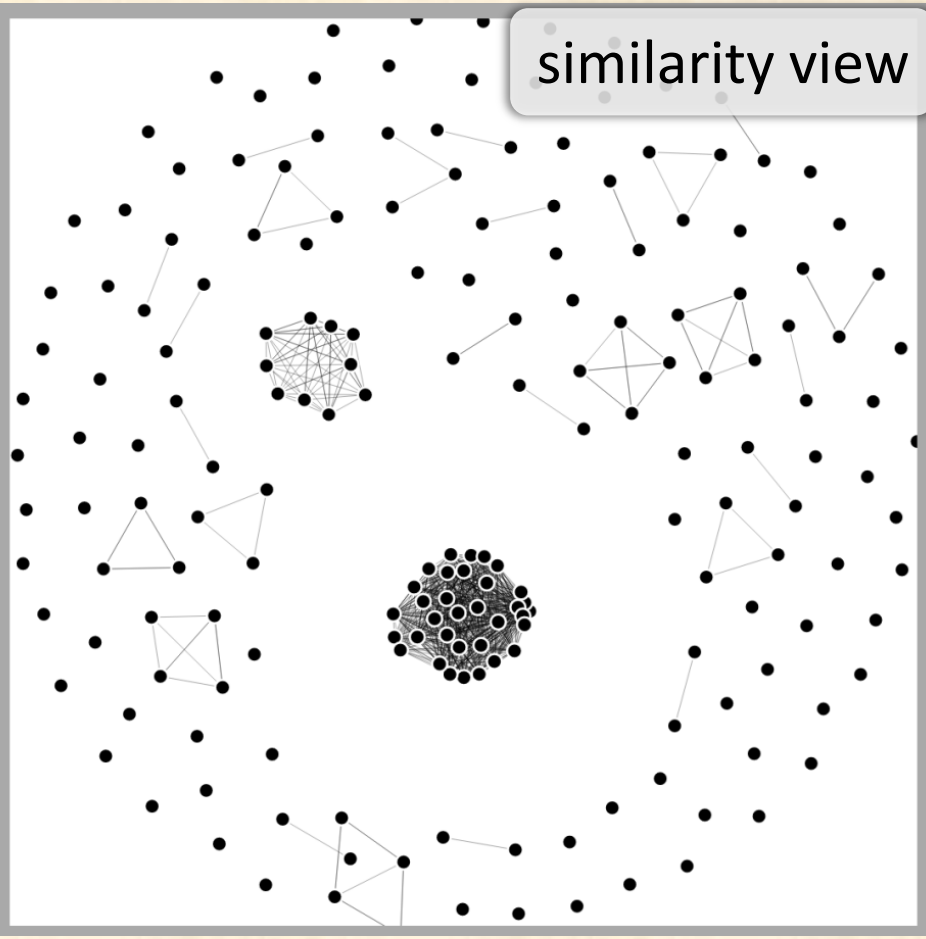
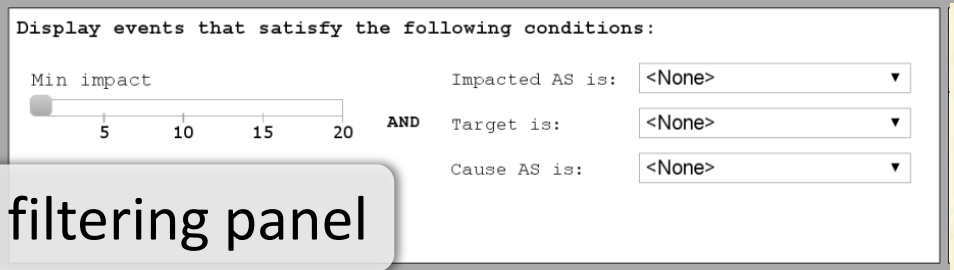


similarity view

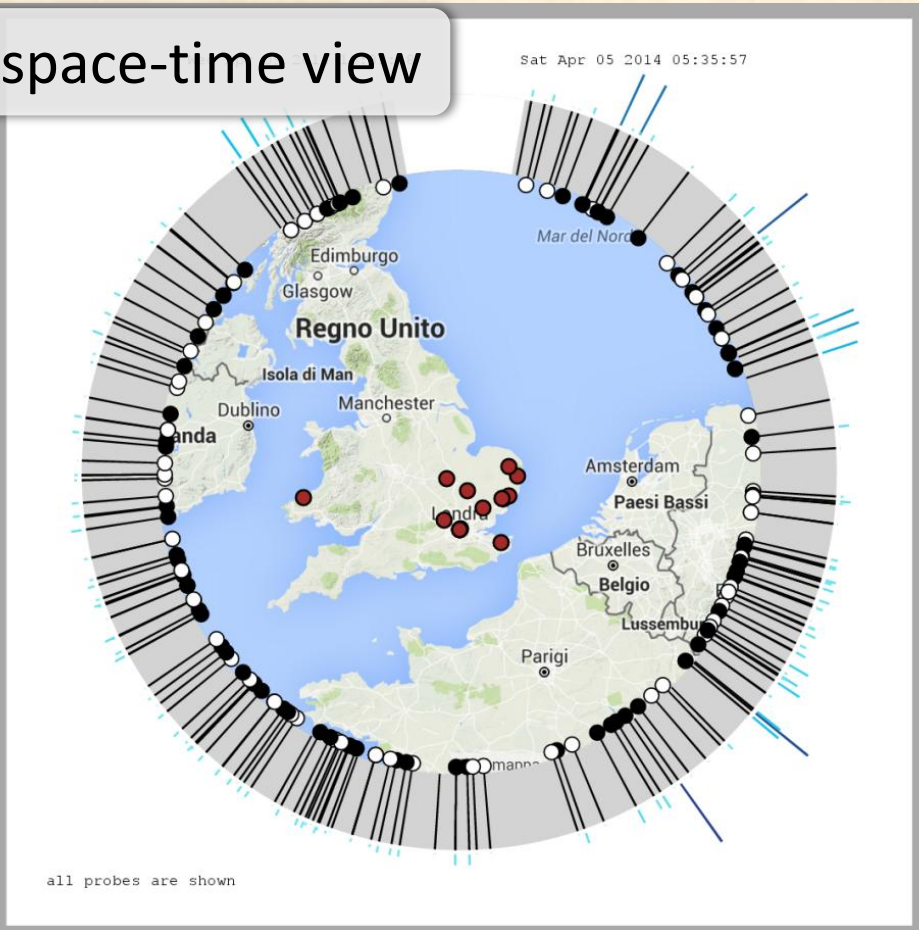




filtering panel

User interface

space-time view



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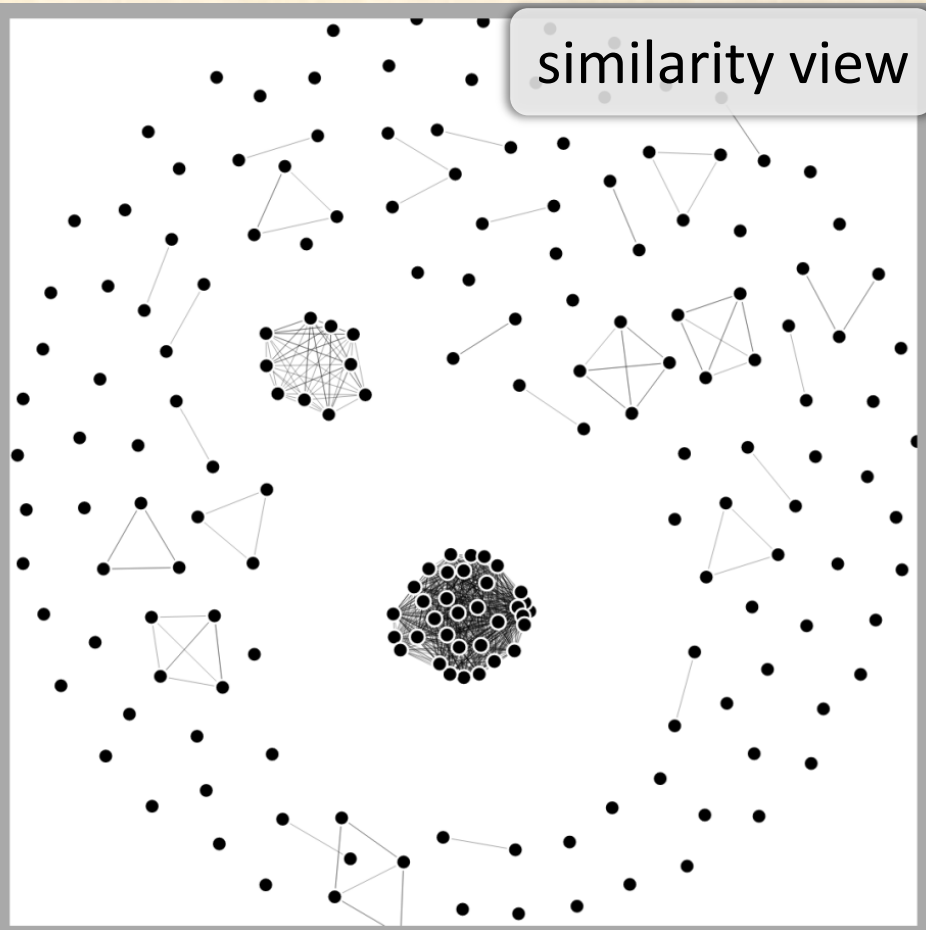

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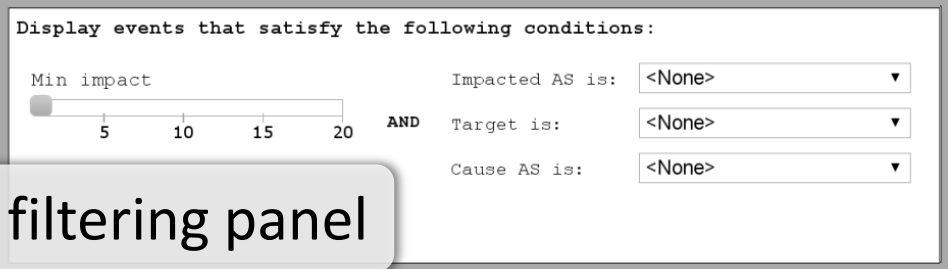

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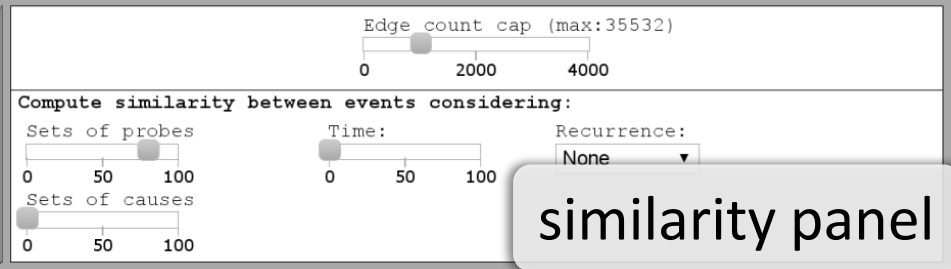

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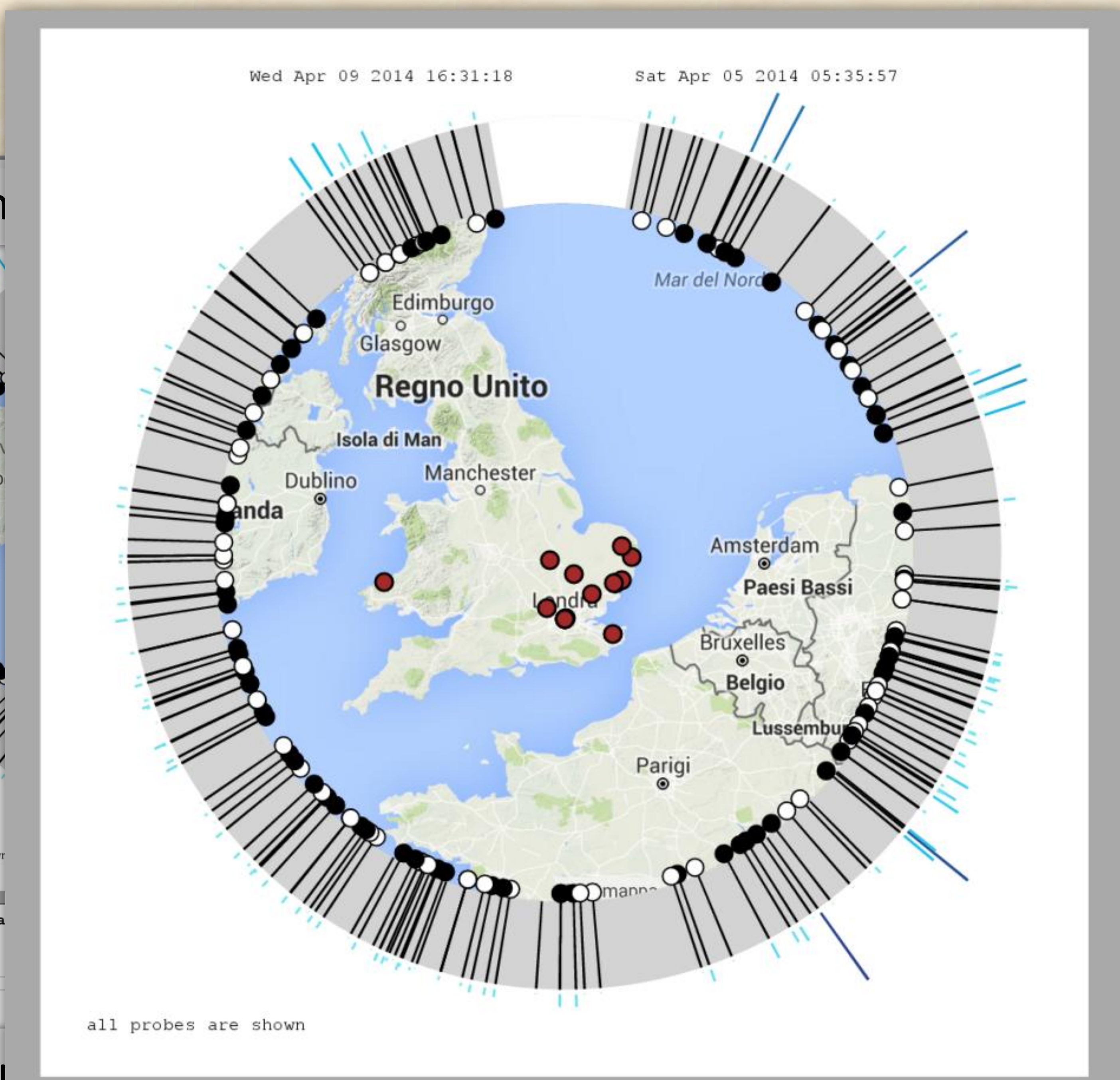

all probes are shown

Display events tha

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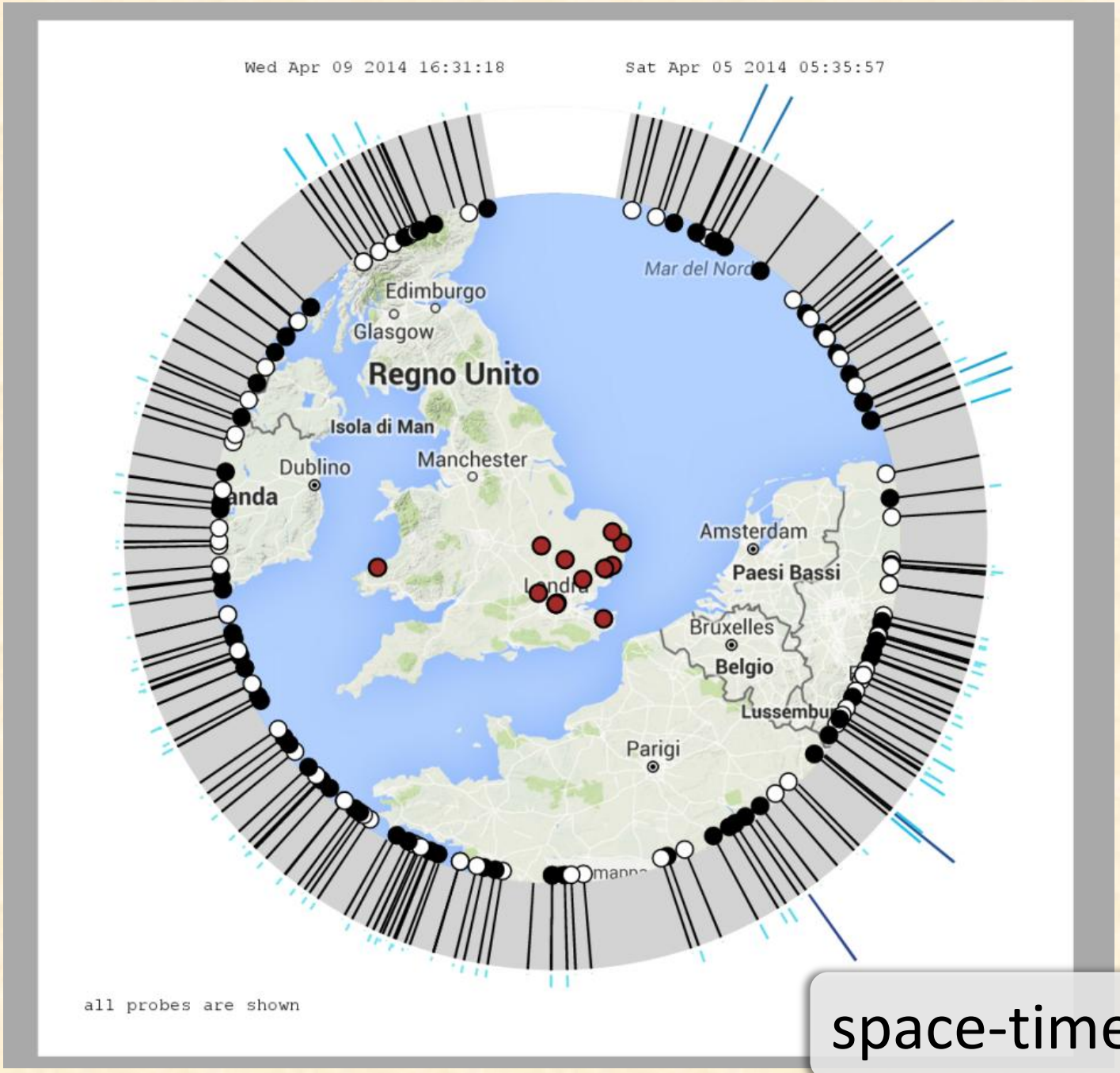
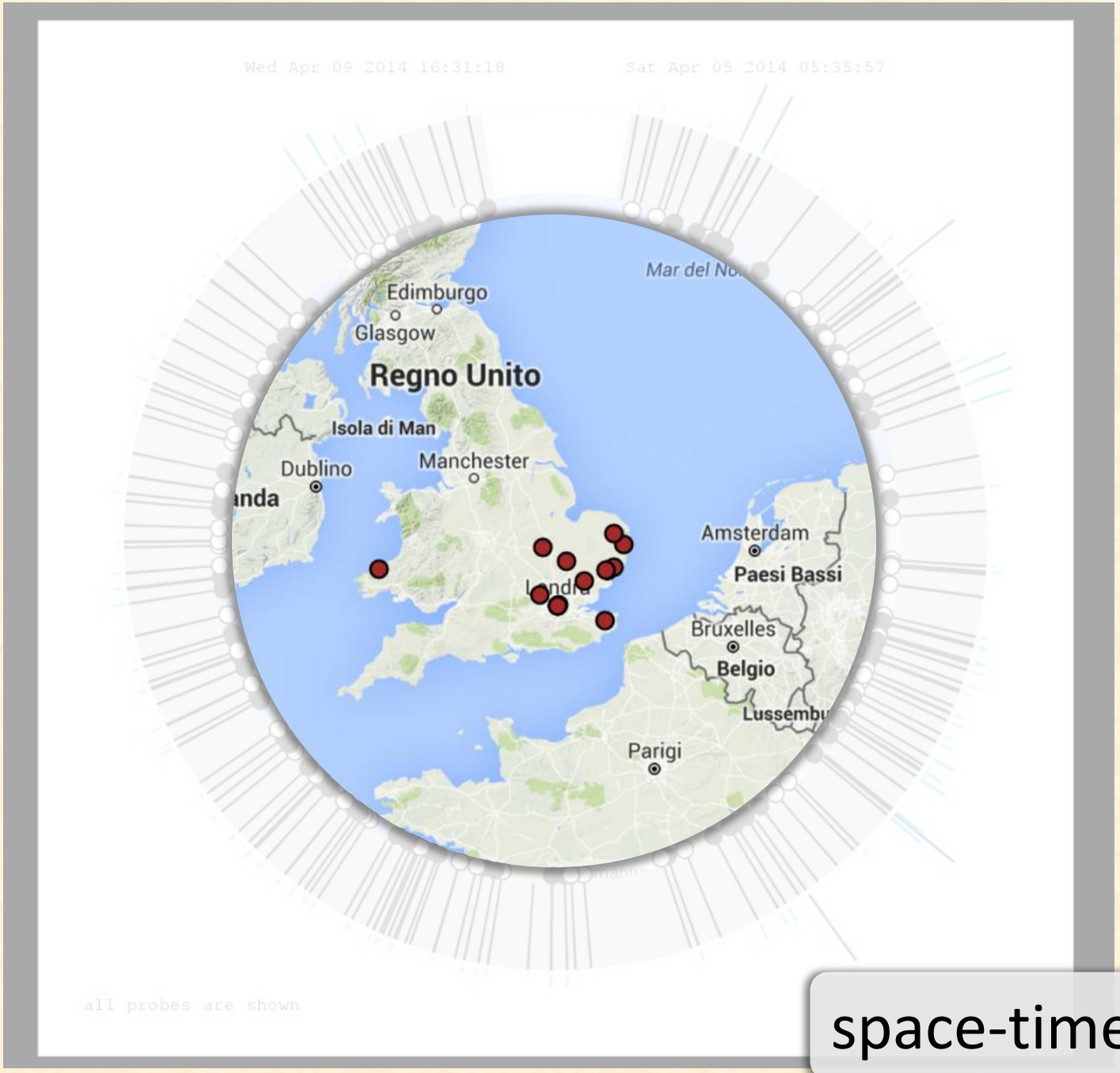
filtering p

