Large Scale Internet Queueing Delay Tomography

Y. Shavitt, E. Shir, J. Stéger,

G. Simon, G. Vattay, I. Csabai

History

- Distributed measurements and simulation (Dimes) and the European Traffic Observatory Measurement InfrastruCture (Etomic) are two efforts in the framework of EU funded project Evergrow.
- In Etomic an EU wide hardware based, precise GPS synchronized, active measurement infrastructure was built in 2004-2005
- In Dimes thousands of software based agents were distributed to volunteers to let Internet measure itself in a SETI@home fashion
- The Etomic infrastructure can take tomographic snapshots of queuing delay over the European part of the Internet.
- The two systems together can produce the world's largest Internet tomography project, where thousands of Dimes agents can send and Etomic stations can receive packets with high precision.

Snapshot of queuing delays in Europe

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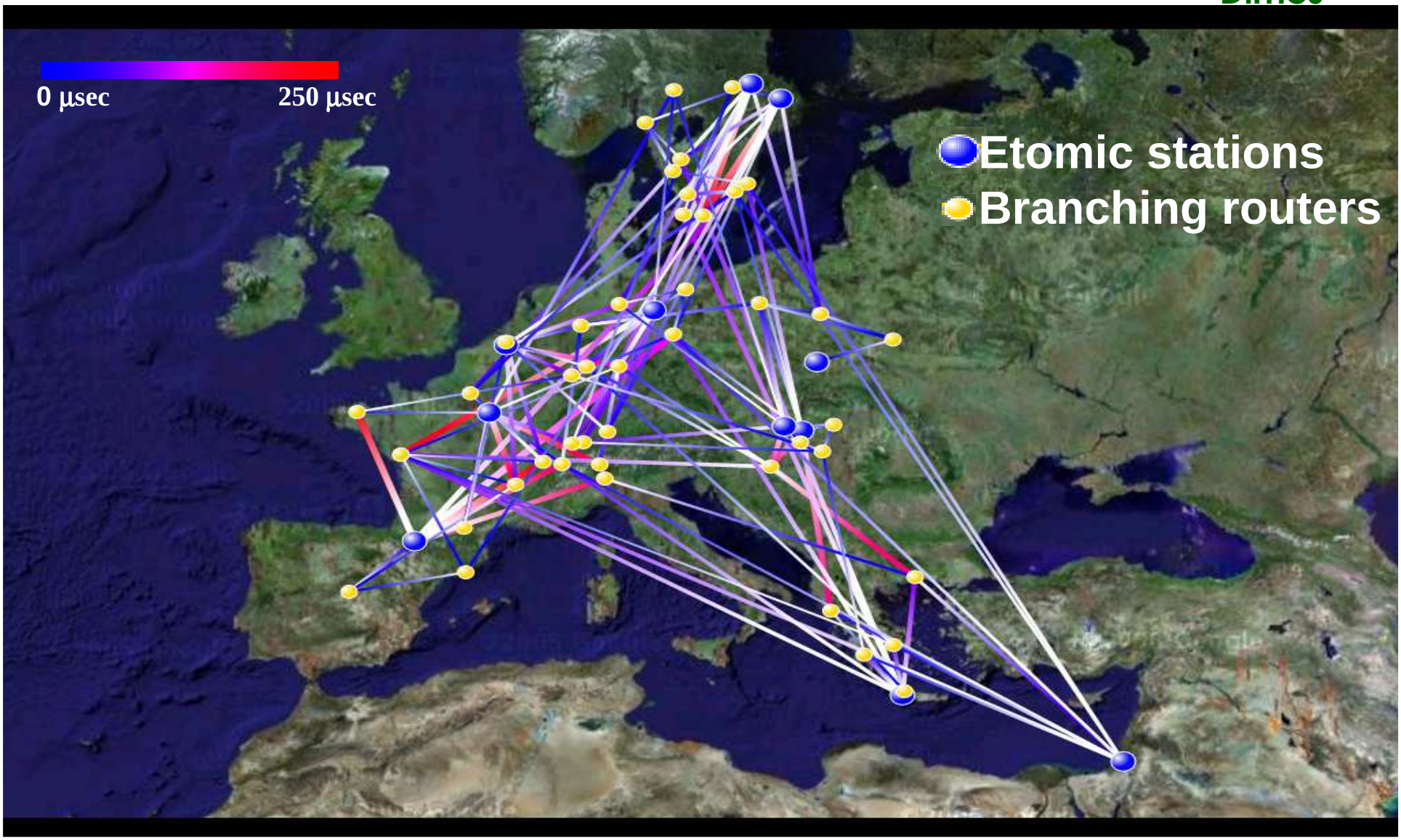
Dimes



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Architecture

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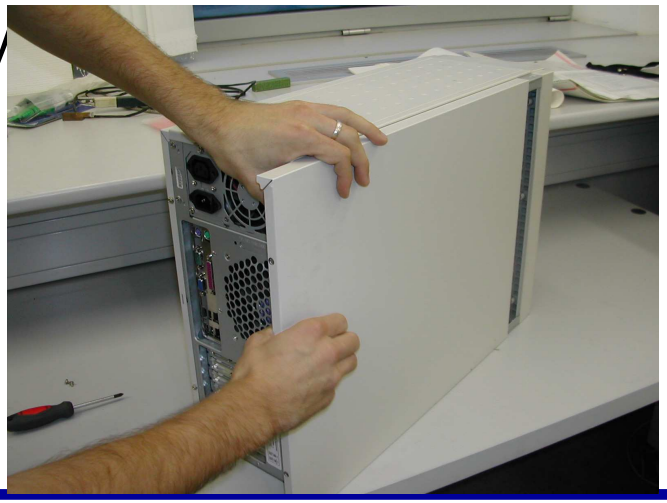
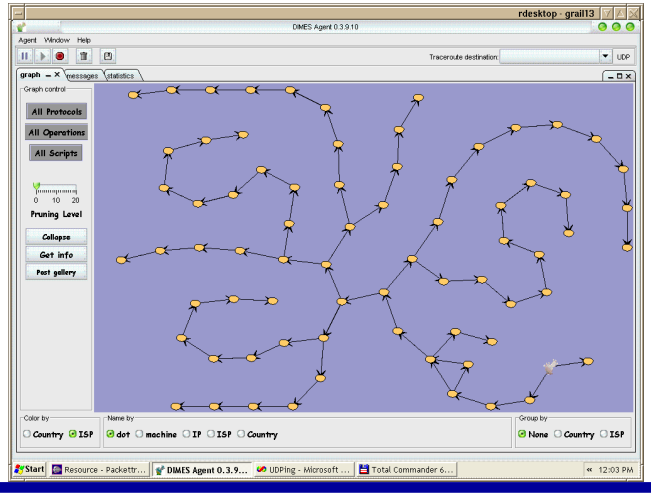
Etomic measurement stations

