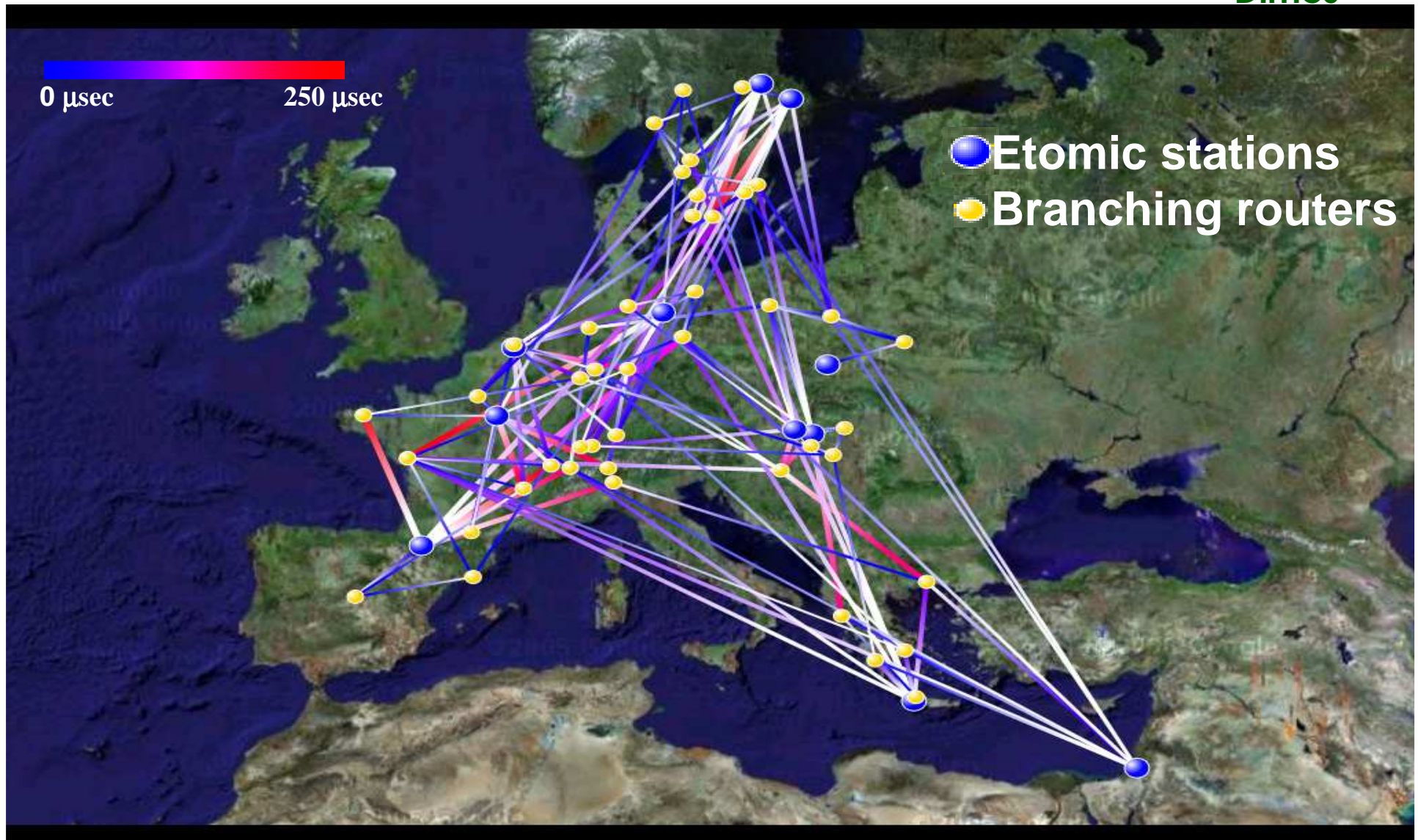


Large Scale Internet Queueing Delay Tomography

Y. Shavitt, E. Shir, J. Stéger,
G. Simon, G. Vattay, I. Csabai

- 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.