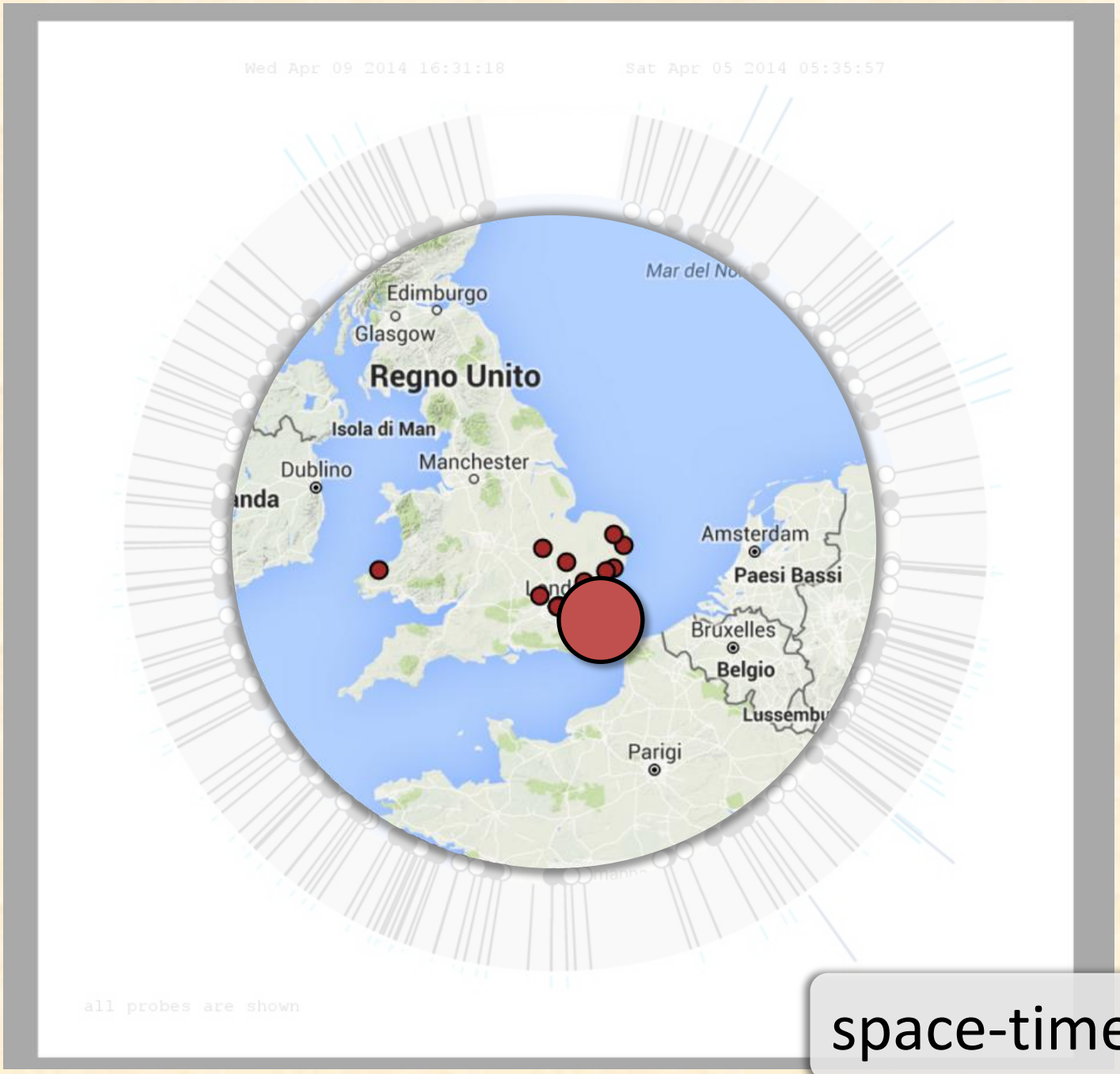
rity panel



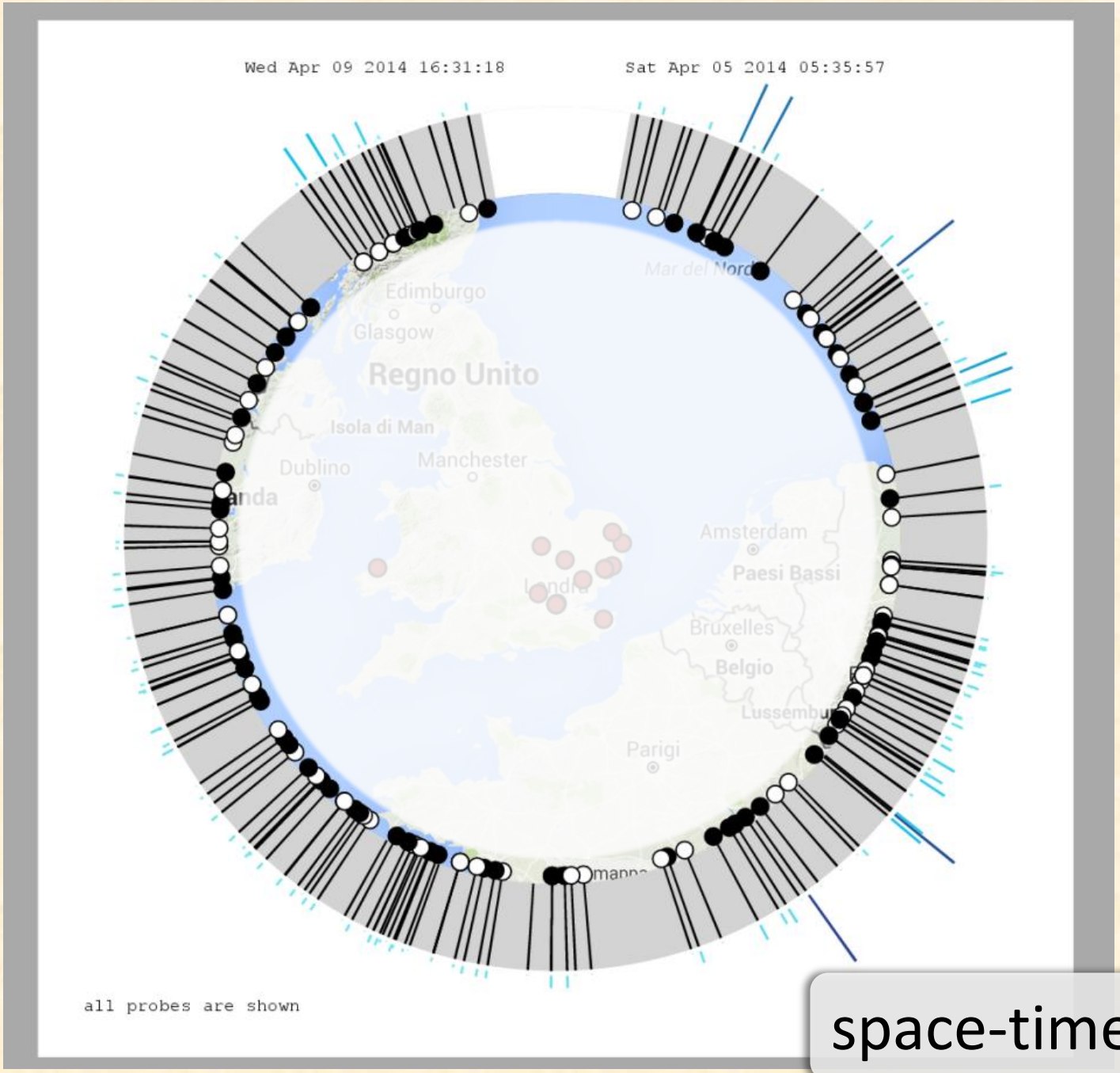
space-time view



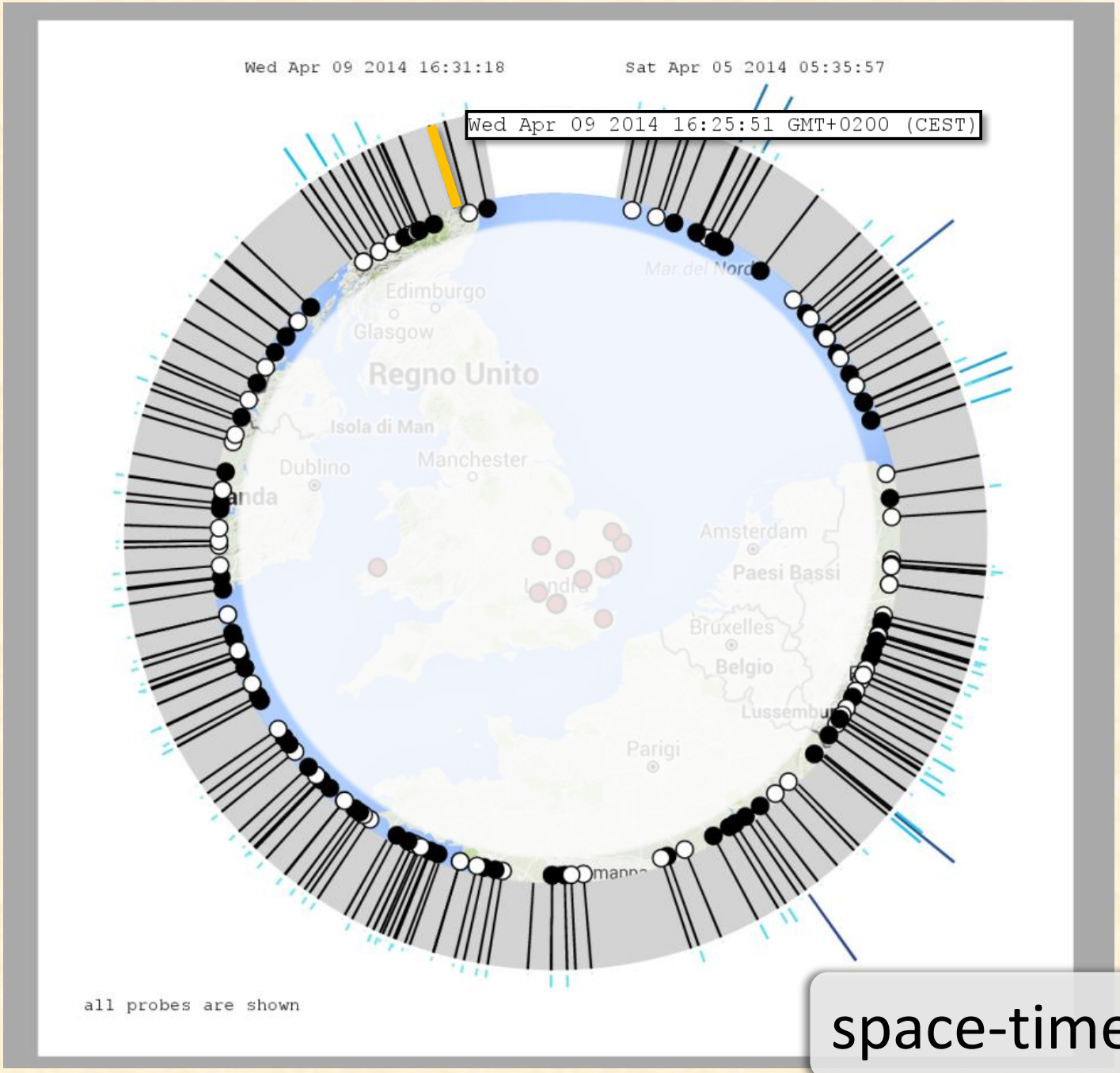
space-time view



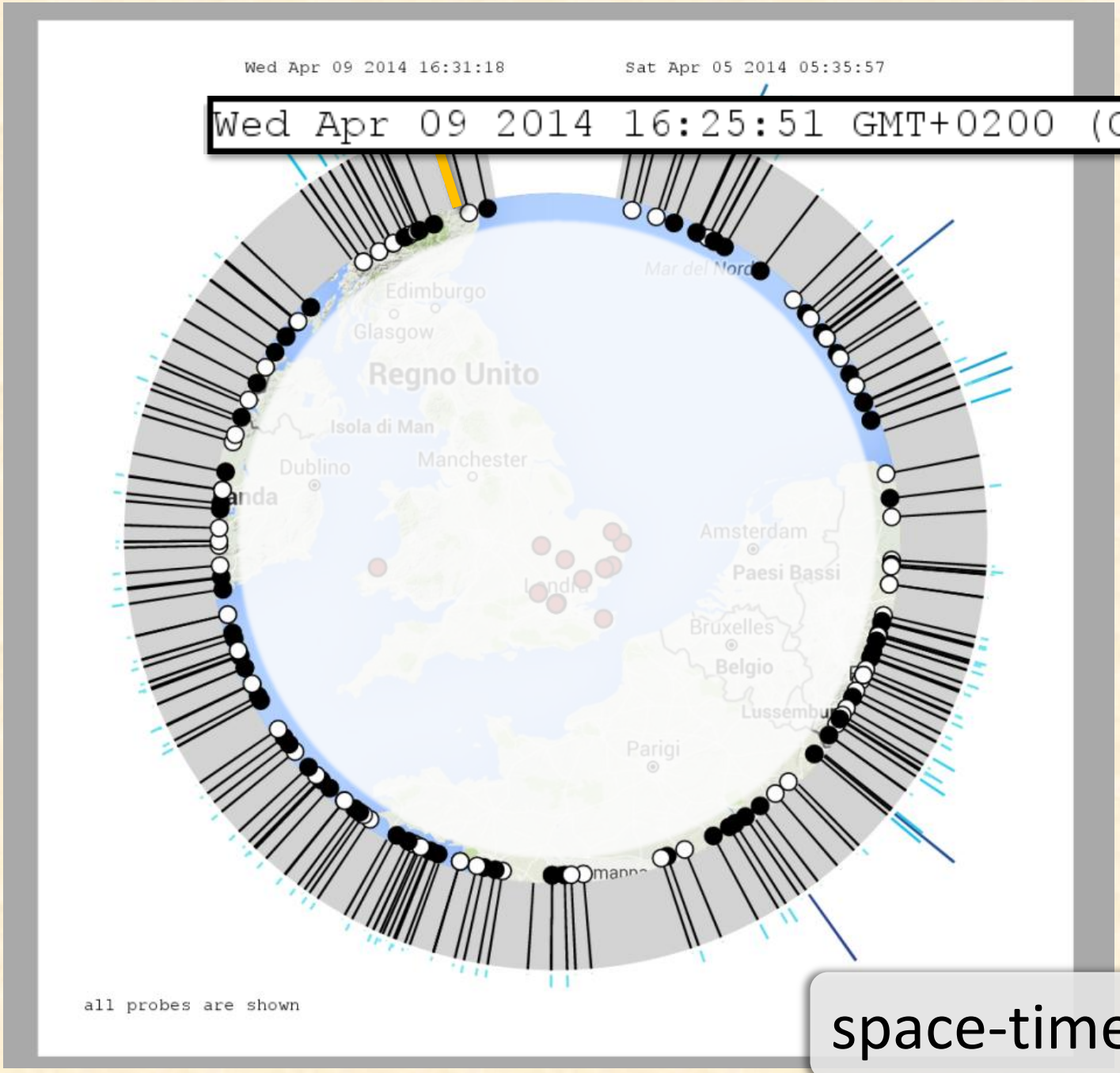
space-time view



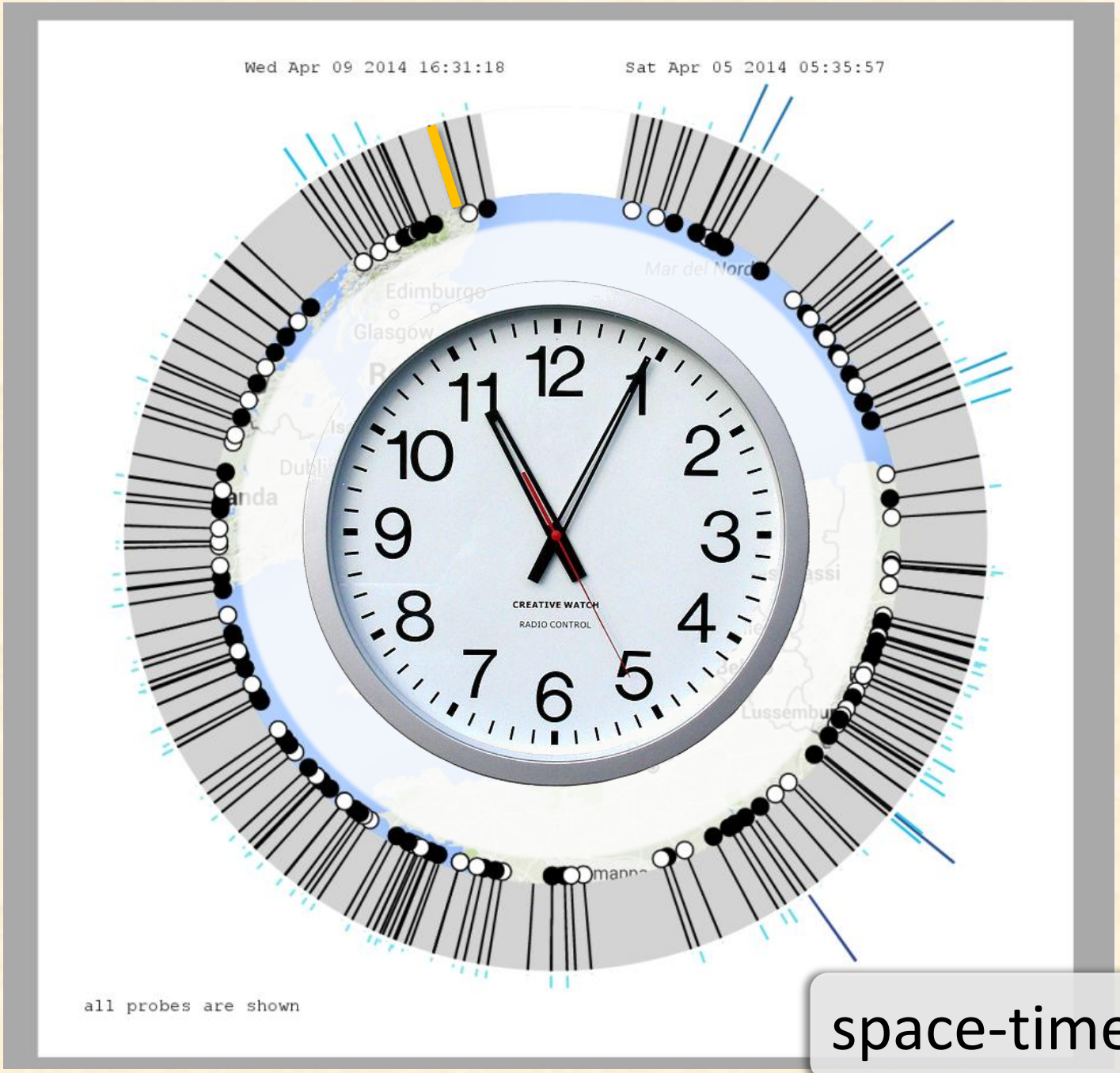
space-time view



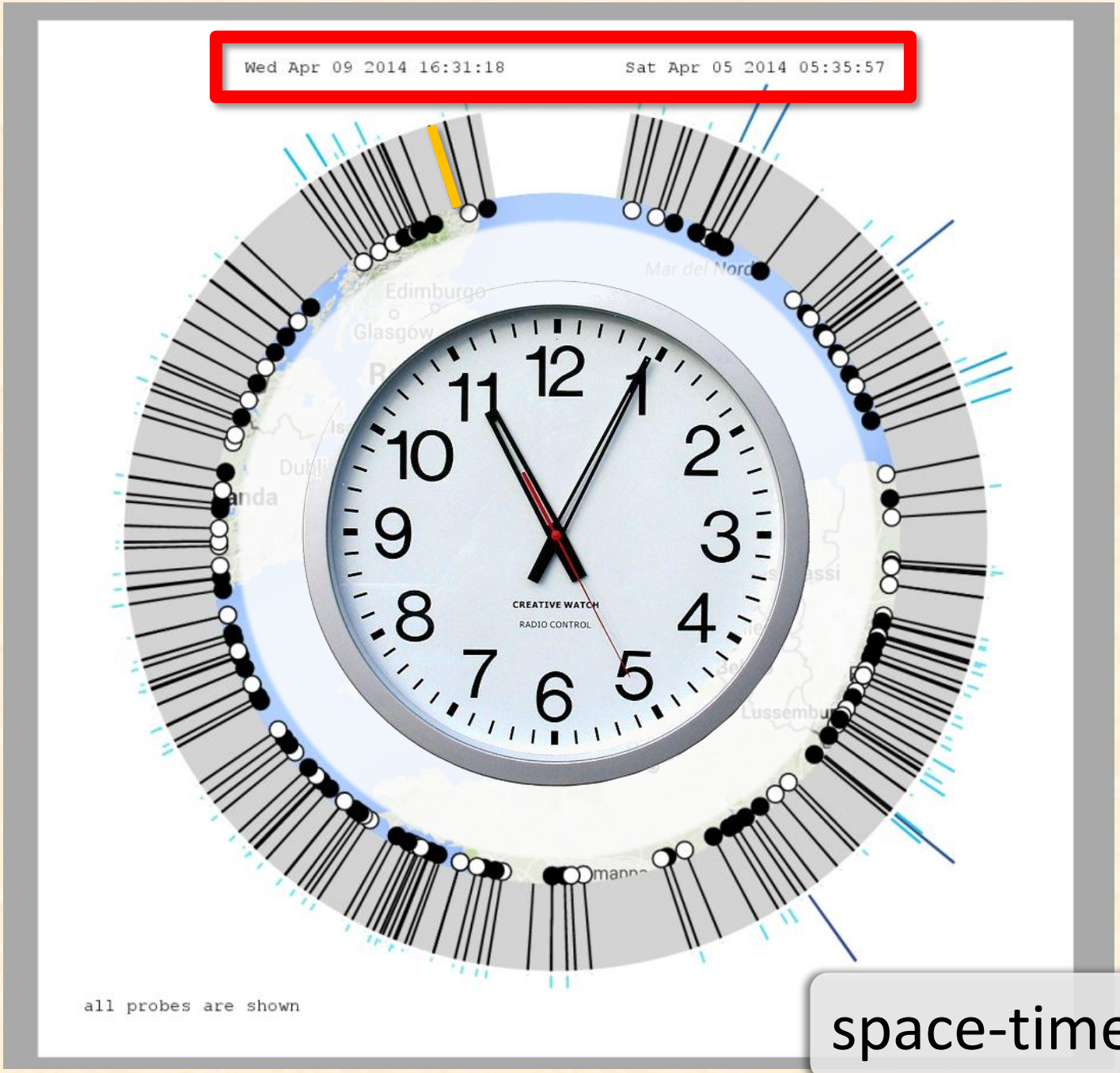
space-time view



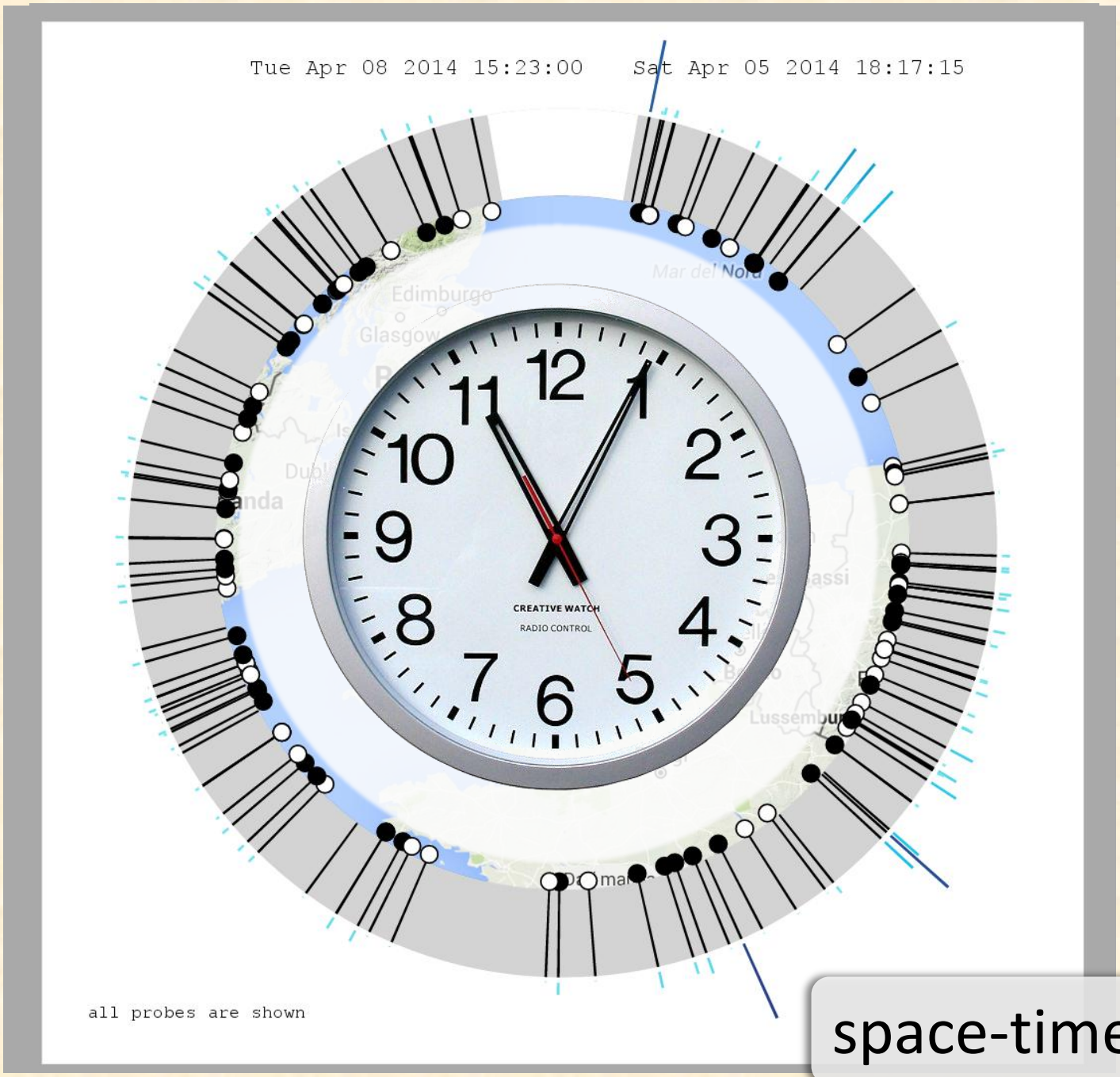
space-time view



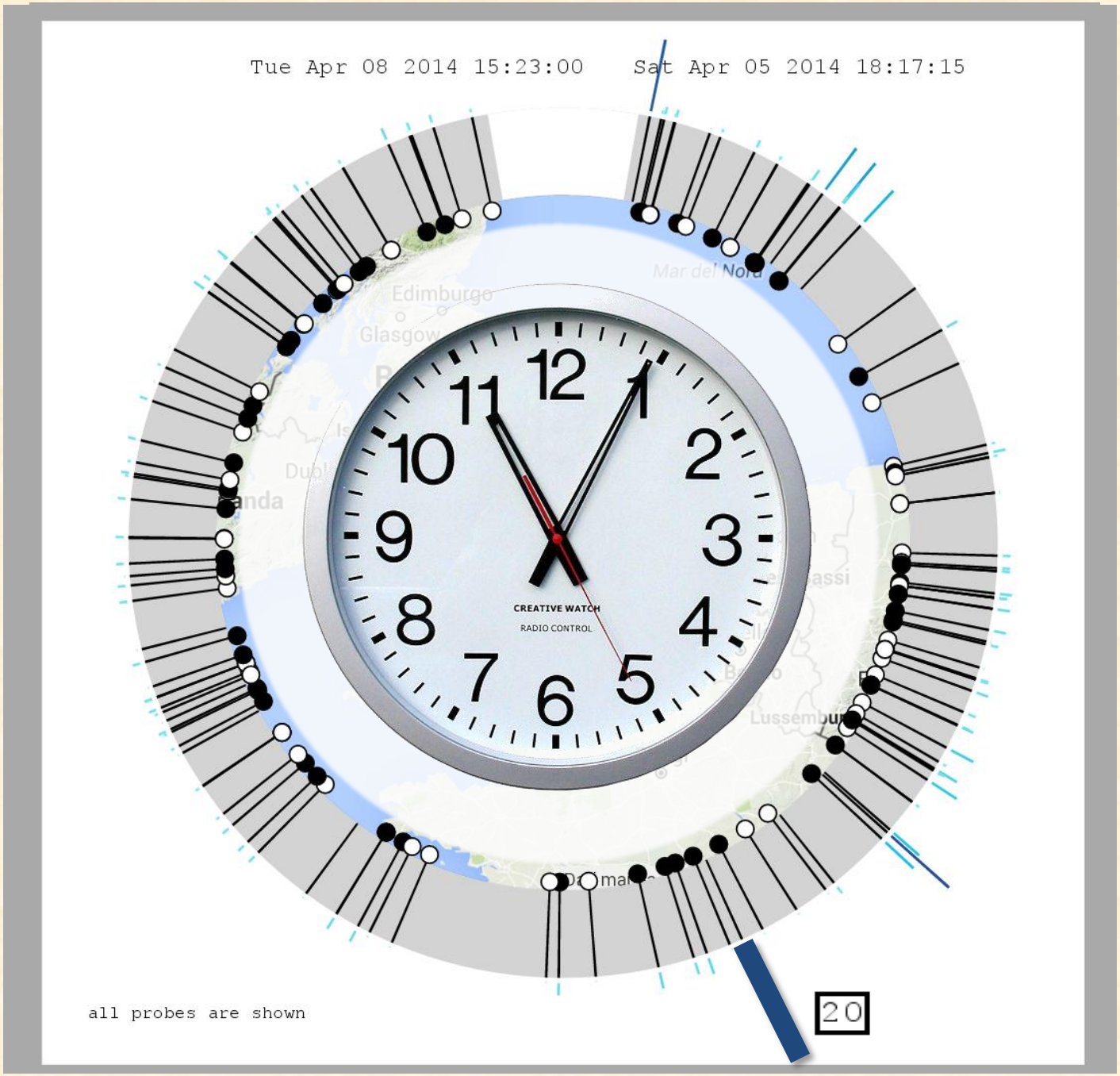
space-time view

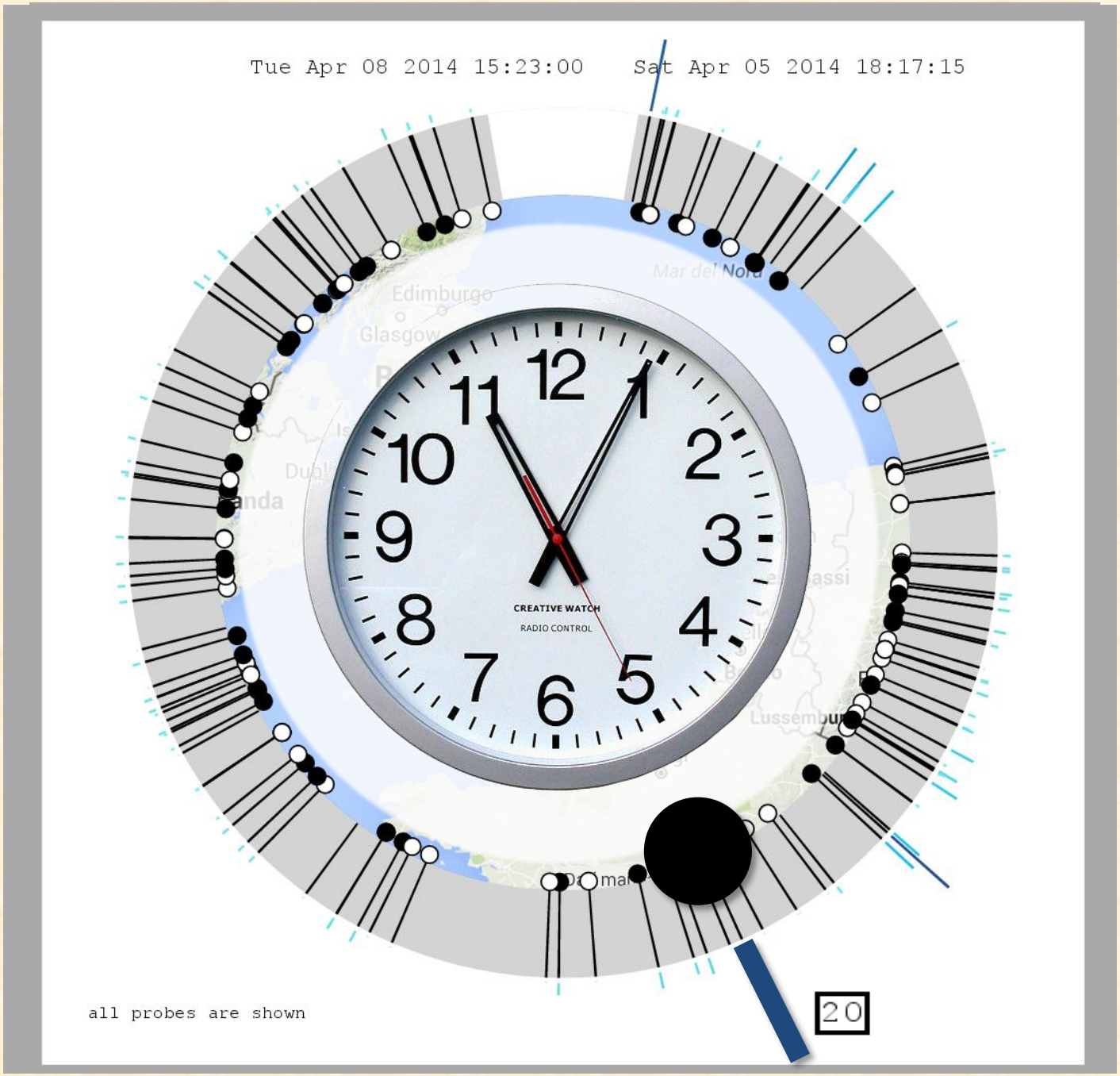


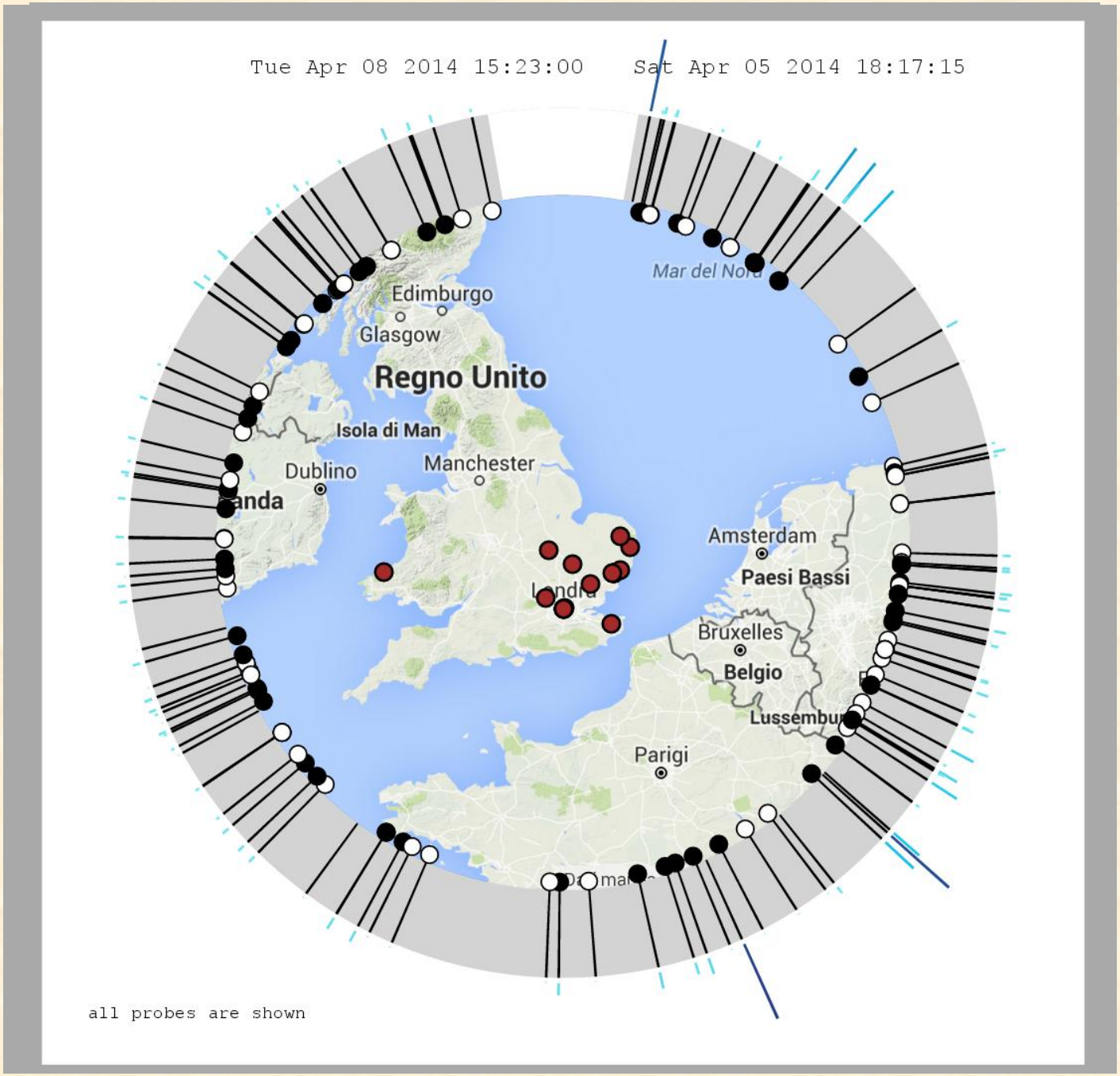
space-time view

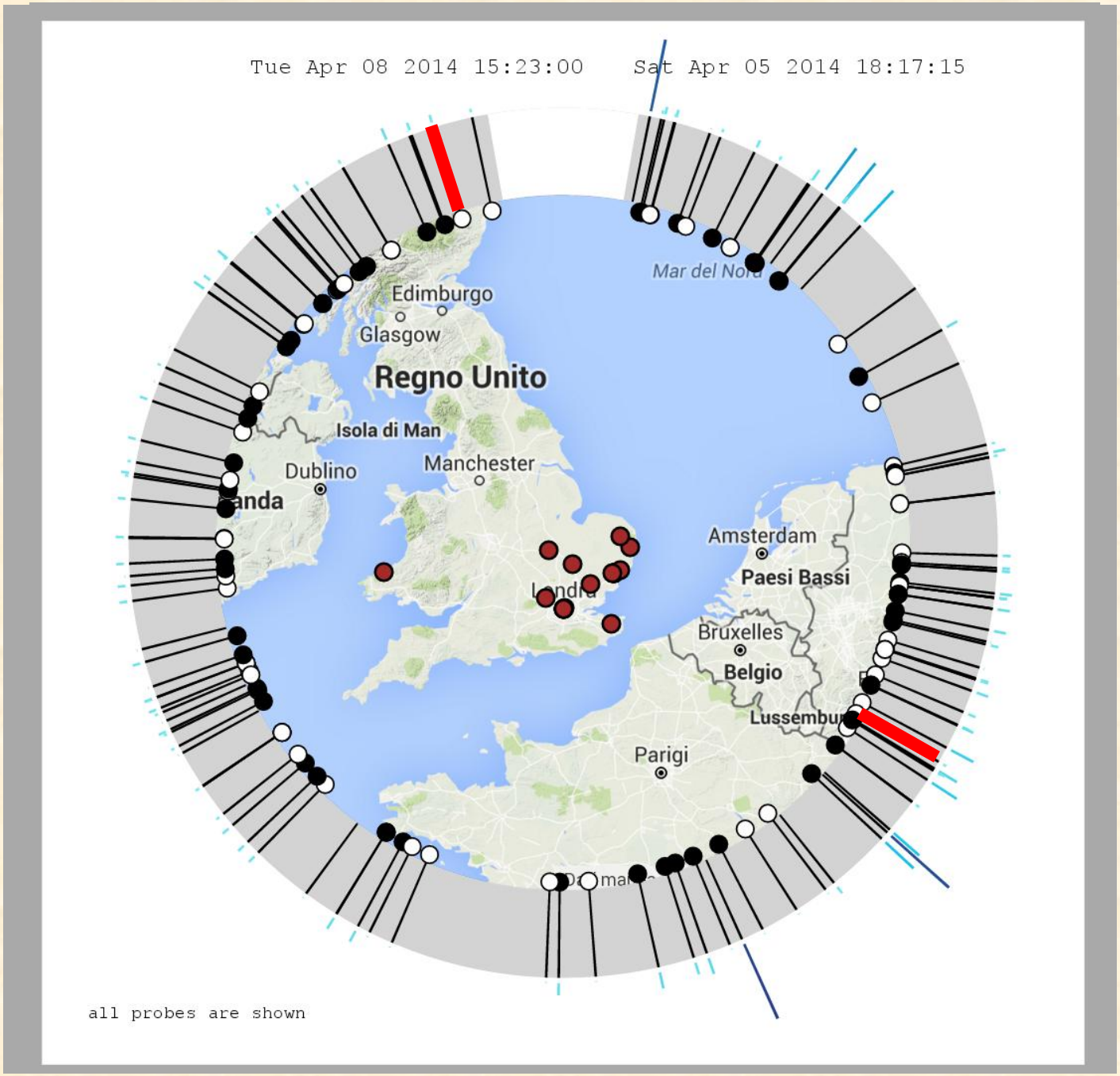


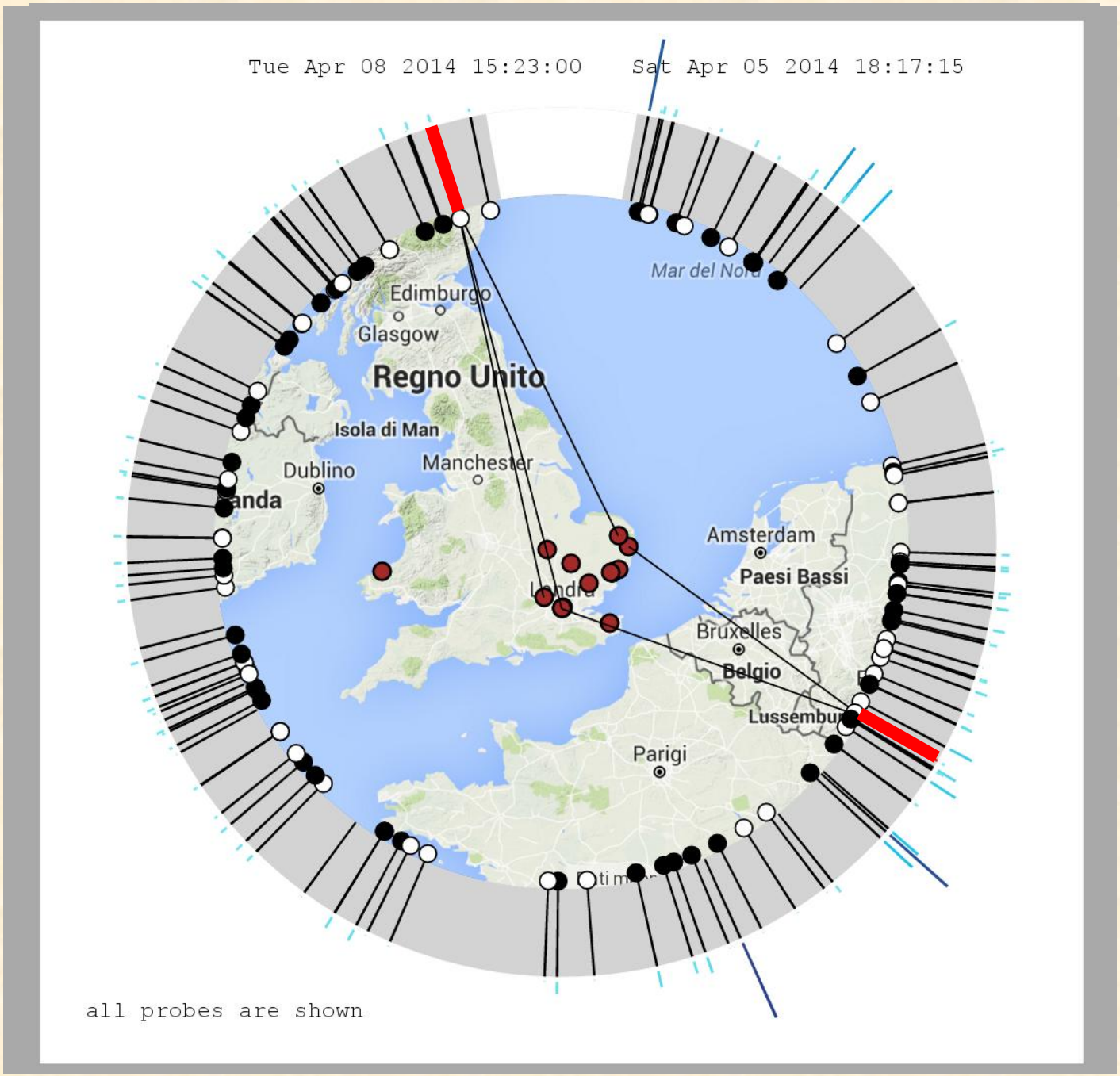
space-time view

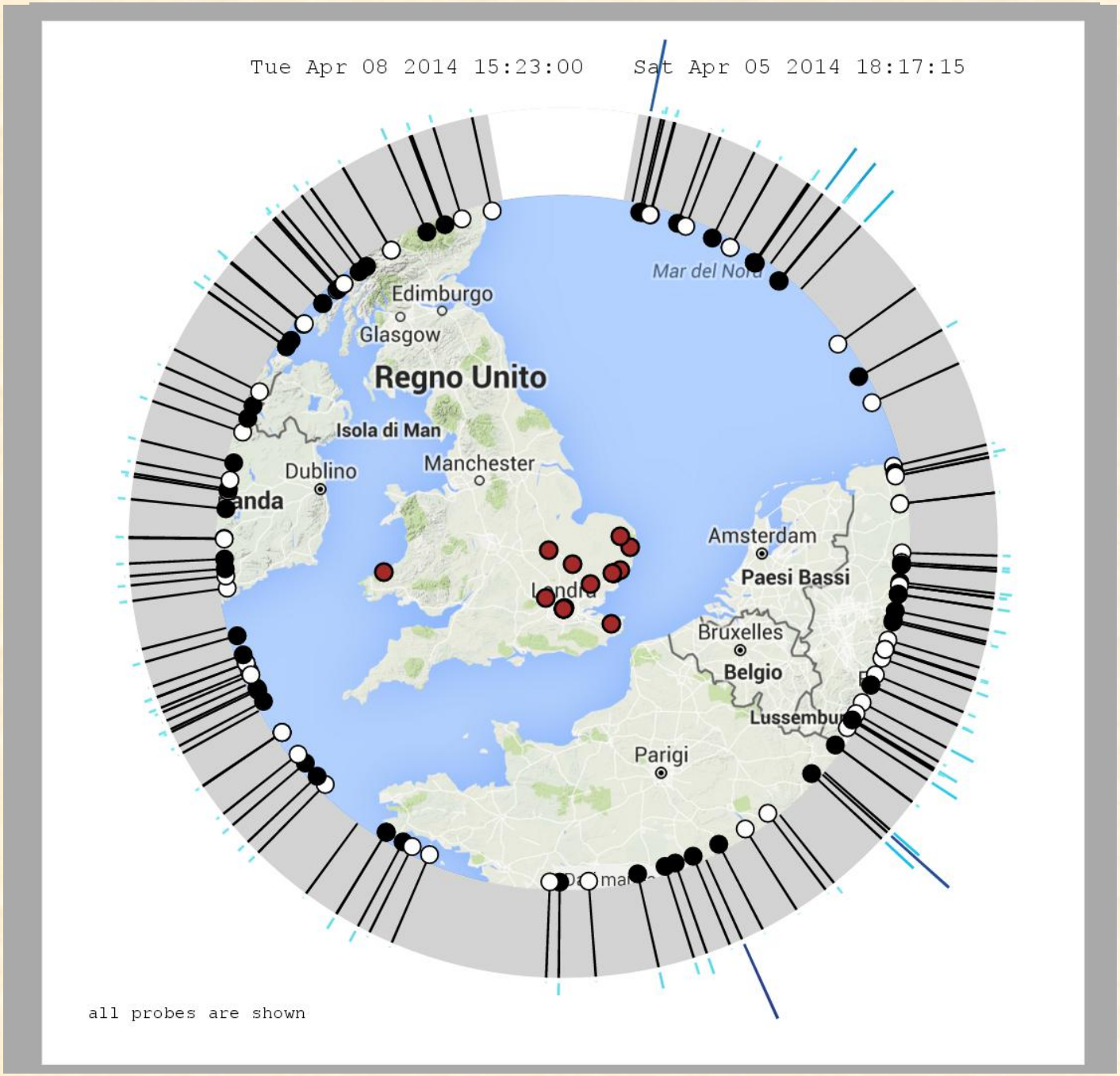

Tue Apr 08 2014 15:23:00
Sat Apr 05 2014 18:17:15
CREATIVE WATCH
RADIO CONTROL
all probes are shown
20


Tue Apr 08 2014 15:23:00
Sat Apr 05 2014 18:17:15
CREATIVE WATCH
RADIO CONTROL
all probes are shown
20


Tue Apr 08 2014 15:23:00
Sat Apr 05 2014 18:17:15