- Standard server PC
- DAG 3.6 GE card
- GPS antenna (Garmin 35HVS) for time sy



Dimes measurement agents

- Userspace GUI application
- Windows OS, Linux OS
- Experiments: ping, traceroute, packettrain



Web interfaces 1.

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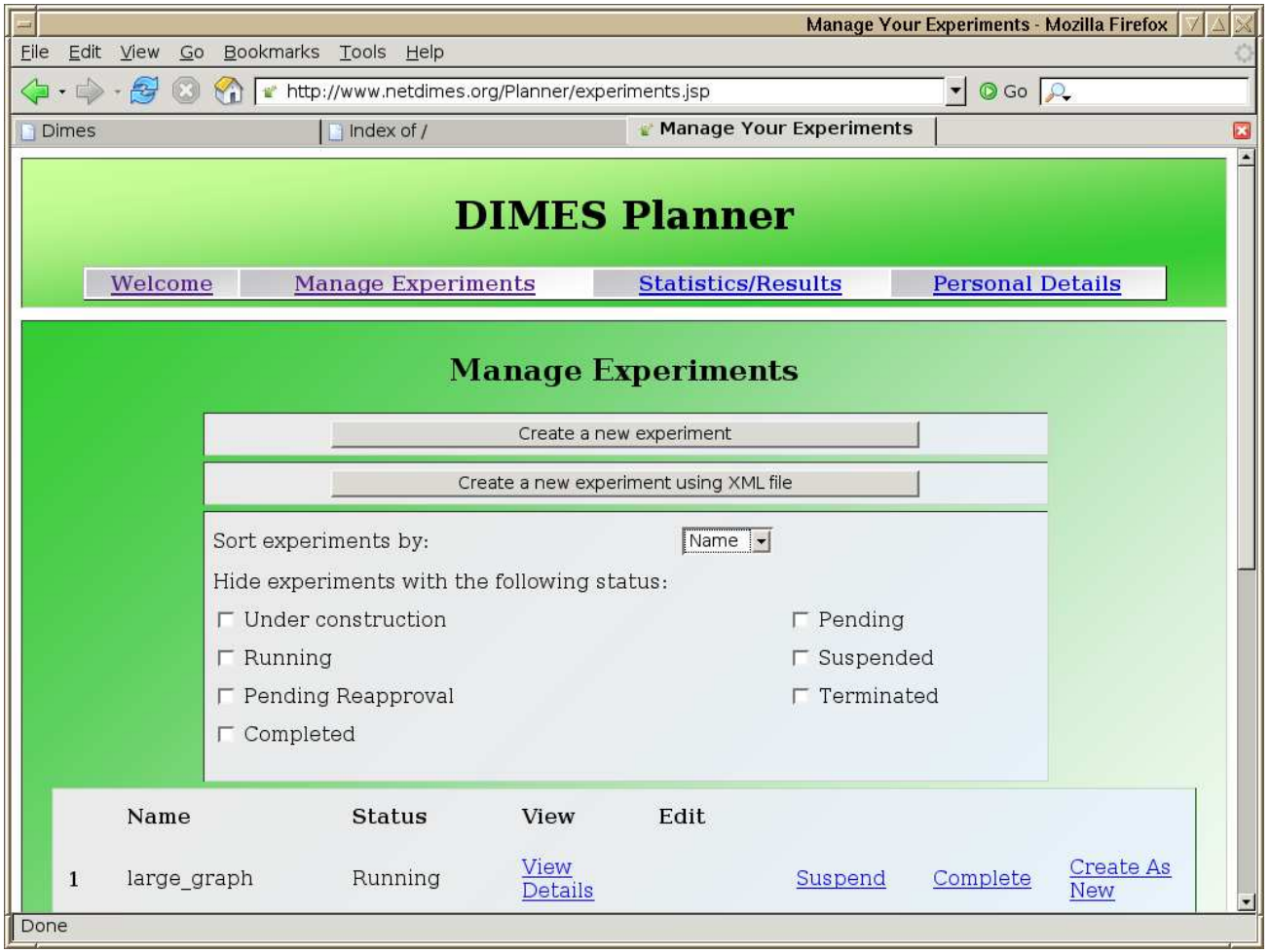
Dimes

www.etomic.org

Web interfaces 2.