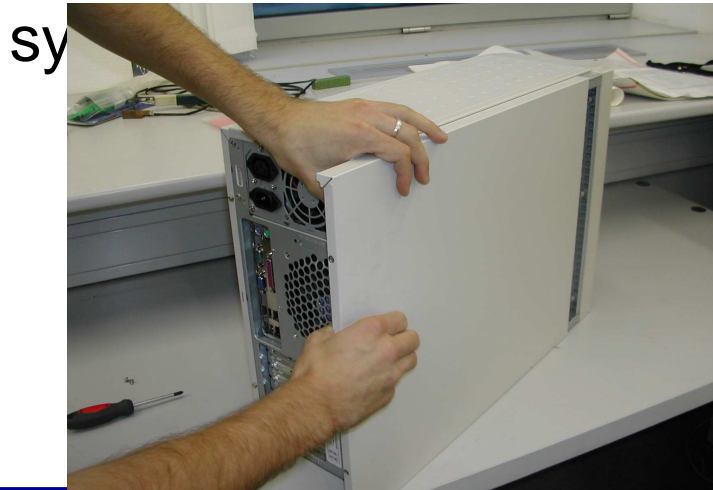
Snapshot of queuing delays in Europe





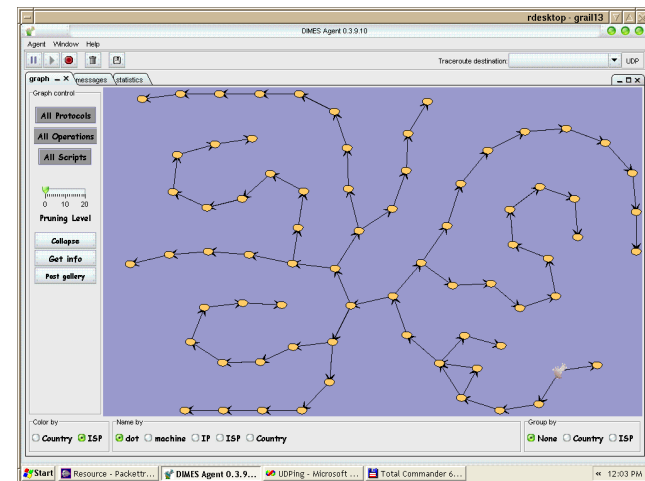
Etomic measurement stations

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




Dimes measurement agents

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





www.etomic.org



Create a bundle - Mozilla Firefox

Fájl Szerkesztés Nézet Ugrás Könyvjelzők Eszközök Súgó

<https://etomic.tlm.unavarra.es/researcher/bundle2.php#ericsson>

Researcher menu

- Upload file
- Edit/View files
- Shared files
- New bundle**
- Edit/View bundles
- New experiment
- Periodic experiment
- Experiments
- Publish in Open Repos.
- Open Repository
- Manual and API
- Logout

New bundle: etomic_demo


Next step is defining wich files will be used in each agent. An agent will run a program or eventually more than one.

Name: ericsson
Description: N/A
Country: Sweden
Organization: Ericsson
Interfaces:

- ericsson.etomic.org - 192.71.20.150
- ericsson-dag.etomic.org - 192.71.20.151

DAG

(Click on a node name to configure it)



- brussels (Belgium)
- chania (N/A)
- colbud (Hungary)
- elie (Hungary)
- ericsson (Sweden)
- jerusalem (Israel)
- krakow (Poland)
- magdeburg (Germany)
- pamplona (Spain)
- paris (France)
- salzburg (Austria)
- sics (Sweden)
- telia (Sweden)
- univet (Hungary)

Configuring ericsson *(Click on a node to configure it)*

ericsson Add binary | data file | Hard disk: 75 MB.

Binary file: etomic_check.bash *<parameters>*

etomic_check.bash Select

From h. m. to h. m.
 since experiment starts

Add command ->

delete	Start	End	Command
	+0h 0m	no limit	"etomic_check.bash "

Data file: etomic_check.tar.gz *<tar zxf etomic_check.tar.gz>*

Description:

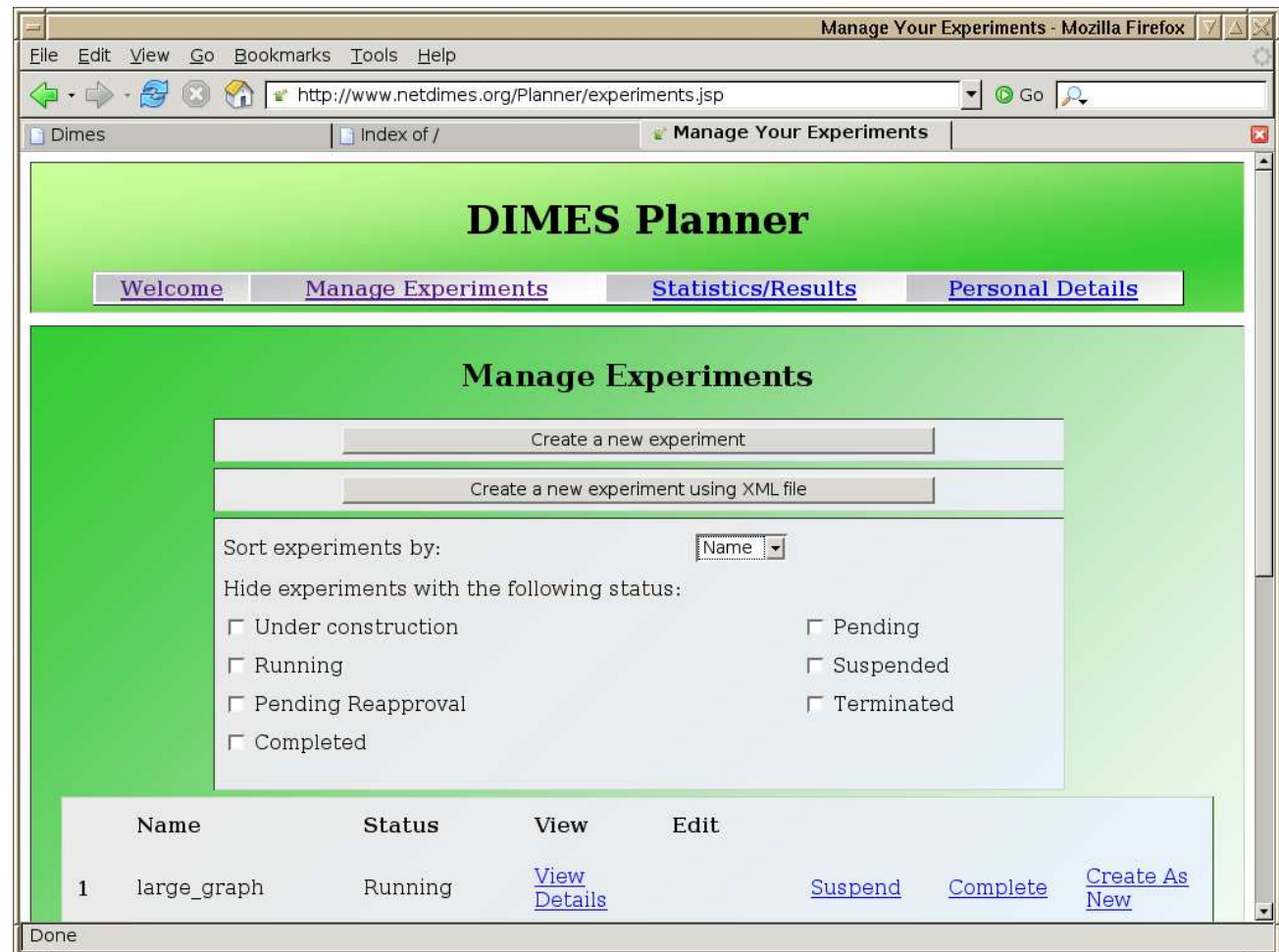
<- go back | Display copy options | Save bundle