Edimburgo
Glasgow
Regno Unito
Isola di Man
Dublino
Manchester
Amsterdam
Paesi Bassi
Bruxelles
Belgio
Parigi
all probes are shown


Tue Apr 08 2014 15:23:00
Sat Apr 05 2014 18:17:15
Edimburgo
Glasgow
Regno Unito
Isola di Man
Dublino
Manchester
Amsterdam
Paesi Bassi
Bruxelles
Belgio
Parigi
all probes are shown


Tue Apr 08 2014 15:23:00
Sat Apr 05 2014 18:17:15
Mar del Nord
Edimburgo
Glasgow
Regno Unito
Isola di Man
Dublino
Manchester
Amsterdam
Paesi Bassi
Bruxelles
Belgio
Parigi
all probes are shown


Tue Apr 08 2014 15:23:00
Sat Apr 05 2014 18:17:15
Edimburgo
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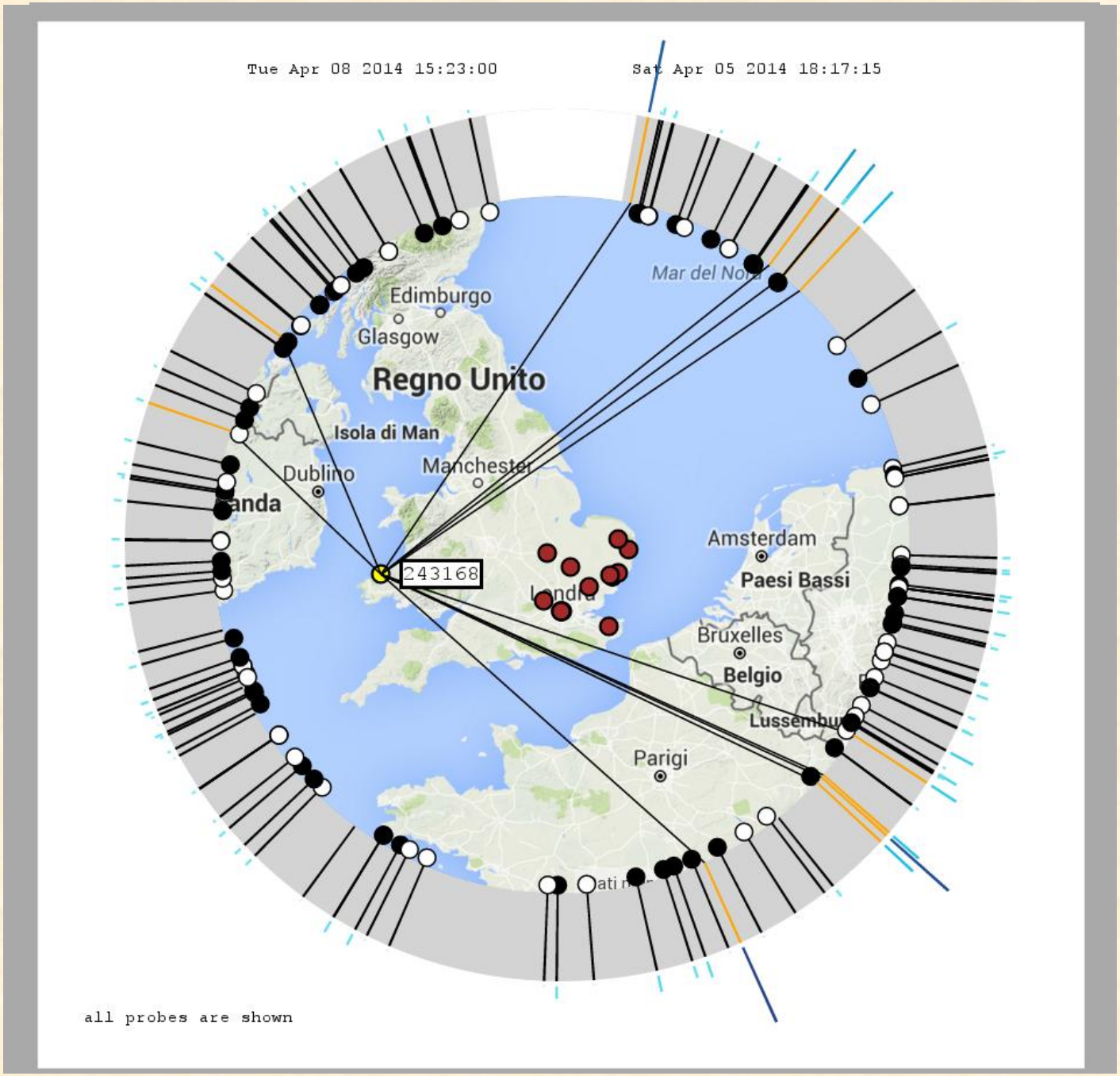
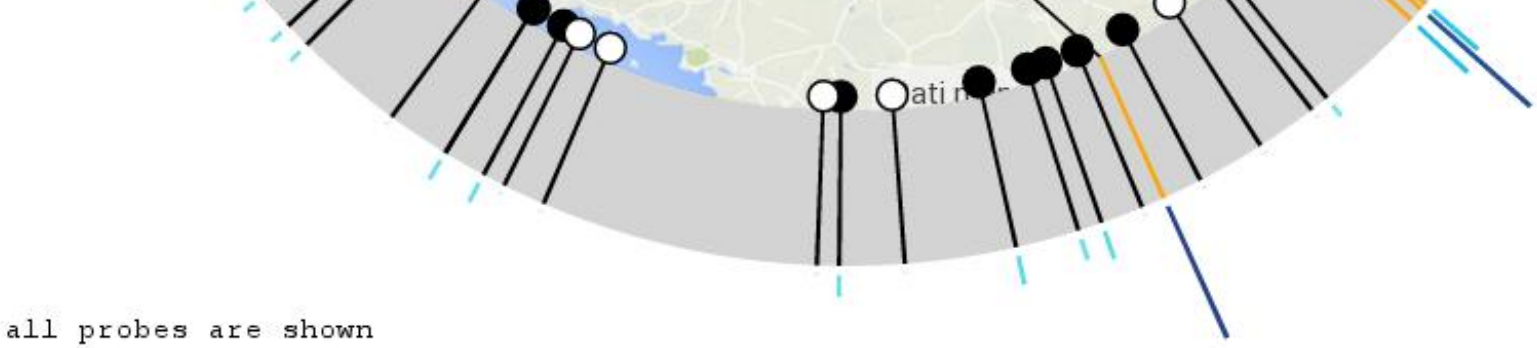
Regno Unito
Isola di Man
Dublino
Manchester
Amsterdam
Paesi Bassi
Bruxelles
Belgio
Parigi
all probes are shown


Tue Apr 08 2014 15:23:00
Sat Apr 05 2014 18:17:15
Edimburgo
Glasgow
Regno Unito
Isola di Man
Dublino
Manchester
243168
Amsterdam
Paesi Bassi