Dimes

netdimes.org/Planner



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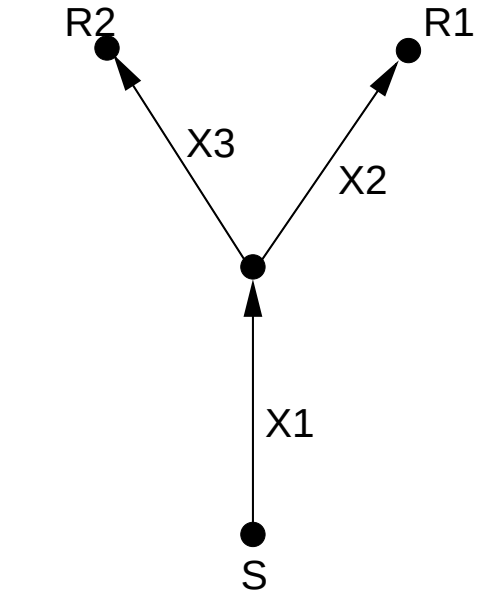
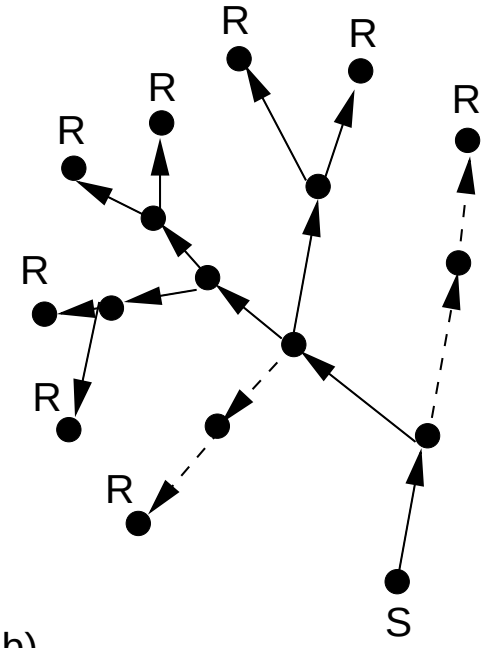
Network Tomography

Dimes

Getting delay statistics from the interior of the network, where we don't have monitoring stations



a)



b)

Shoot back-to-back packet patterns …
and measure their delay at arrival with very high precision

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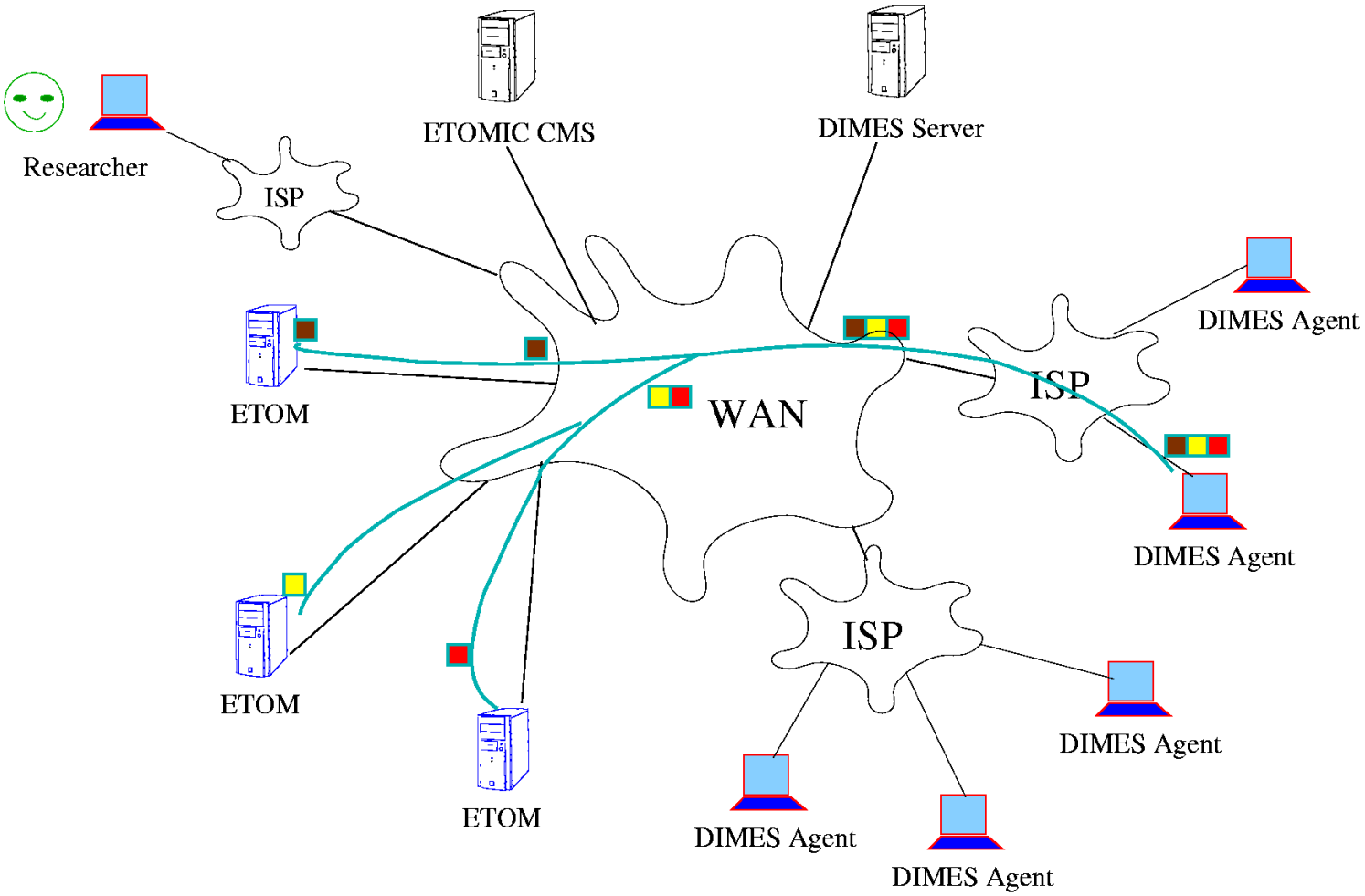
Measurement scheme