Bruxelles
Belgio
Parigi
all probes are shown



all probes are shown

Display events that satisfy the following conditions:

Min impact

5 10 15 20

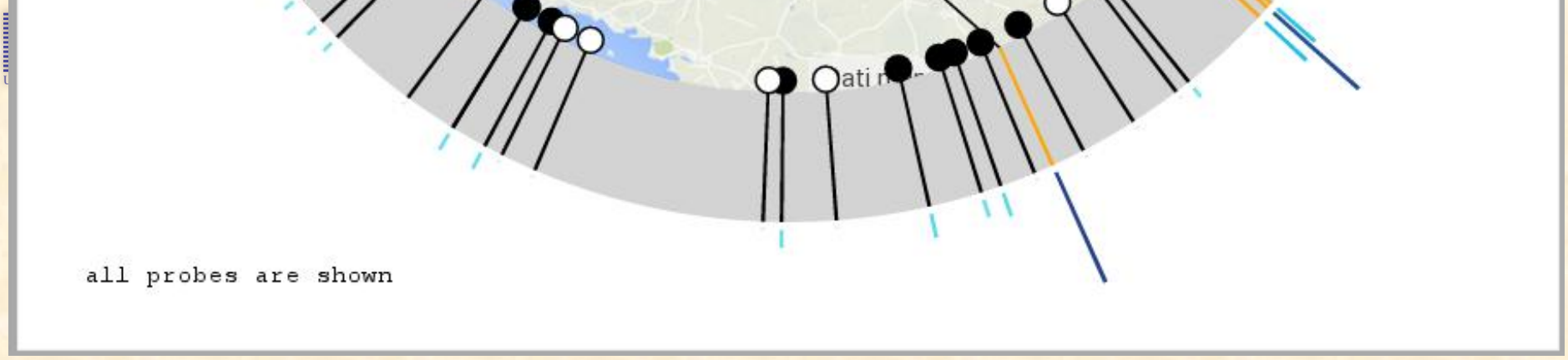
AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

filtering panel



all probes are shown

Display events that satisfy the following conditions:

Min impact

5 10 15 20

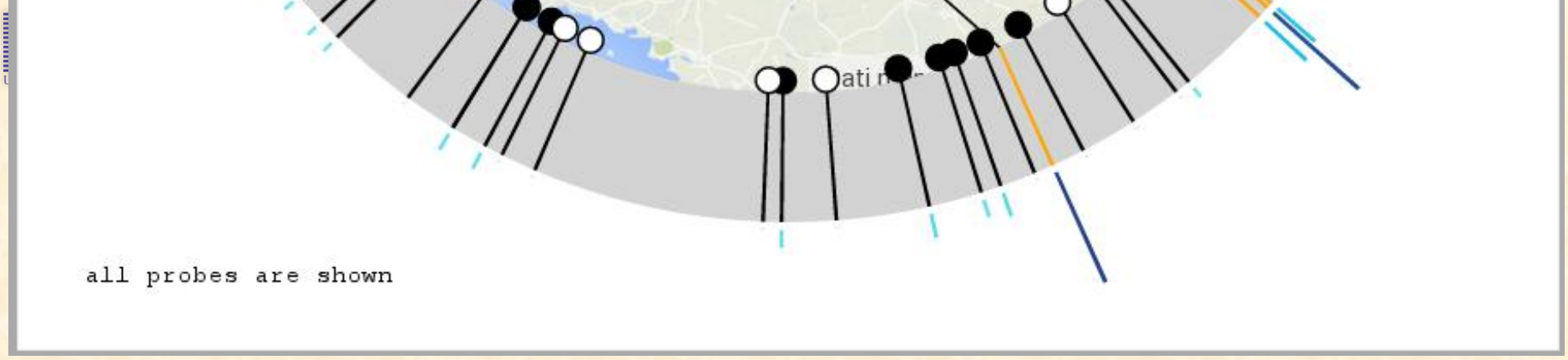
AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

filtering panel



all probes are shown

Display events that satisfy the following conditions:

Min impact

5 10 15 20

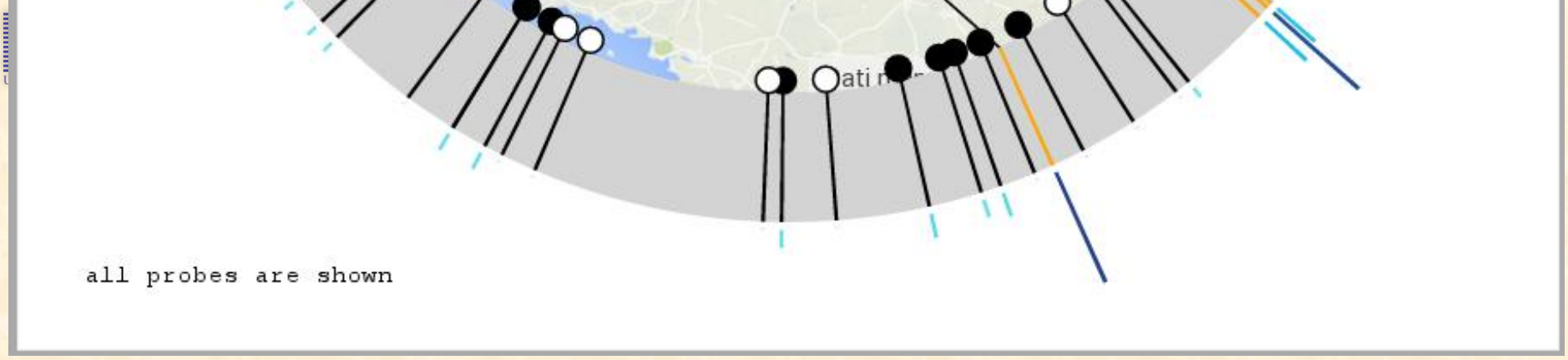
AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

filtering panel



Display events that satisfy the following conditions:

Min impact

5 10 15 20

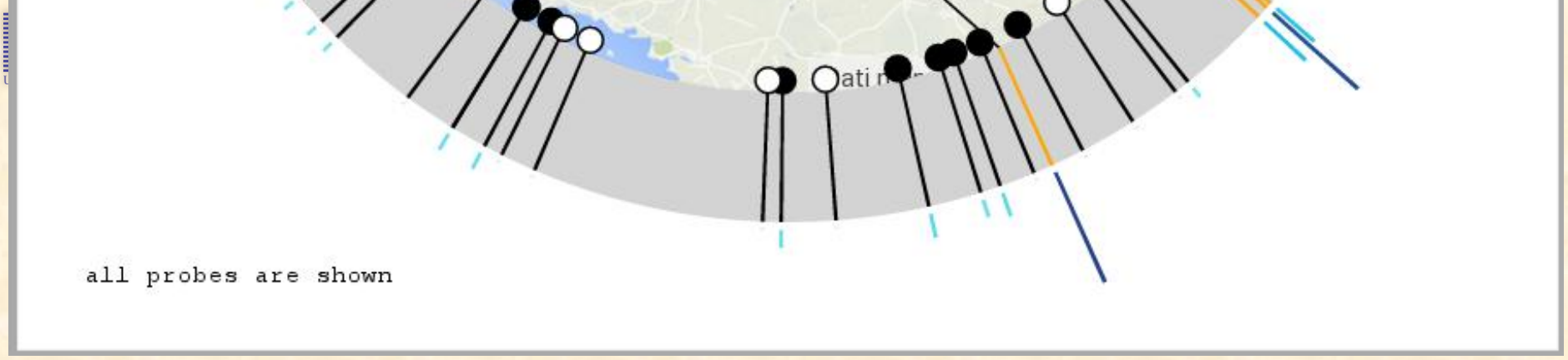
AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

filtering panel



all probes are shown

Display events that satisfy the following conditions:

Min impact

5 10 15 20

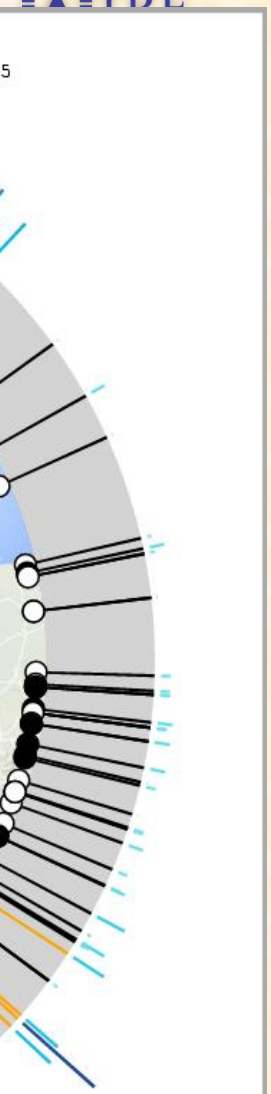
AND

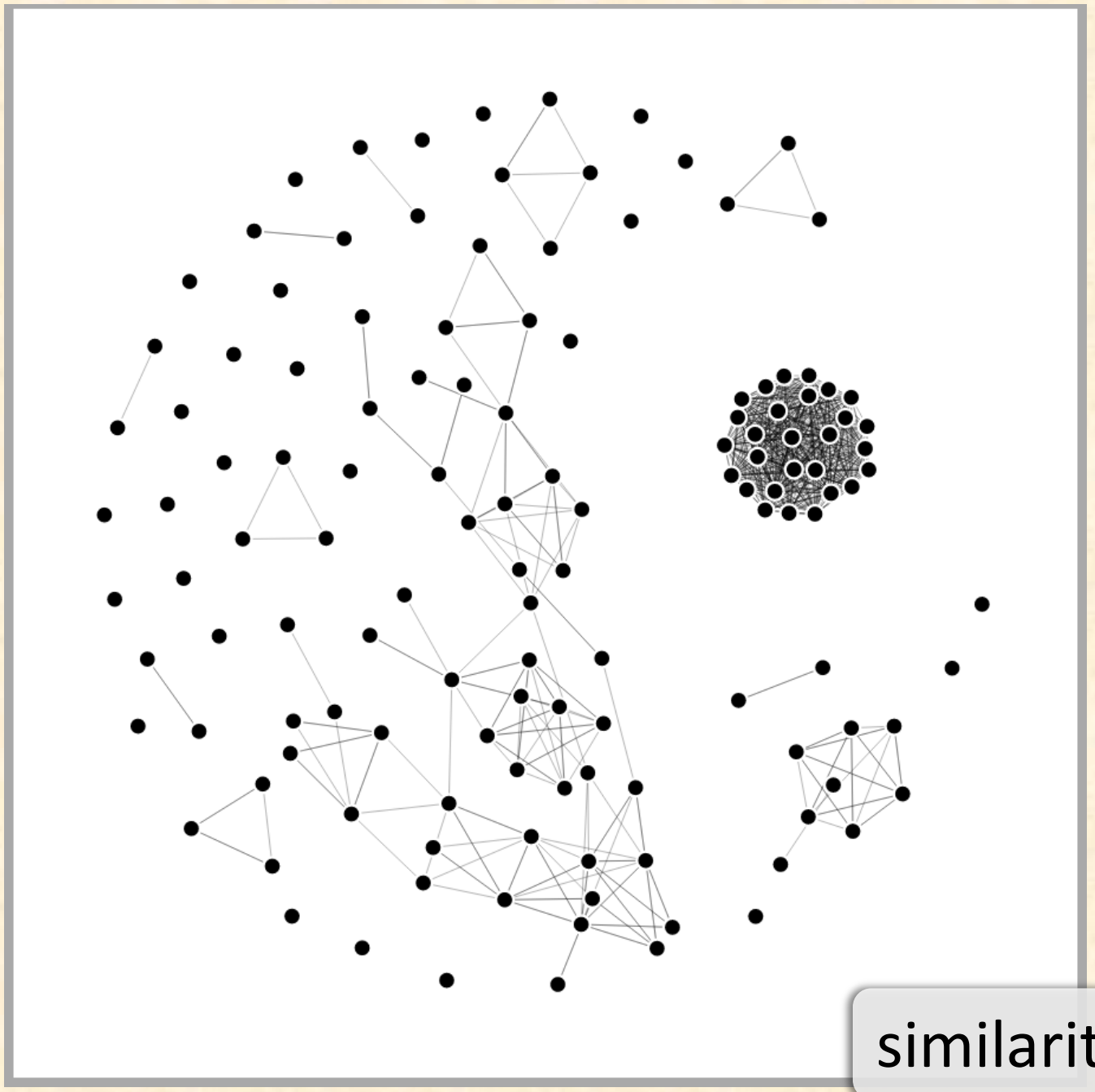
Impacted AS is: <None>

Target is: <None>

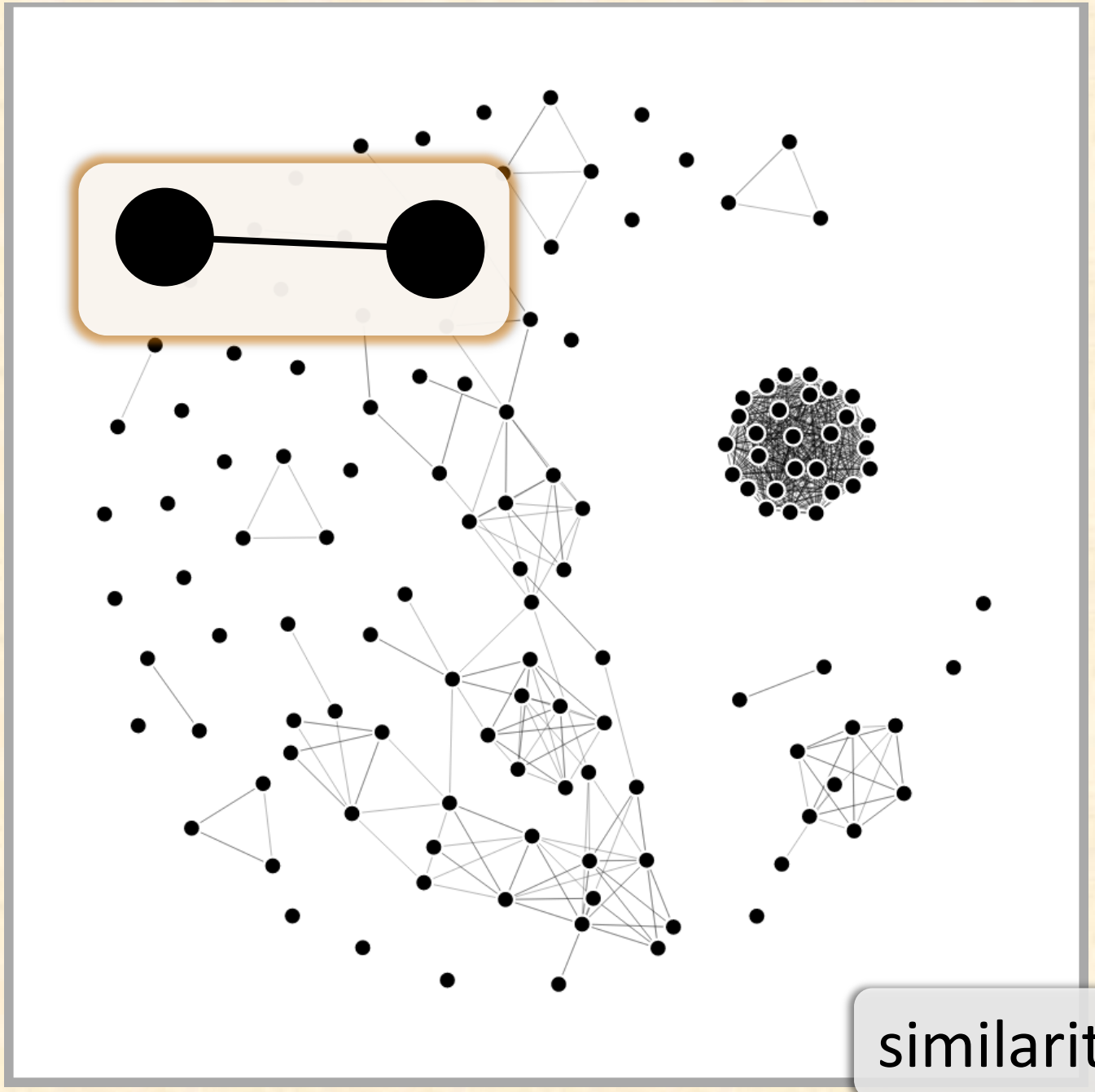
Cause AS is: <None>

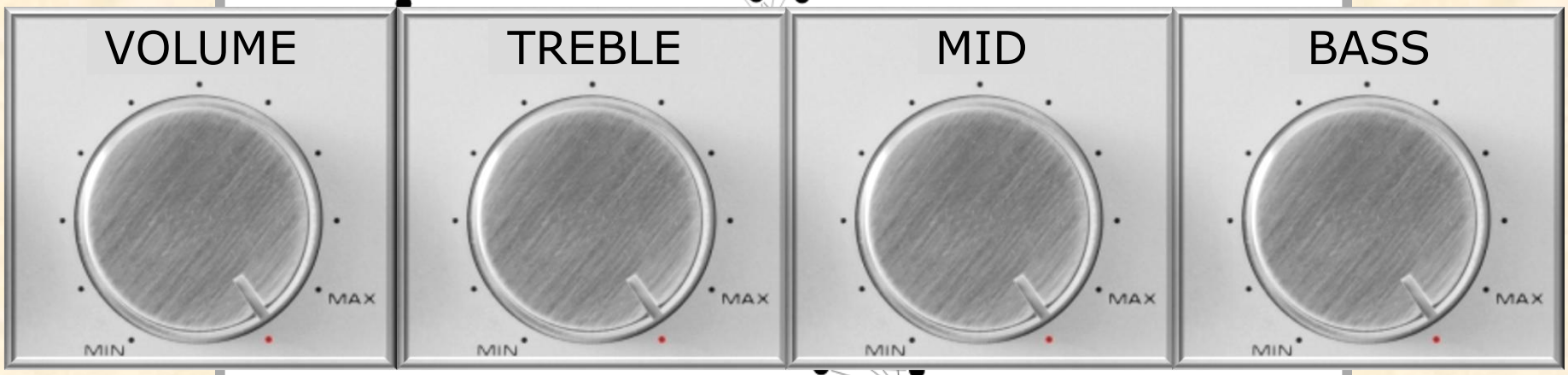
filtering panel





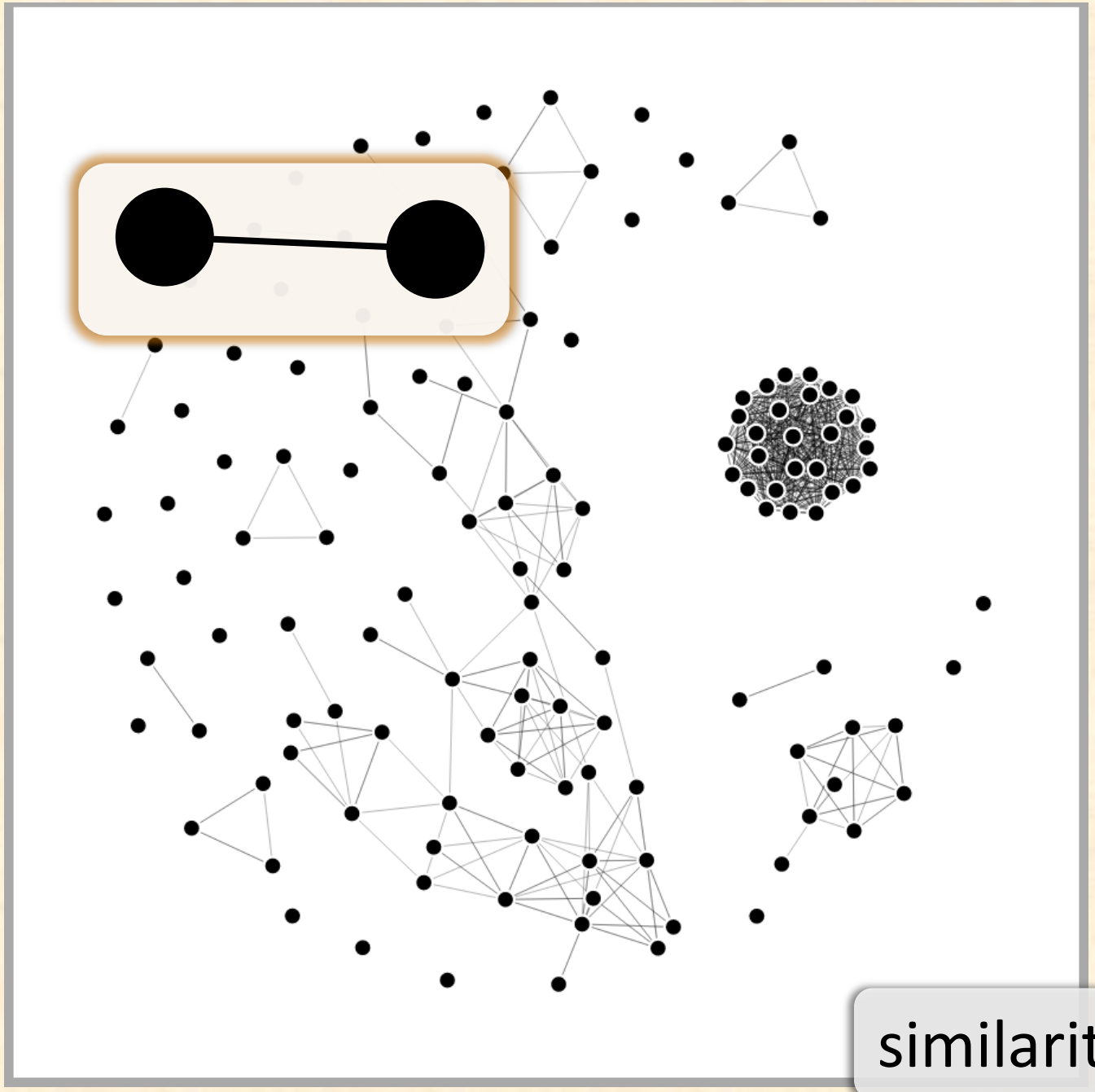
similarity view

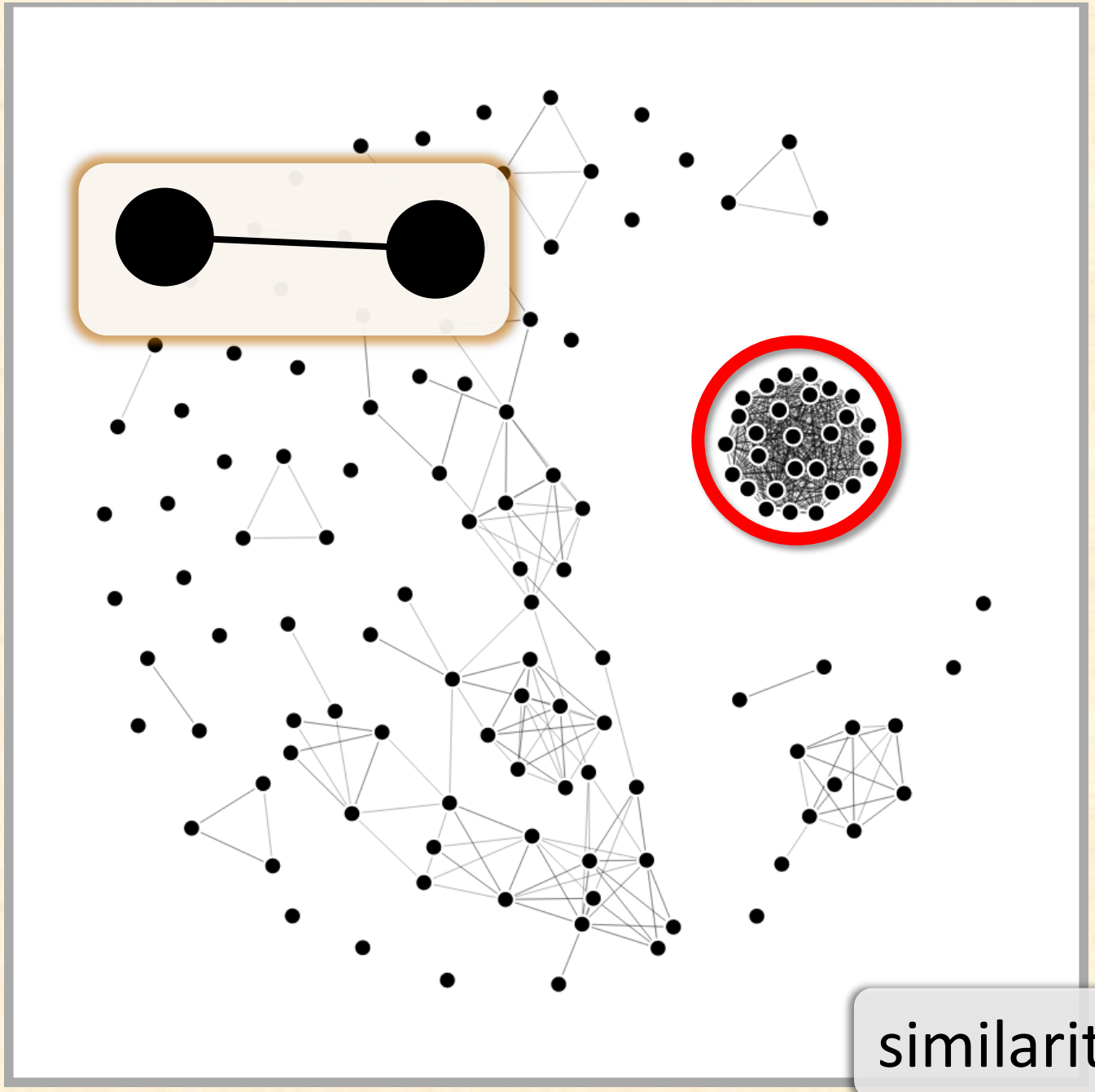

similarity view



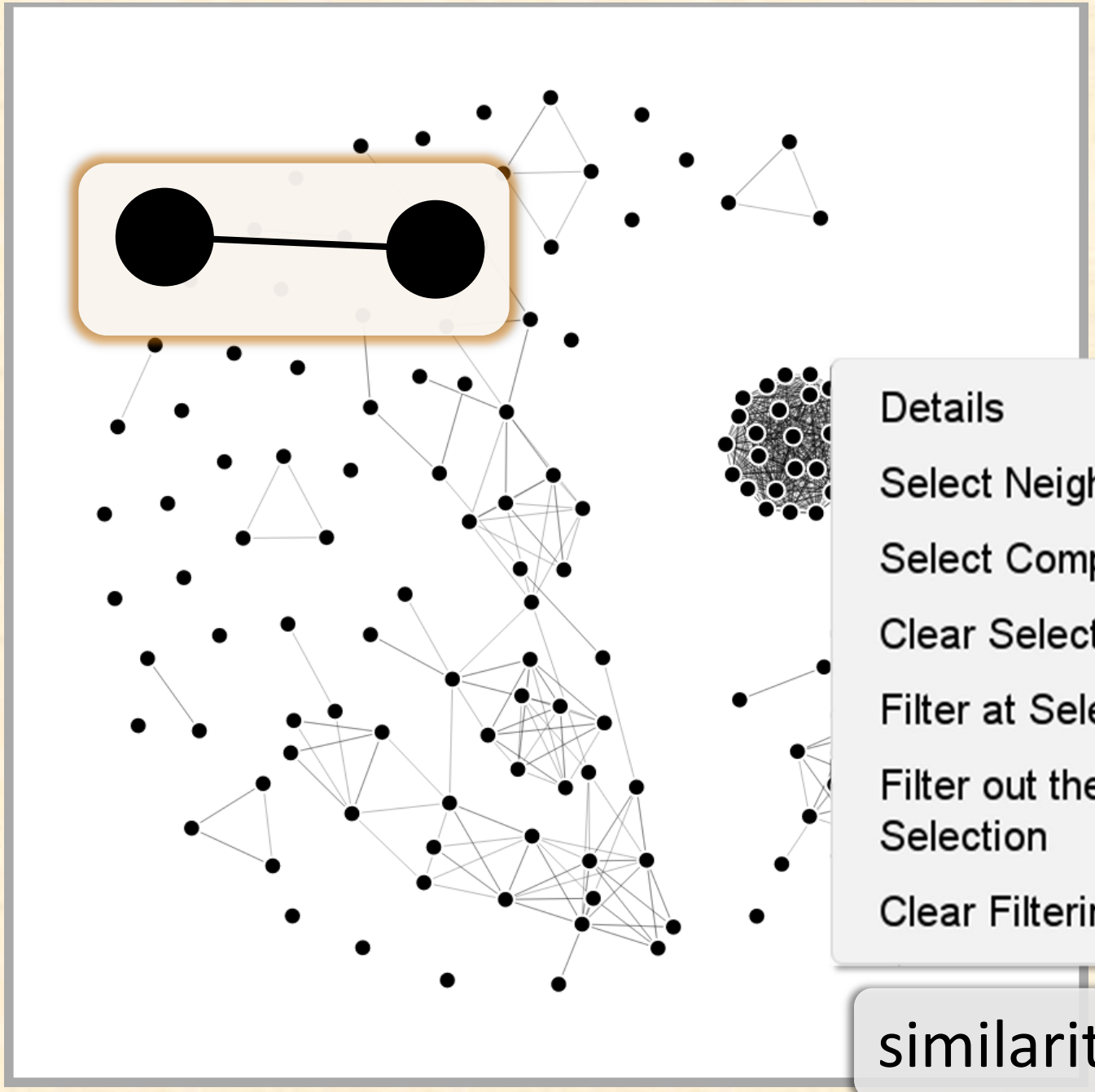
similarity view

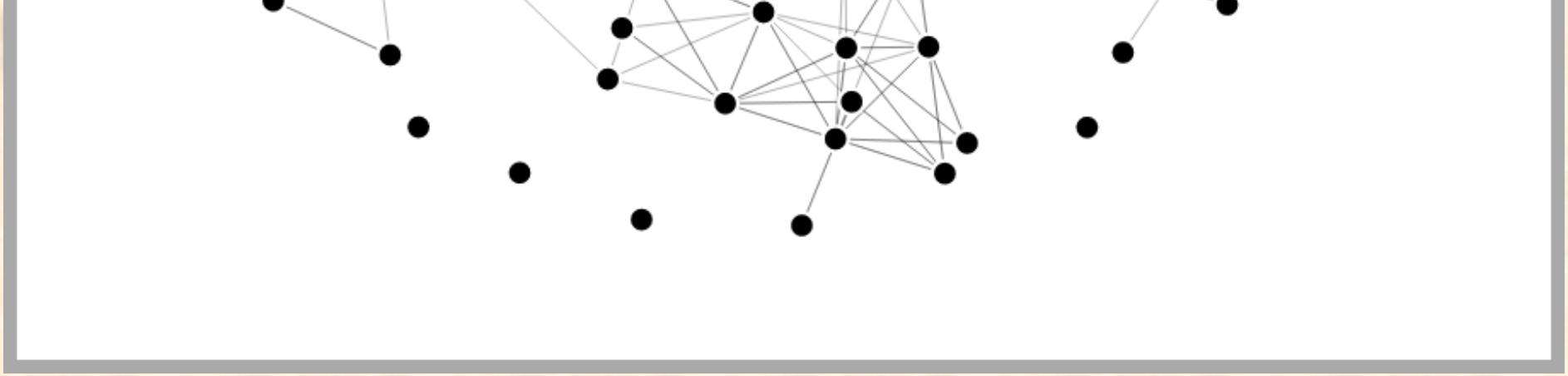
similarity view


similarity view



similarity view


Details
Select Neighbors
Select Component
Clear Selection
Filter at Selection
Filter out the Selection
Clear Filtering
similarity view



Edge count cap (max:35532)

0 2000 4000

Compute similarity between events considering:

Sets of probes

0 50 100

Time:

0 50 100

Recurrence:

None

Sets of causes

0 50 100

similarity panel

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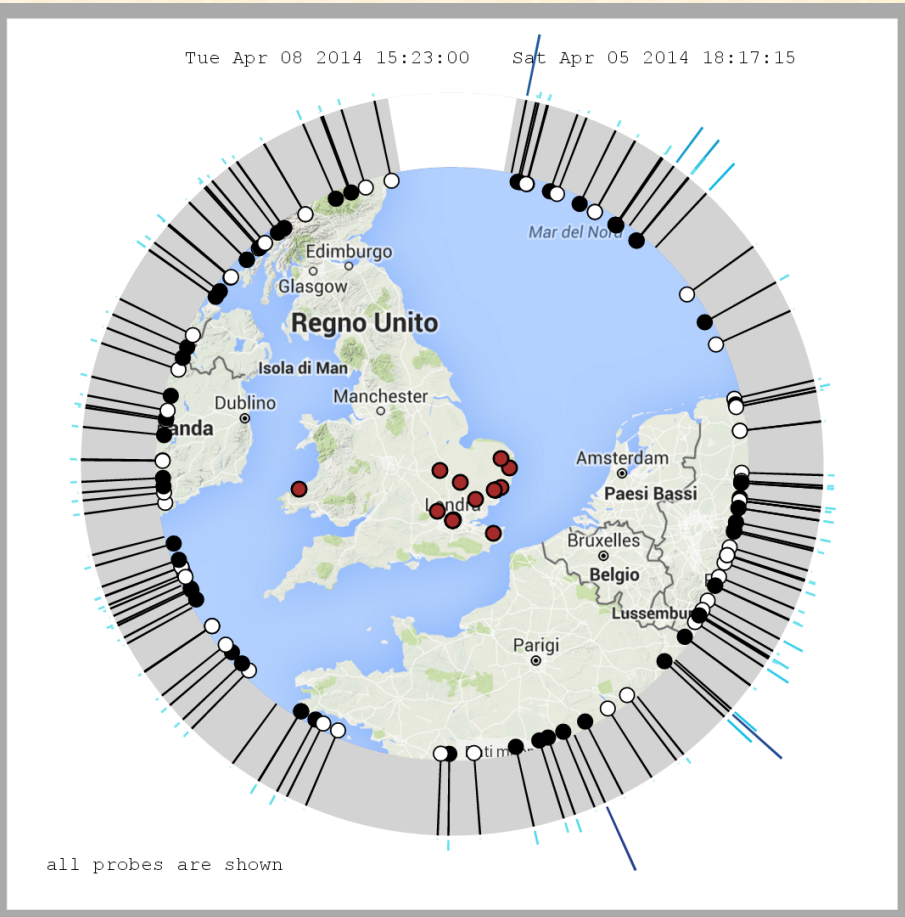

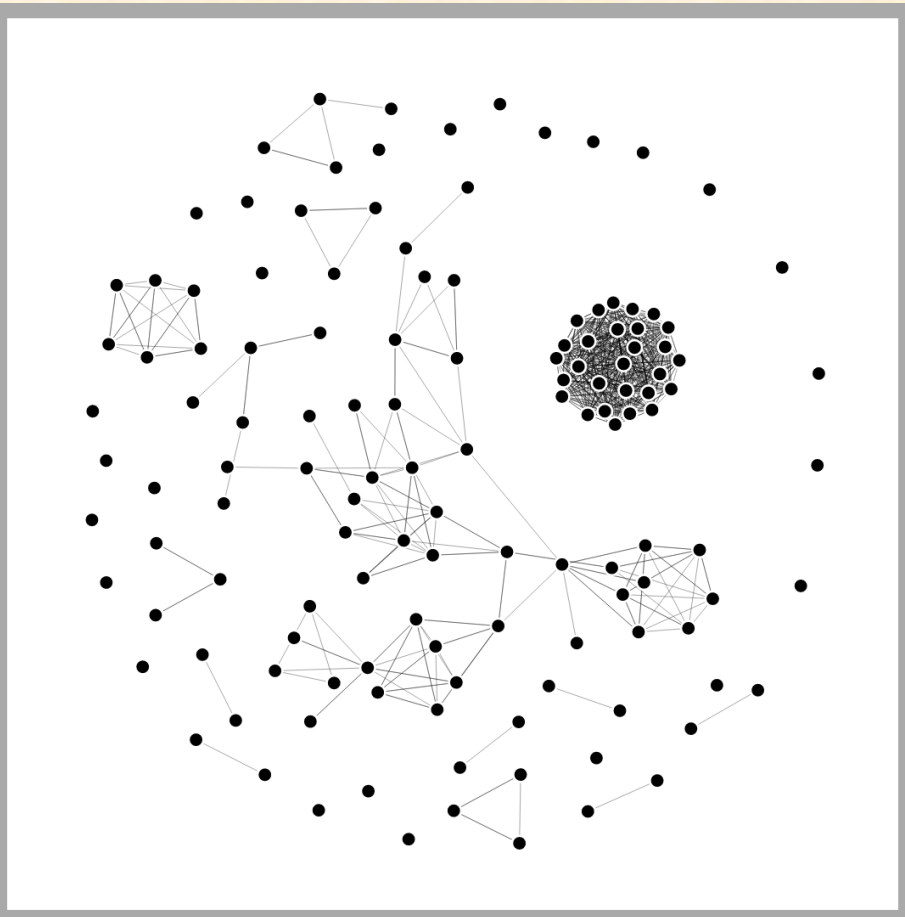

Display events that satisfy the following conditions:

Min impact
5 10 15 20

AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

Edge count cap (max:17292)
0 2000 4000

Compute similarity between events considering:

Sets of probes
0 50 100

Time:
0 50 100

Recurrence:
None

Sets of causes
0 50 100

ROMA TRE
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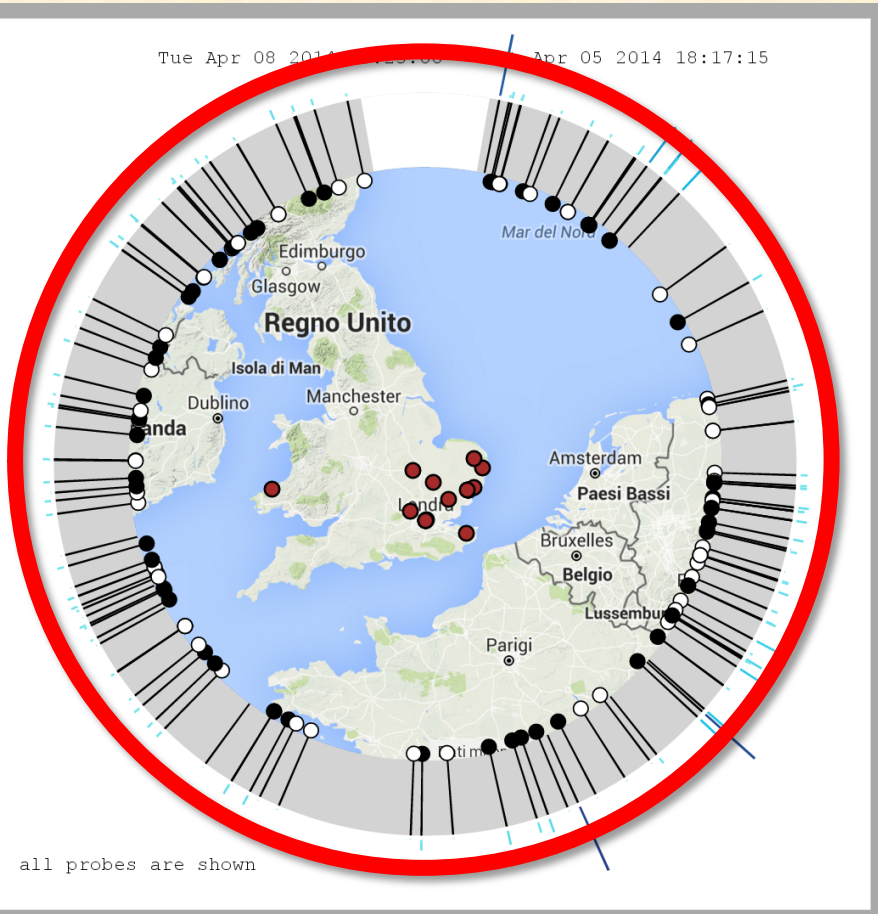
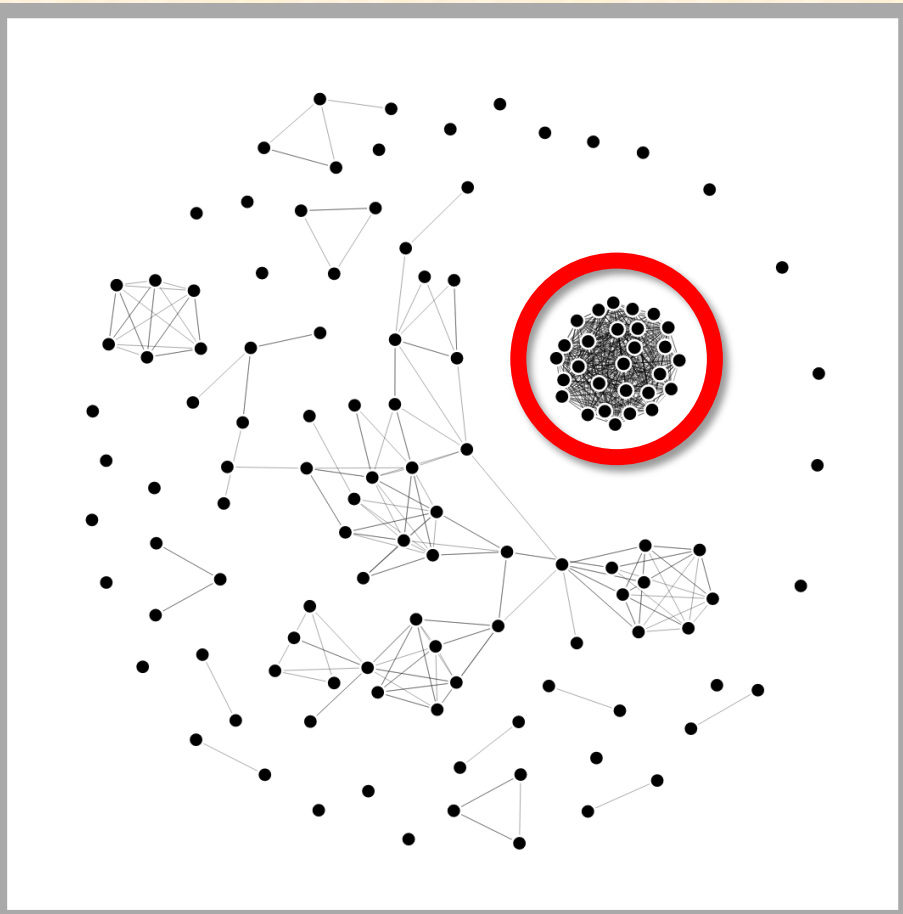




Display events that satisfy the following conditions:

Min impact
5 10 15 20

AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

Edge count cap (max:17292)
0 2000 4000

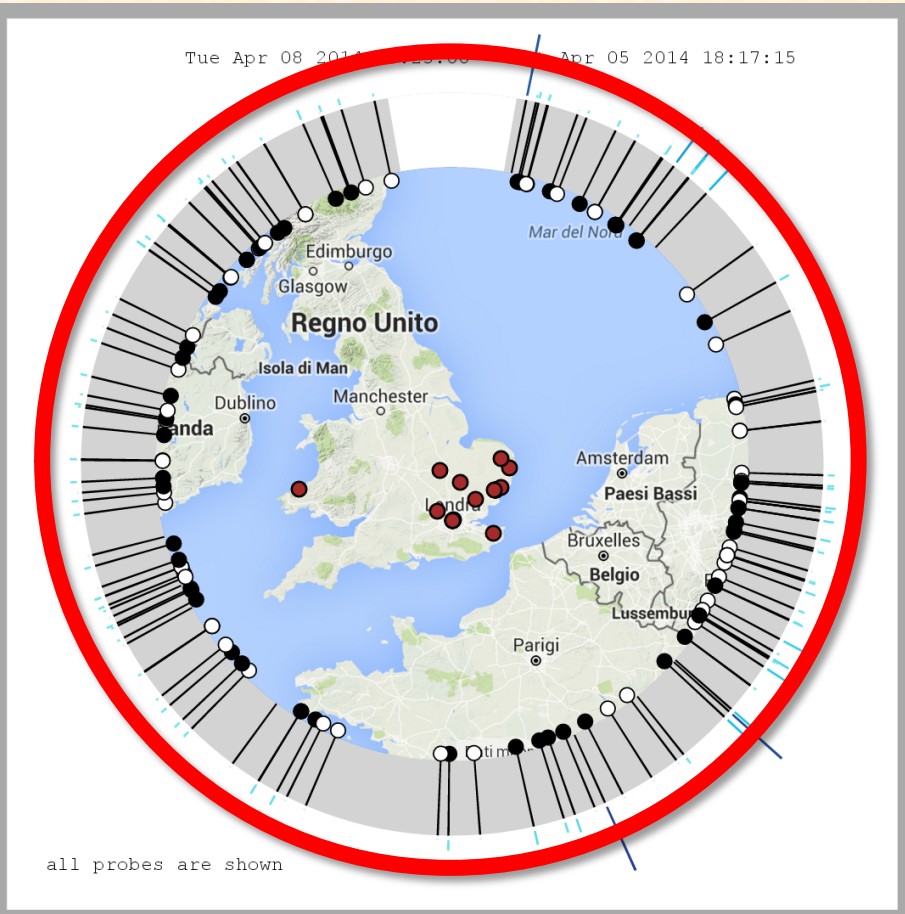
Compute similarity between events considering:

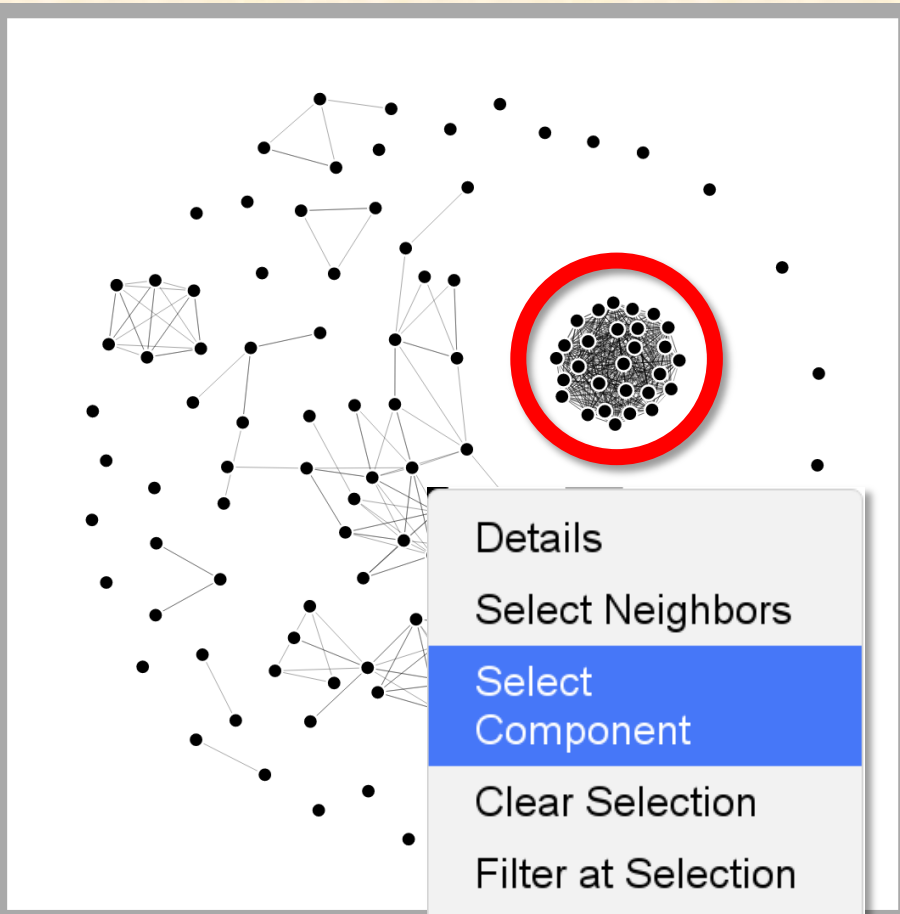
Sets of probes
0 50 100

Time:
0 50 100

Recurrence:
None

Sets of causes
0 50 100





Display events that satisfy the following conditions:

Min impact
5 10 15 20

AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

Edge cou
0 2

Compute similarity between events con

Sets of probes
0 50 100

Time:
0 50

Sets of causes
0 50 100

ROMA TRE
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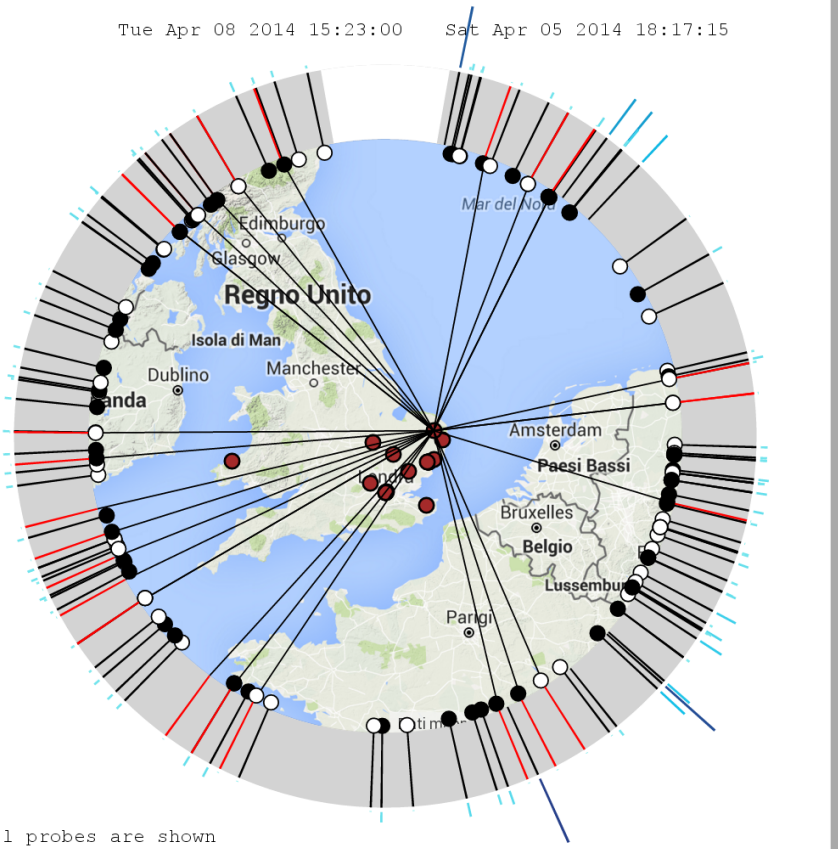