Dimes



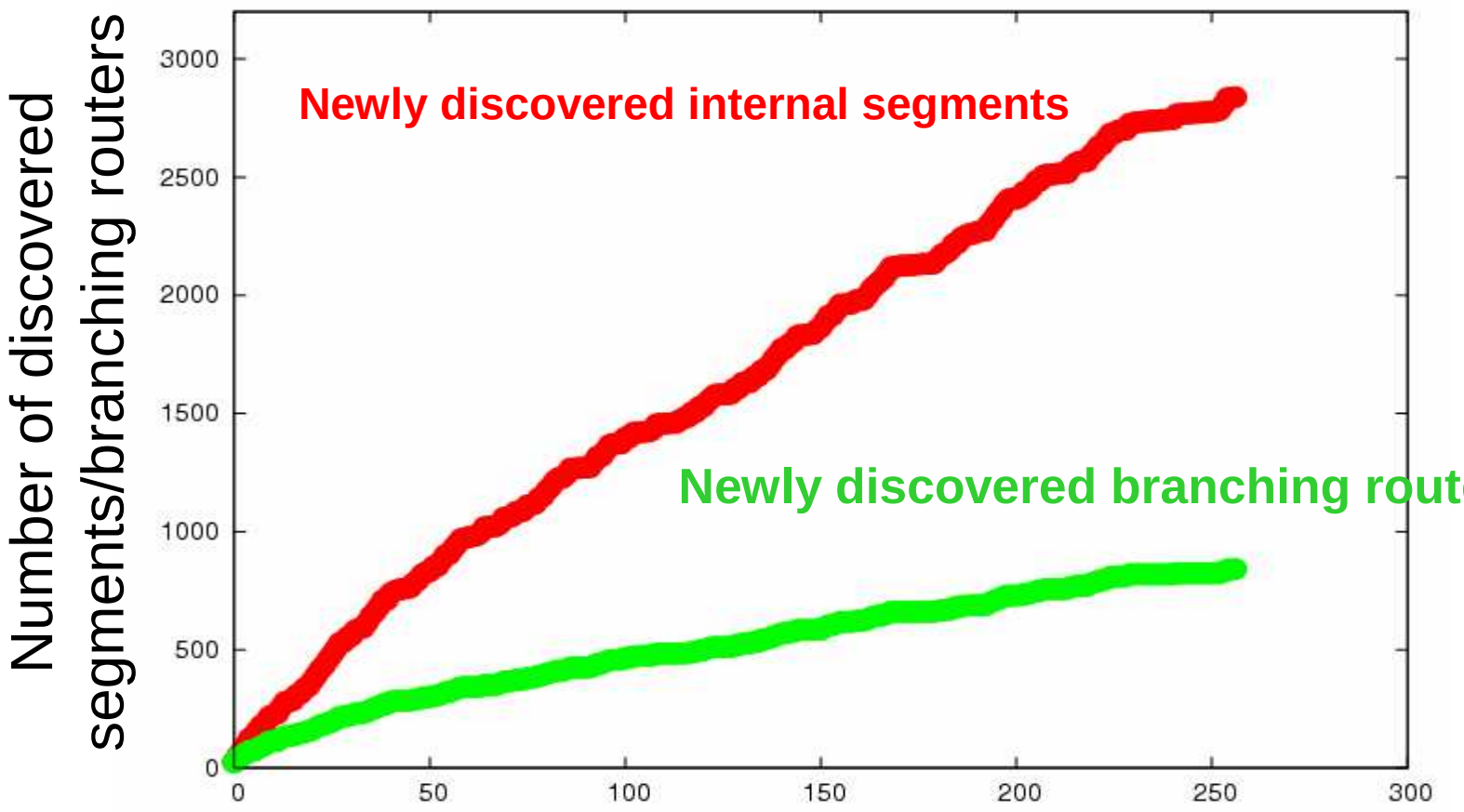
Expectations 1.

Topology discovery (2006 January)

Question	Answer
When?	23th January, 12$^{\underline{46}}$ -- 1st February, 21$^{\underline{49}}$
N° Etoms?	5 Etomic measurement stations targetted
N° Dimes?	257 Dimes agents: traceroute exp.
Measurements?	3913/9509 ≈ 41.2 % translatable routes
New nodes?	2898 unique IP addresses found
New edges?	5359 unique links found
Branching?	826 branching routers 2839 internal segments

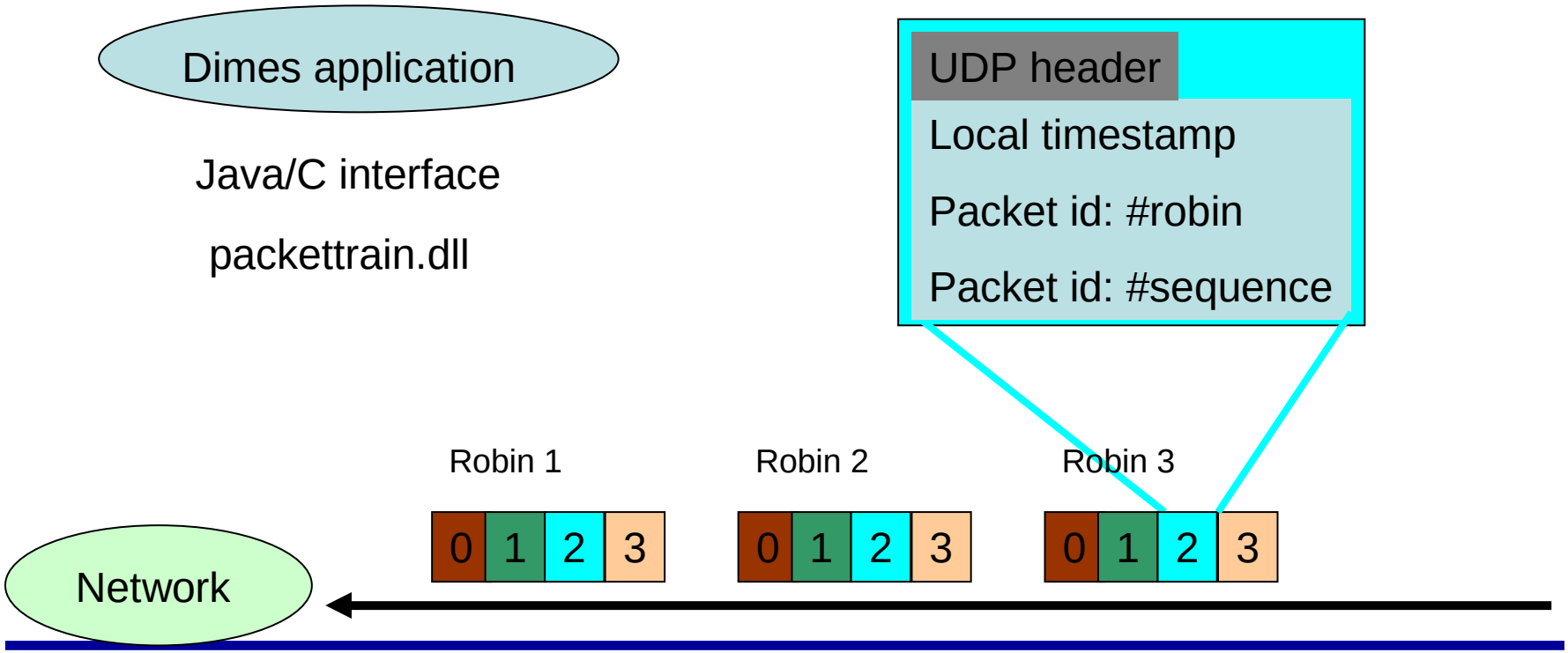
Expectations 2.