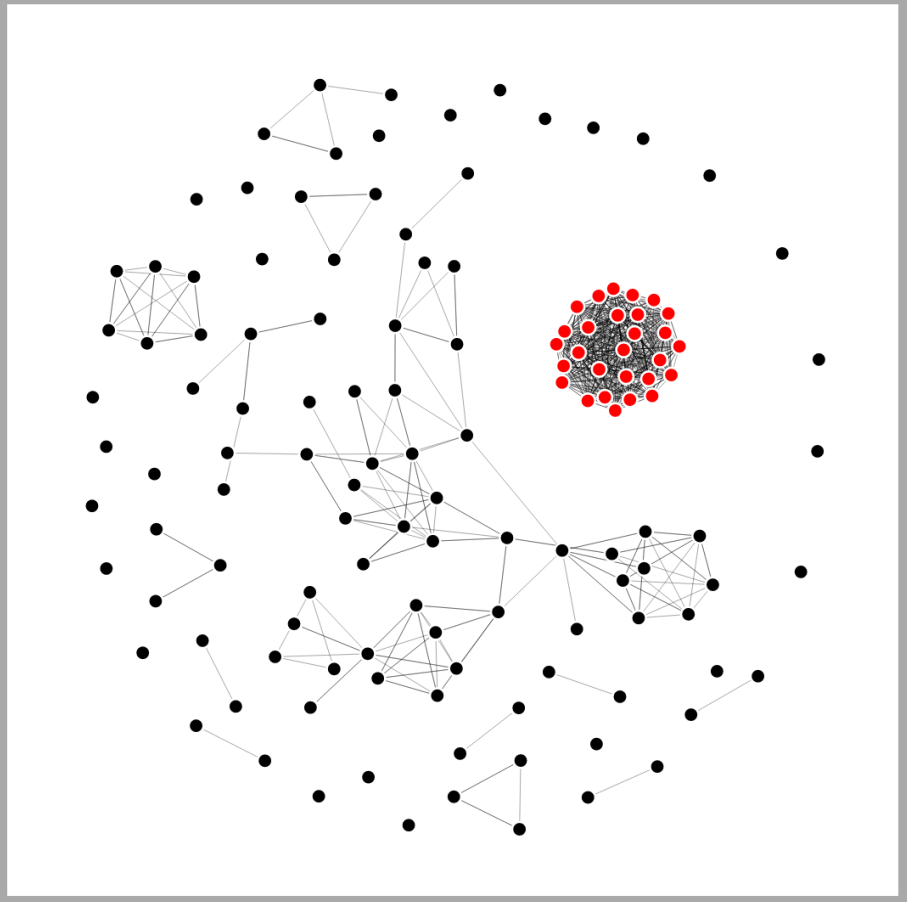

Display events that satisfy the following conditions:

Min impact: 5 10 15 20

AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

Edge count cap (max:17292): 0 2000 4000

Compute similarity between events considering:

Sets of probes: 0 50 100

Time: 0 50 100

Recurrence: None

Sets of causes: 0 50 100

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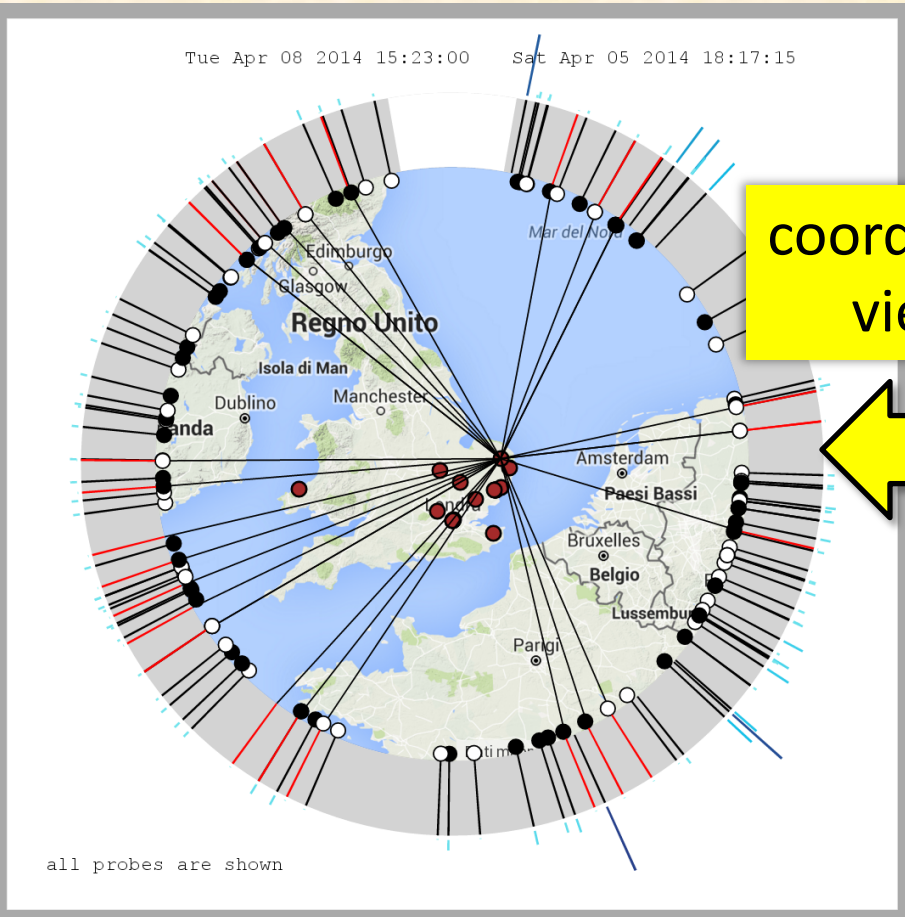
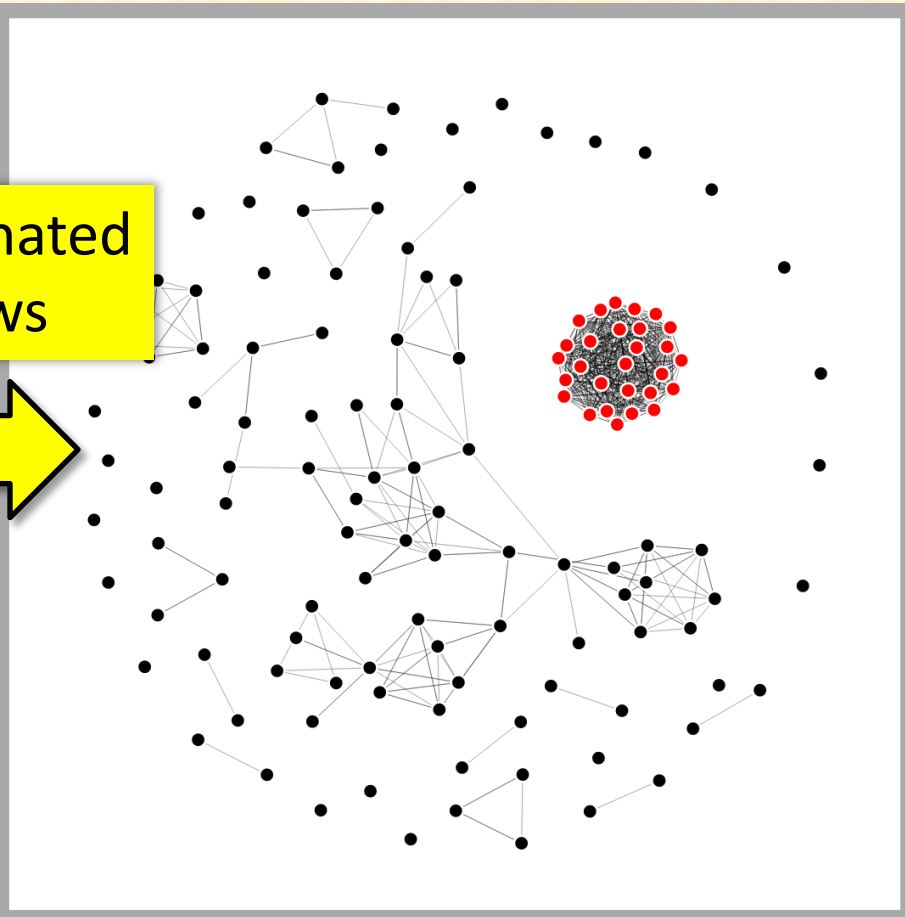


coordinated views



Display events that satisfy the following conditions:

Min impact
5 10 15 20

AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

Edge count cap (max:17292)
0 2000 4000

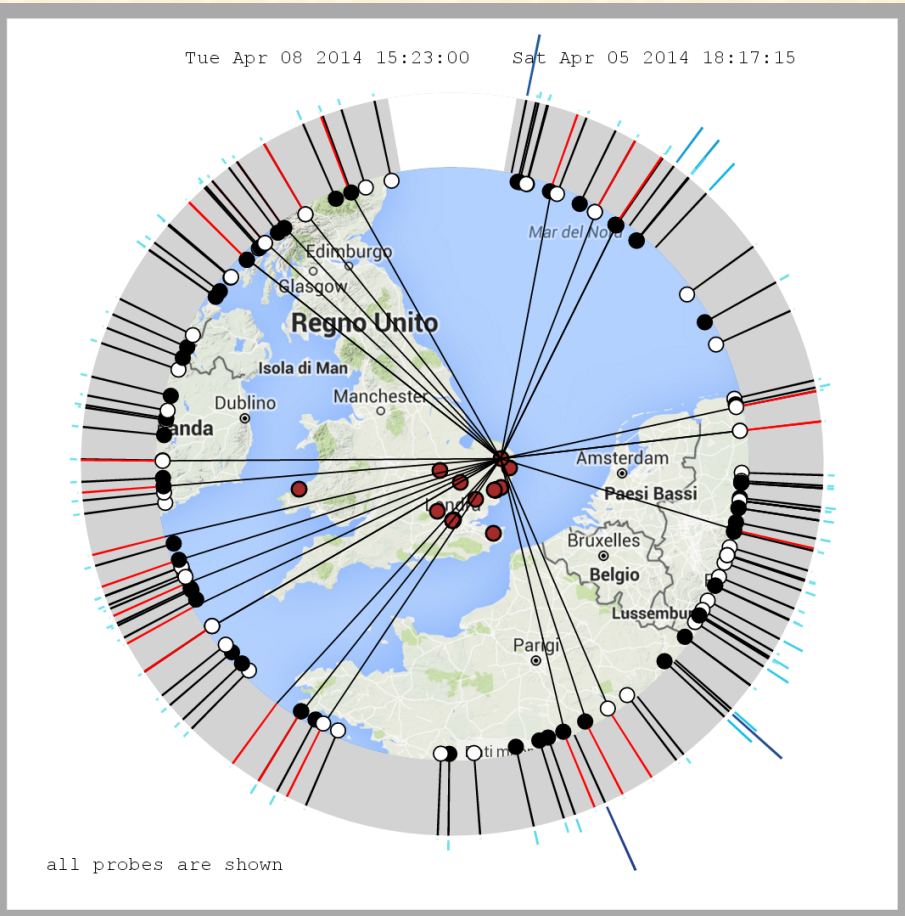
Compute similarity between events considering:

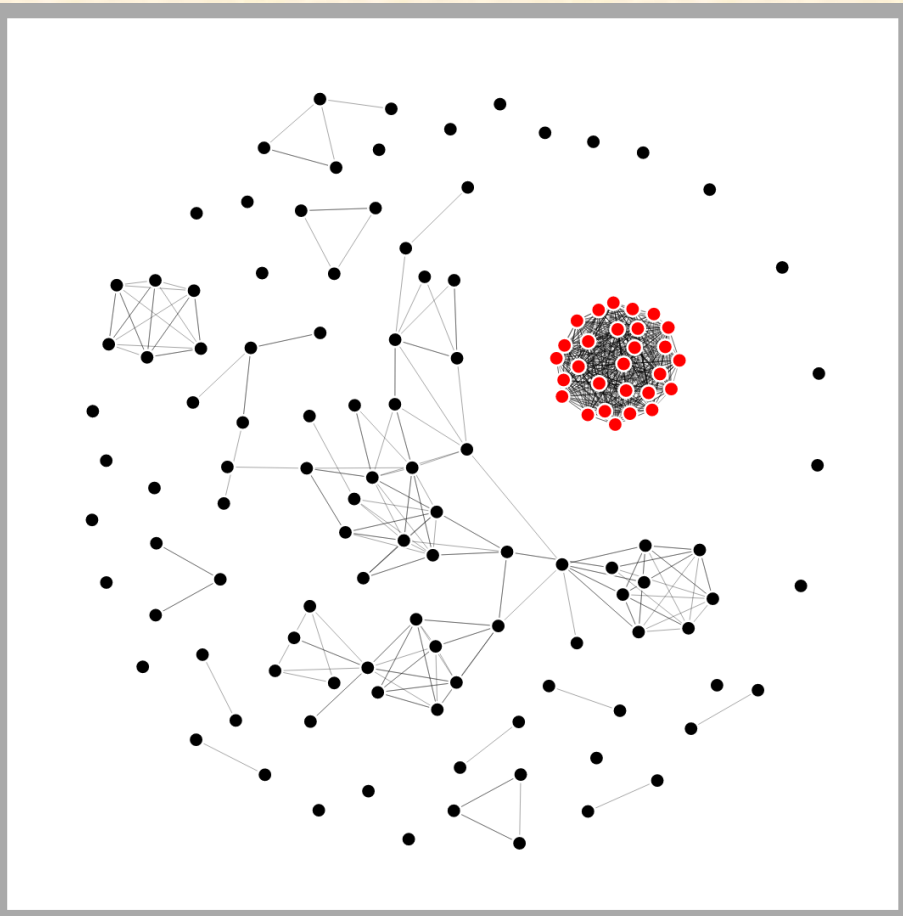
Sets of probes
0 50 100

Time:
0 50 100

Recurrence:
None

Sets of causes
0 50 100





Display events that satisfy the following conditions:

Min impact
5 10 15 20

AND

Impacted AS is: <None>
Target is: <None>
Cause AS is: <None>

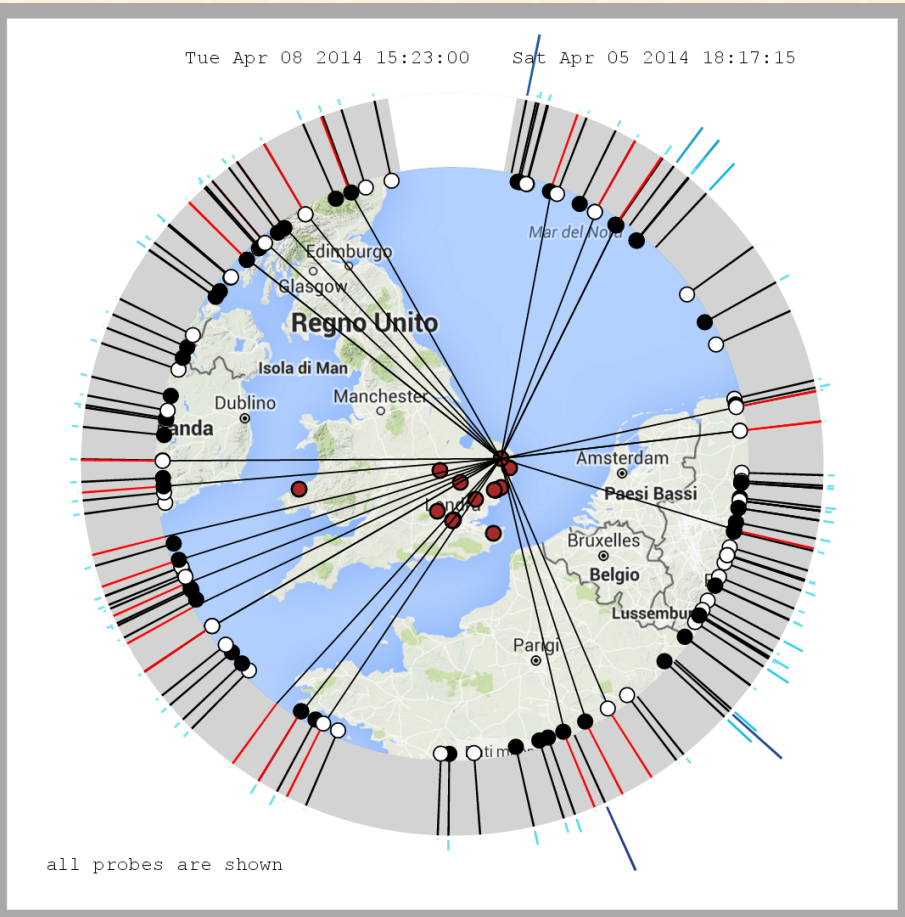
Edge count cap (max:17292)
0 2000 4000

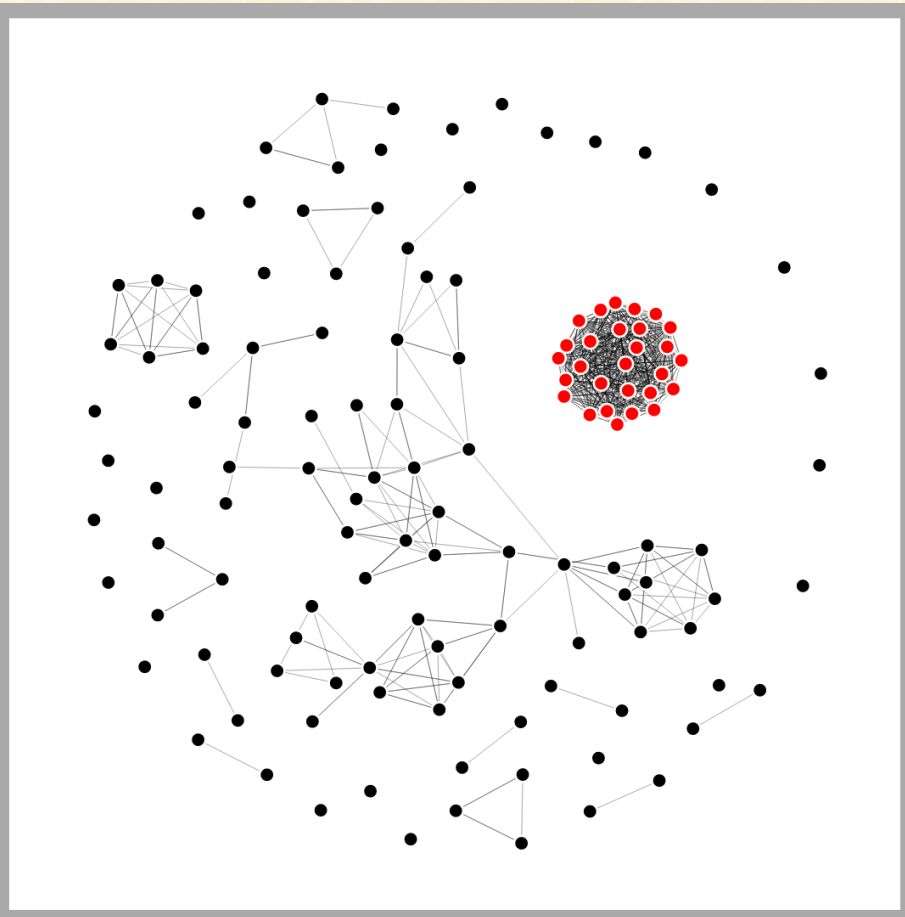
Sets of probes
0 50 100

Time:
0 50 100

Recurrence:
None

0 50 100





Display events that satisfy the following conditions:

Min impact
5 10 15 20

AND

Impacted AS is: <None>
Target is: <None>
Cause AS is: <None>

Edge count cap (max:17292)
0 2000 4000

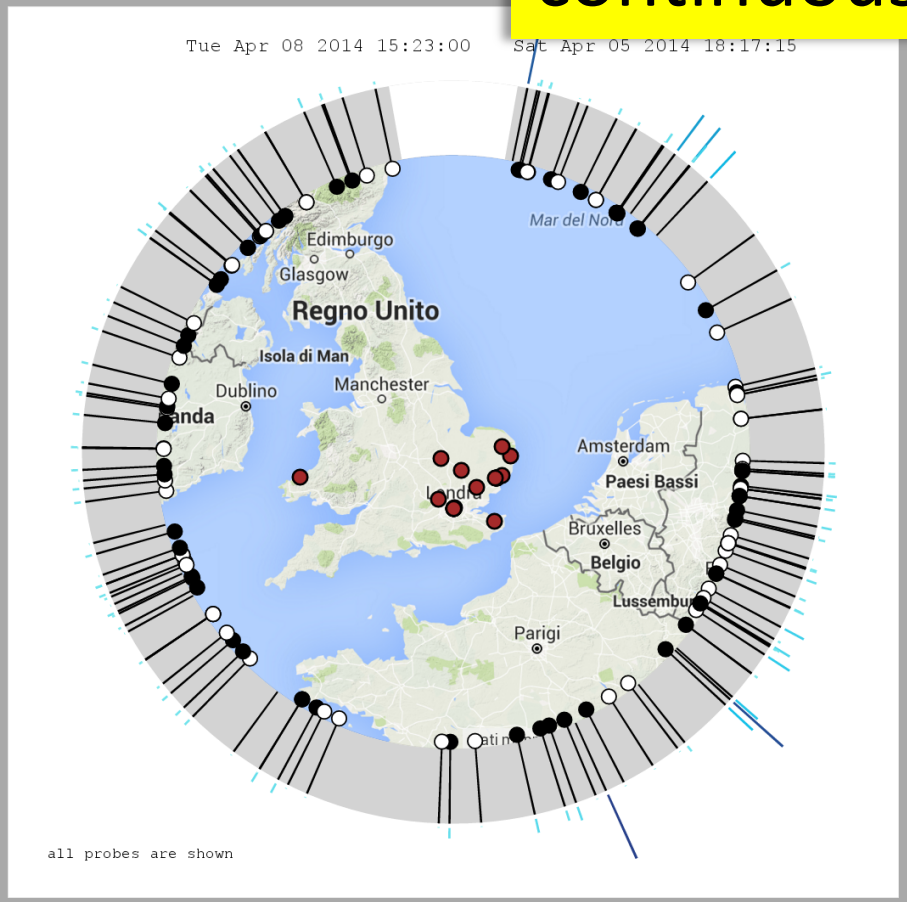
Sets of probes
0 50 100

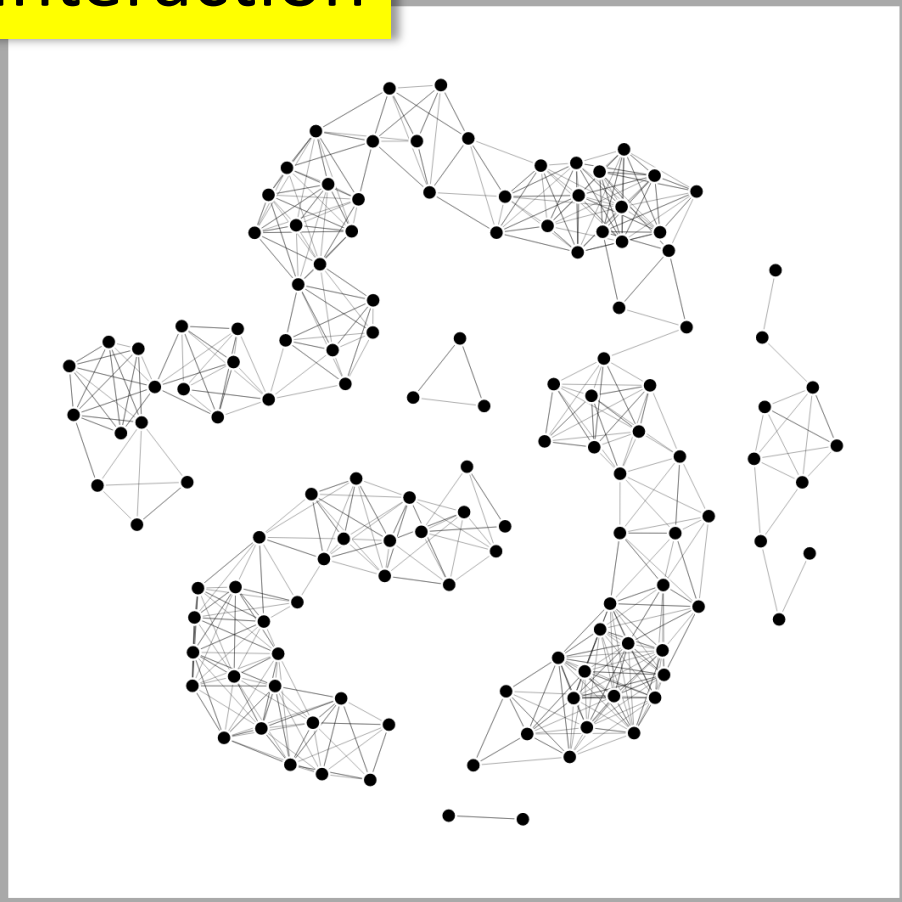
Time:
0 50 100

Recurrence:
Time of day

0 50 100

continuous interaction





Display events that satisfy the following conditions:

Min impact
5 10 15 20

AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

Edge count cap (max:17292)
0 2000 4000

Compute similarity between events considering:

Sets of probes
0 50 100

Time:
0 50 100

Recurrence:
Time of day

Sets of causes
0 50 100

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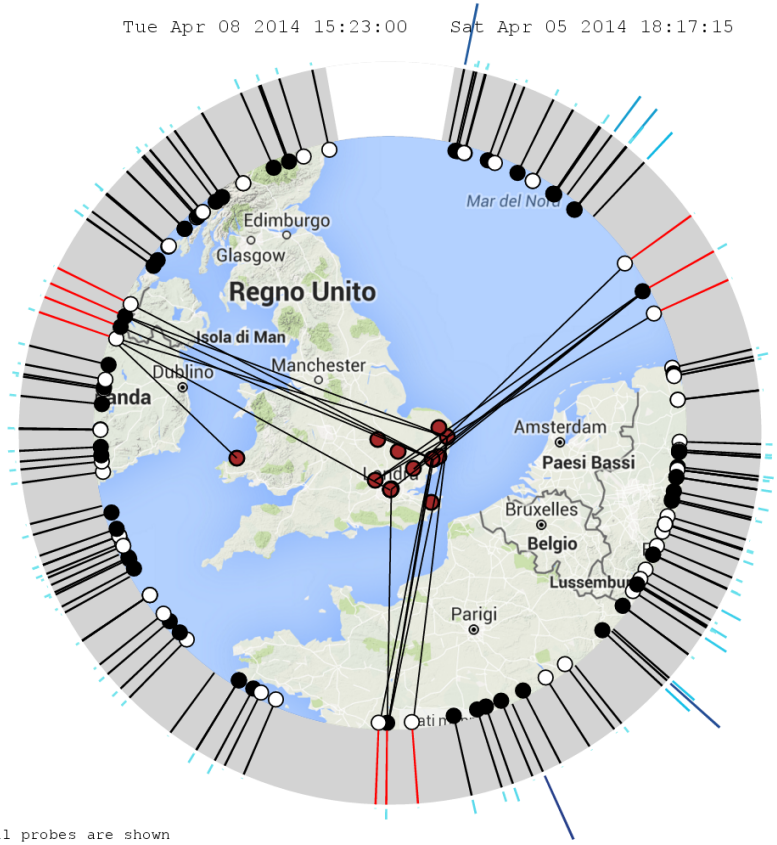

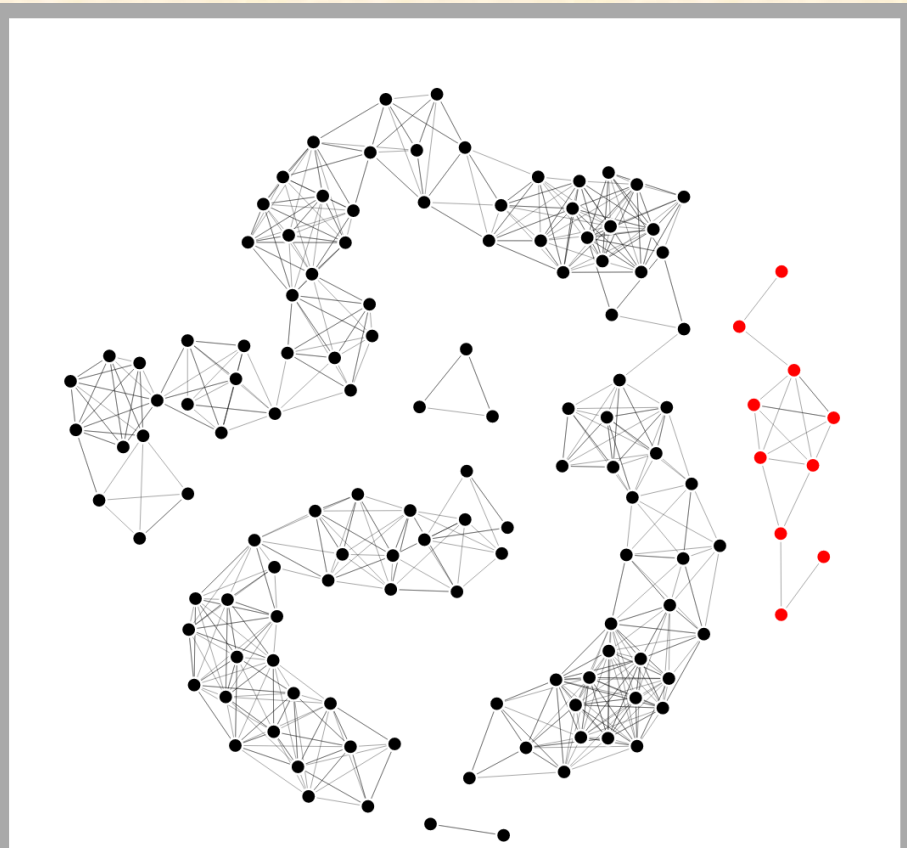

Display events that satisfy the following conditions:

Min impact
5 10 15 20

AND

Impacted AS is: <None>

Target is: <None>

Cause AS is: <None>

Edge count cap (max:17292)
0 2000 4000

Compute similarity between events considering:

Sets of probes
0 50 100

Time:
0 50 100

Recurrence:
Time of day

Sets of causes
0 50 100

User study

- User sample: employees of the R&D of a prominent italian ISP (experts in IP edge innovation, cyber-security threats, video/multimedia platforms)

User study

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- Questionnaire results:

1 5

User study

- User sample: employees of the R&D of a prominent italian ISP (experts in IP edge innovation, cyber-security threats, video/multimedia platforms)
- Questionnaire results:

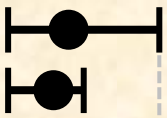
1 5

- events are a useful aggregation of routing dynamics

User study

- User sample: employees of the R&D of a prominent italian ISP (experts in IP edge innovation, cyber-security threats, video/multimedia platforms)
- Questionnaire results:

1 5



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User study

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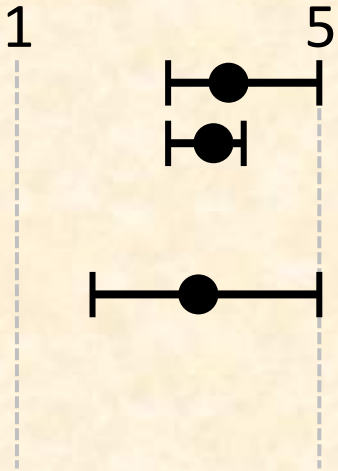

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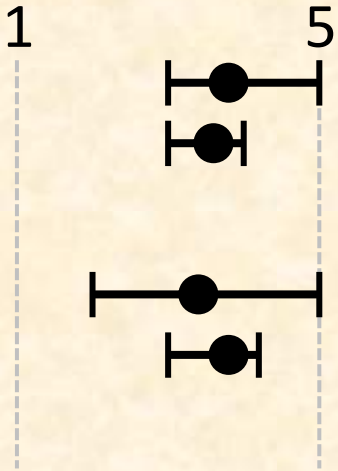

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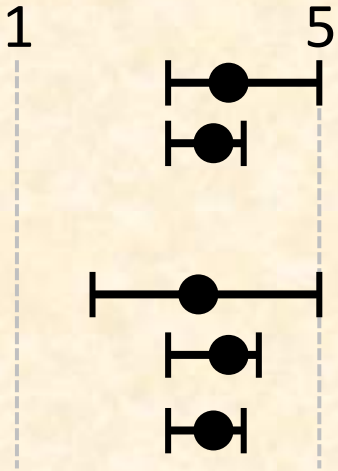

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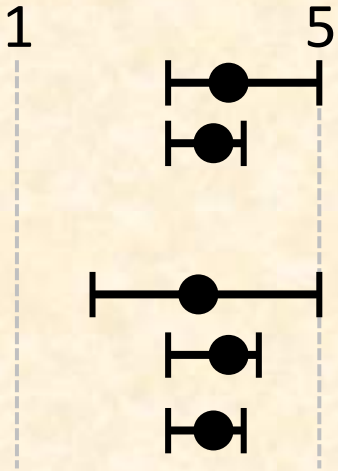

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Filters

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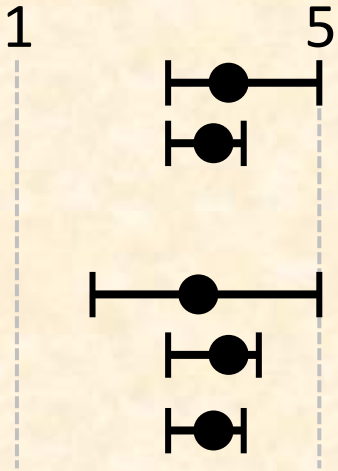

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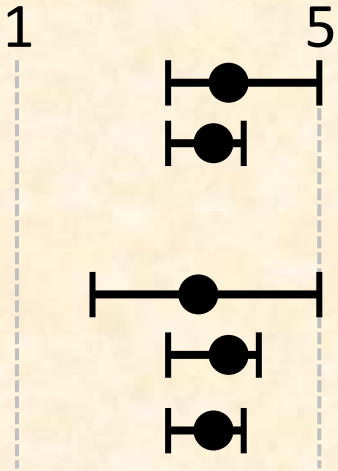

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Filters

Event patterns

"A tool for mining traceroutes"

Future Work

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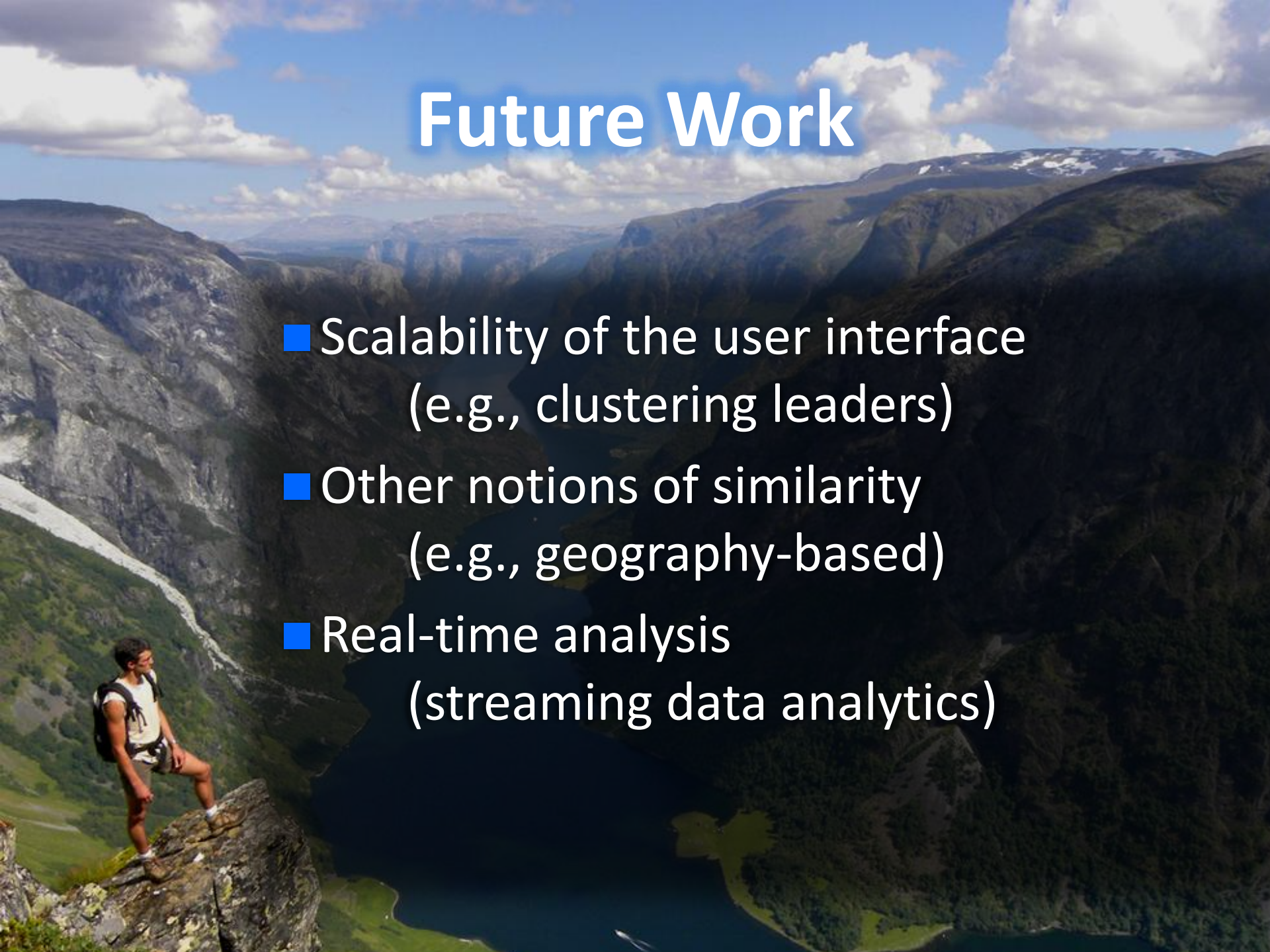

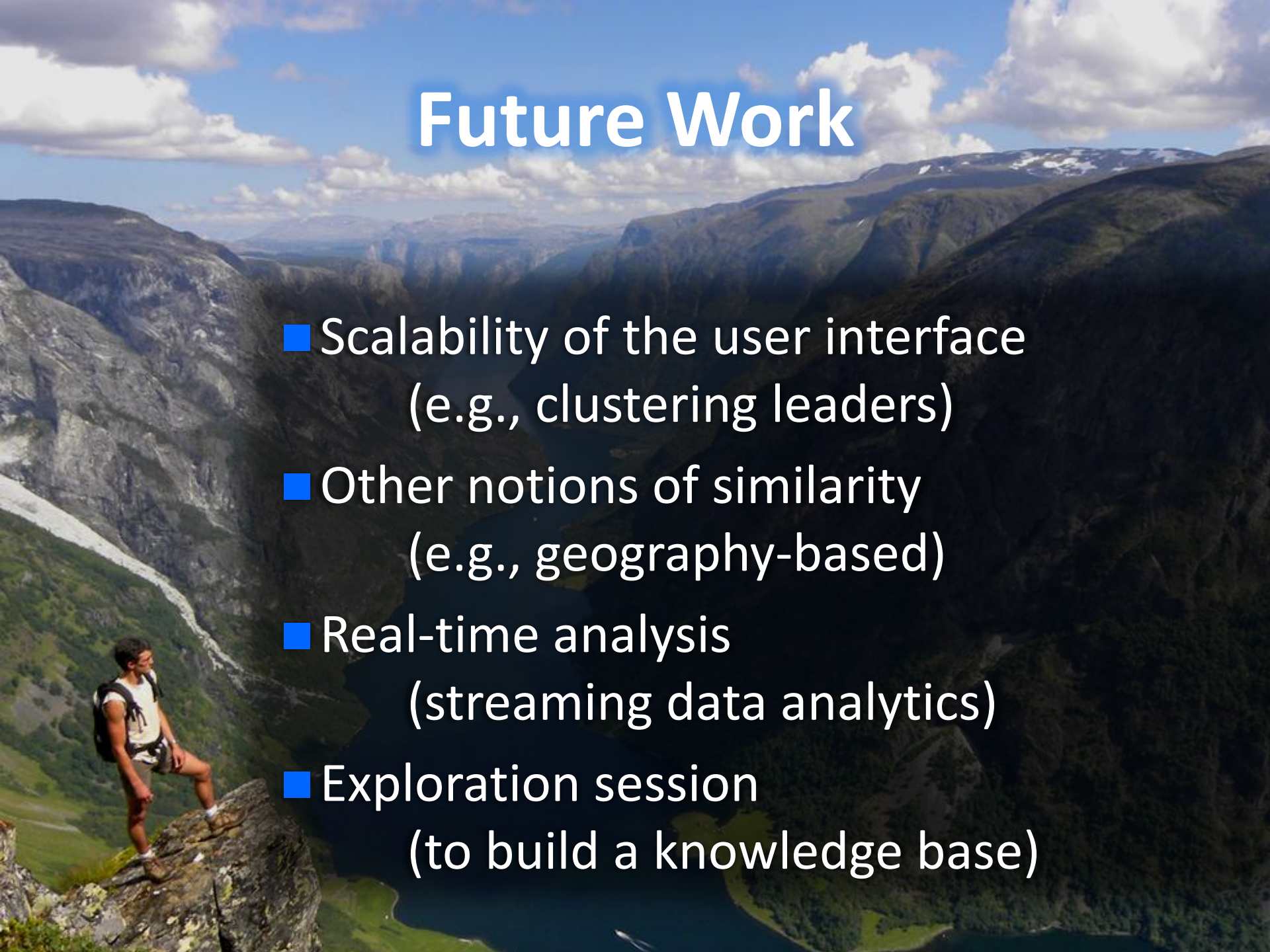

Future Work

- Scalability of the user interface
  (e.g., clustering leaders)
- Other notions of similarity
  (e.g., geography-based)
- Real-time analysis
  (streaming data analytics)
- Exploration session
  (to build a knowledge base)