Traceroute between 257 Dimes agents and 15 Etomic nodes



New module

PACKETTRAIN <no robins> <delay> <packetlength> <packettype> <destination port> <IP list>



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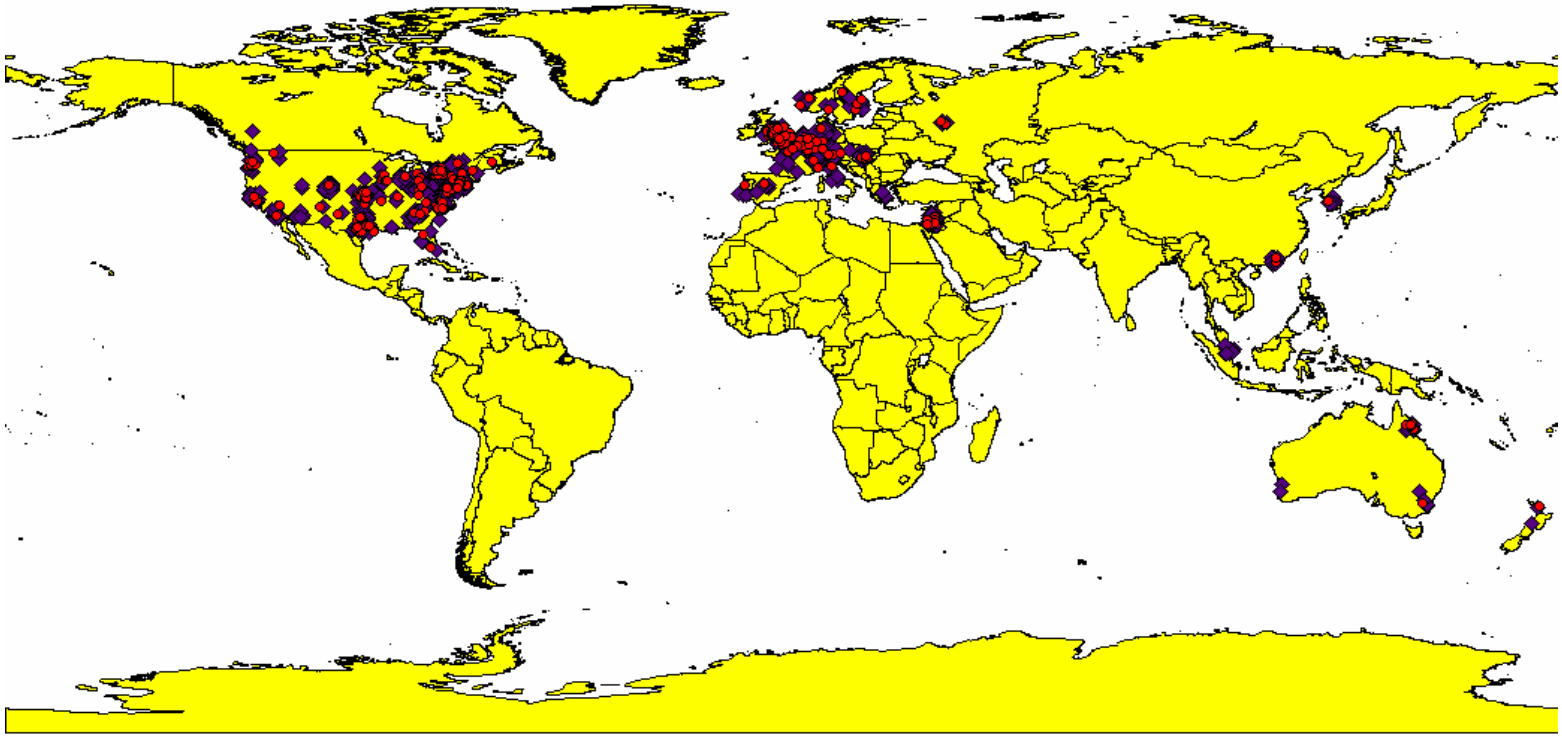
Measurement sites

Dimes



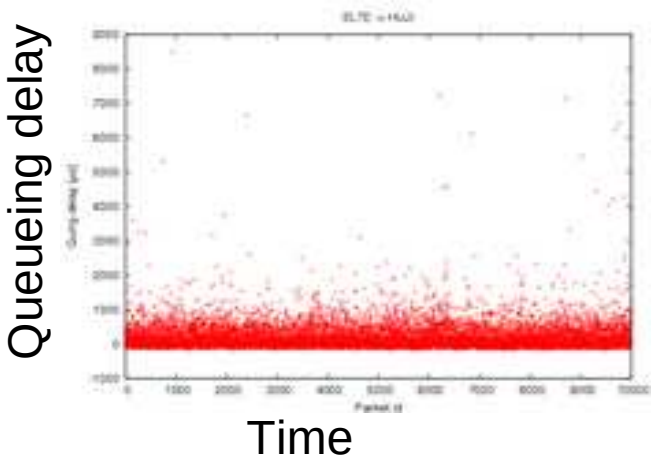
Properly located Dimes agents (red)
Branching routers (blue)

An example 1.

Test experiment

- 12th July 2005
- a dimes agent: Budapest (ELTE)
- Etomic nodes: Budapest (UNIV); Stockholm (ERIC); Birmingham (ASTN); Pamplona (UNAV); Paris (UPAR) and Jerusalem (HUJI).
- Topology revealed using traceroute.
- Probes: 10^4 six packet pattern sent, spaced: 0,1s.

ELTE -> HUJI



1. Step

- Oneway delay constructed
- Clock skew removed
- Outlayer data (1%) removed
- Constant offset removed

An example 2.

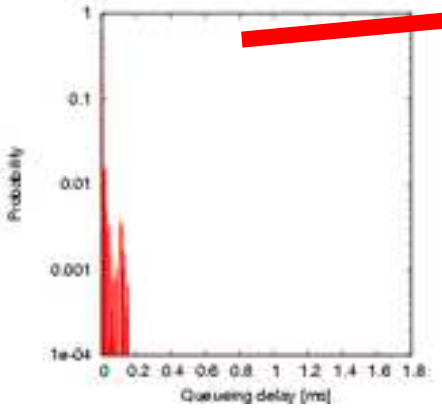
Dimes

2. Step

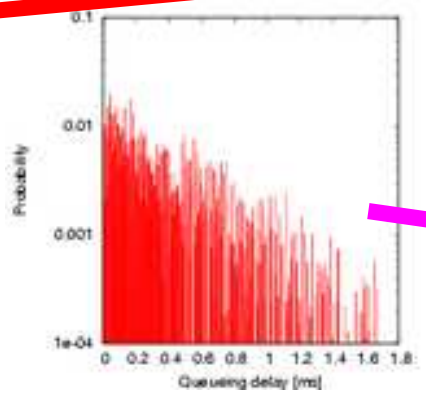
- Topology reconstructed
- Branching routers determined

3. Step

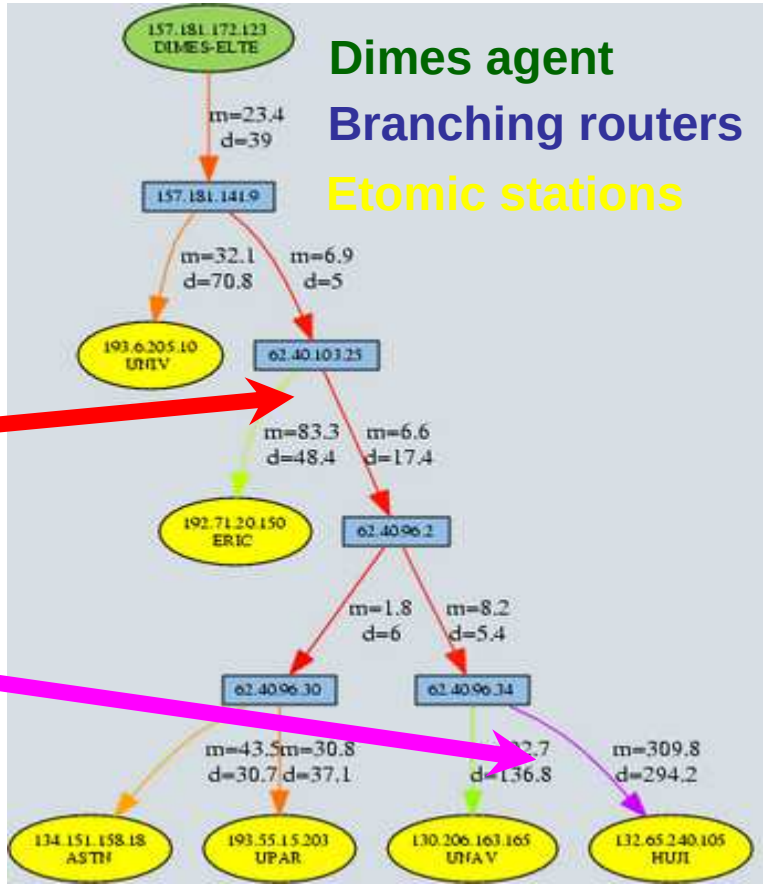
- Revealing queueing delay distributions using EM algorithm for all internal segments



Backbone link



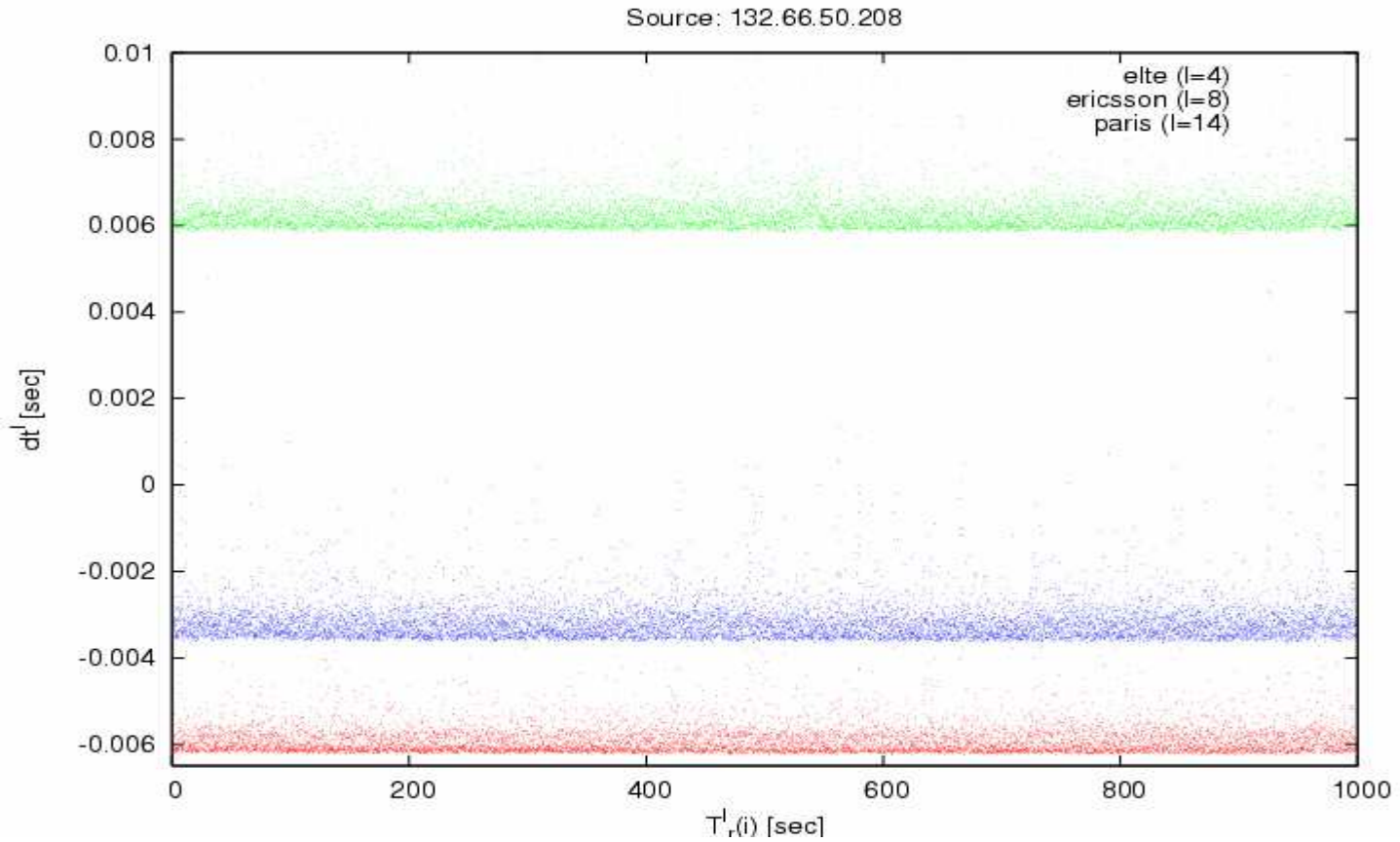
Access link



An example 3.

Link	Avg. q.d.(μs)	Error	Std dev. (μs)	Error
1	23.446	2.738	35.044	4.652
2	6.976	3.883	3.883	2.048
3	32.196	2.779	70.856	2.678
4	6.693	4.016	17.467	10.557
5	83.373	5.730	48.426	1.373
6	1.802	0.707	6.059	4.215
7	8.273	1.452	5.441	0.981
8	43.575		30.752	
9	30.866		37.188	
10	309.853		294.230	
11	92.723		136.885	

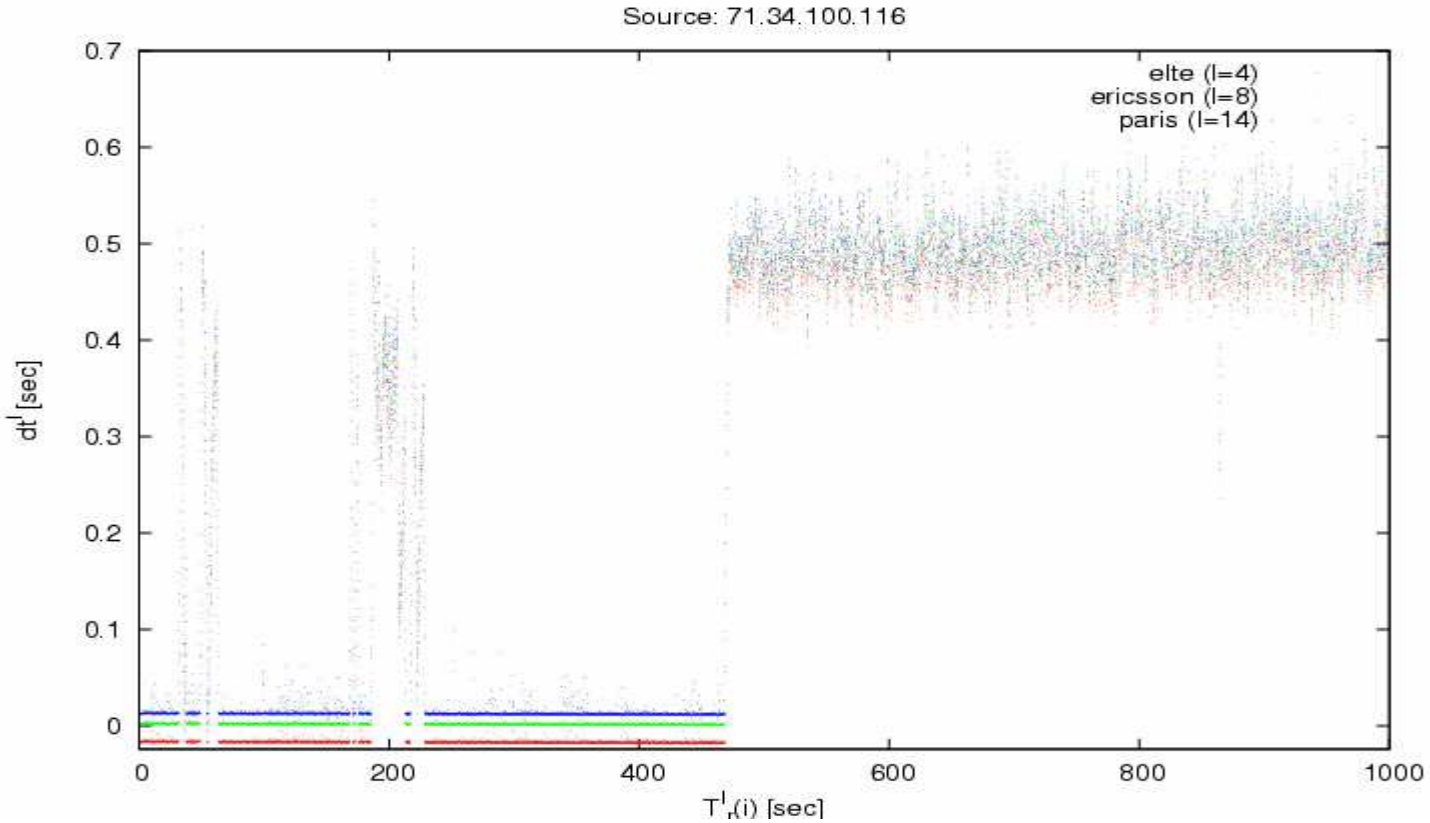
Timeseries 1.



Dimes agent probably connected to a high bandwith access link

similar oneway delay series experienced like within internal Etomic measurements

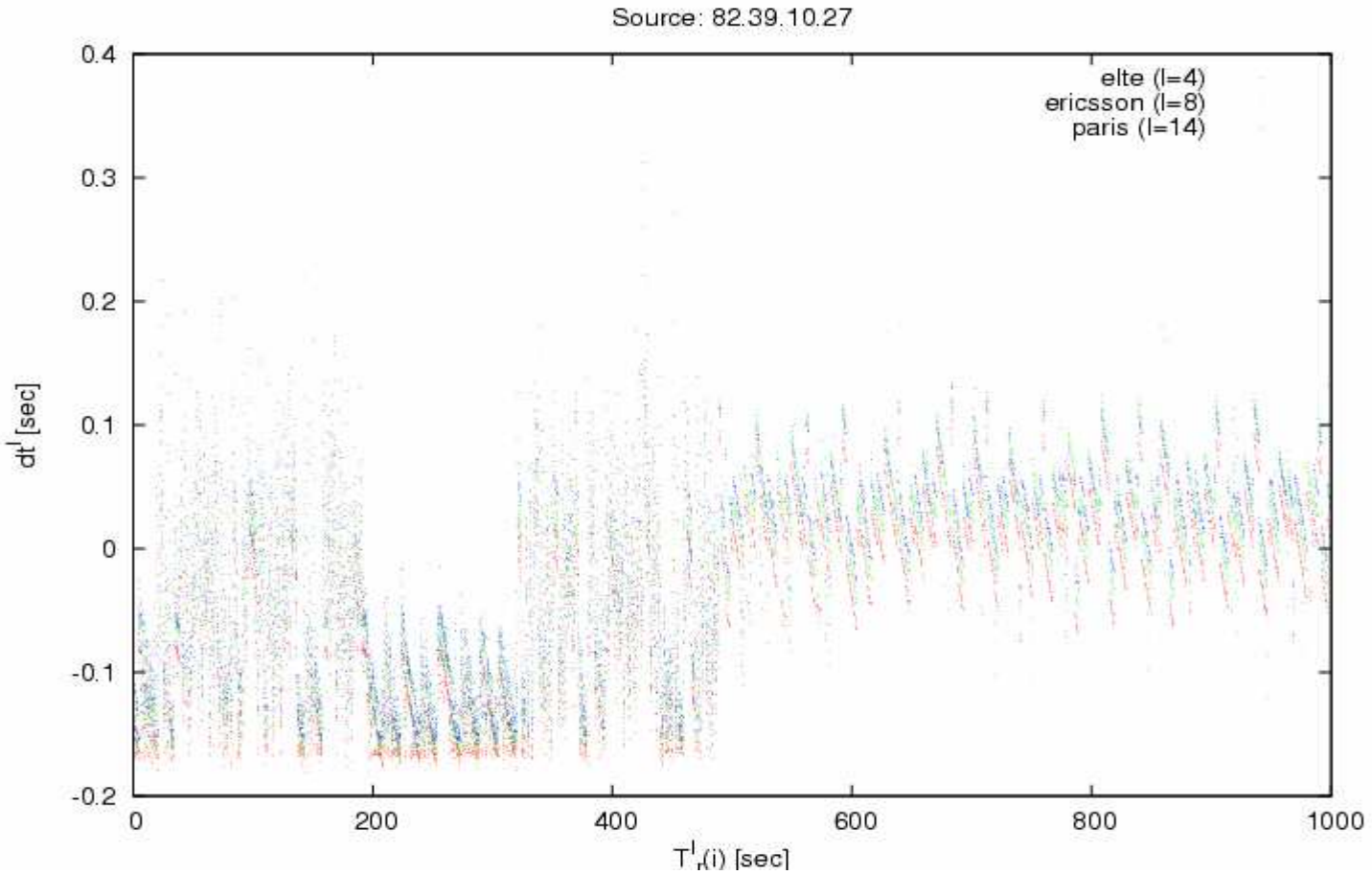
Timeseries 2.



Dimes agent probably connected to a high bandwith access link

first similar delay series experienced like within internal Etomic measurements, then drastic step in delay series: probably dimes ran on in the background

Timeseries 3.



Dimes agent probably connected to a low bandwith access link

heavy cross traffic causes large fluctuations in queueing delay

The future

The two systems, Dimes agents and Etomic infrastructure, together can produce the world's largest Internet tomography project.
Precise Etomic stations cooperating with thousands of Dimes agents can discover and measure numerous segments of the Internet across the world.
Defining and implementing new measurement modules for the two systems may open new dimensions in designing and conducting experiments, for example bandwidth tomography or packet loss tomography.

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Thanks!

NKTH
Nemzeti Kutatási és Technológiai Hivatal

IST Future and Emerging Technologies