Kész etomic.tlm.unavarra.es

Large Scale Internet Queuing Delay Tomography



[netdimes.org/
Planner](http://netdimes.org/Planner)



Manage Your Experiments - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

http://www.netdimes.org/Planner/experiments.jsp

Dimes Index of / Manage Your Experiments

DIMES Planner

[Welcome](#) [Manage Experiments](#) [Statistics/Results](#) [Personal Details](#)

Manage Experiments

Create a new experiment

Create a new experiment using XML file

Sort experiments by:

Hide experiments with the following status:

Under construction Pending

Running Suspended

Pending Reapproval Terminated

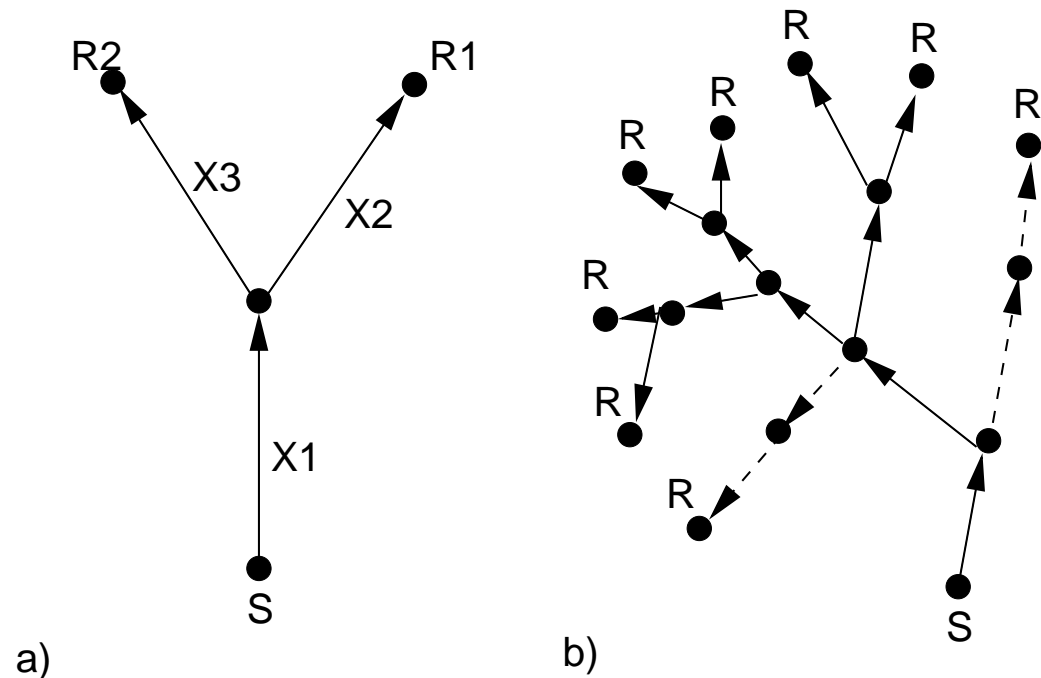
Completed

Name	Status	View	Edit
1 large_graph	Running	View Details	Suspend Complete Create As New

Done

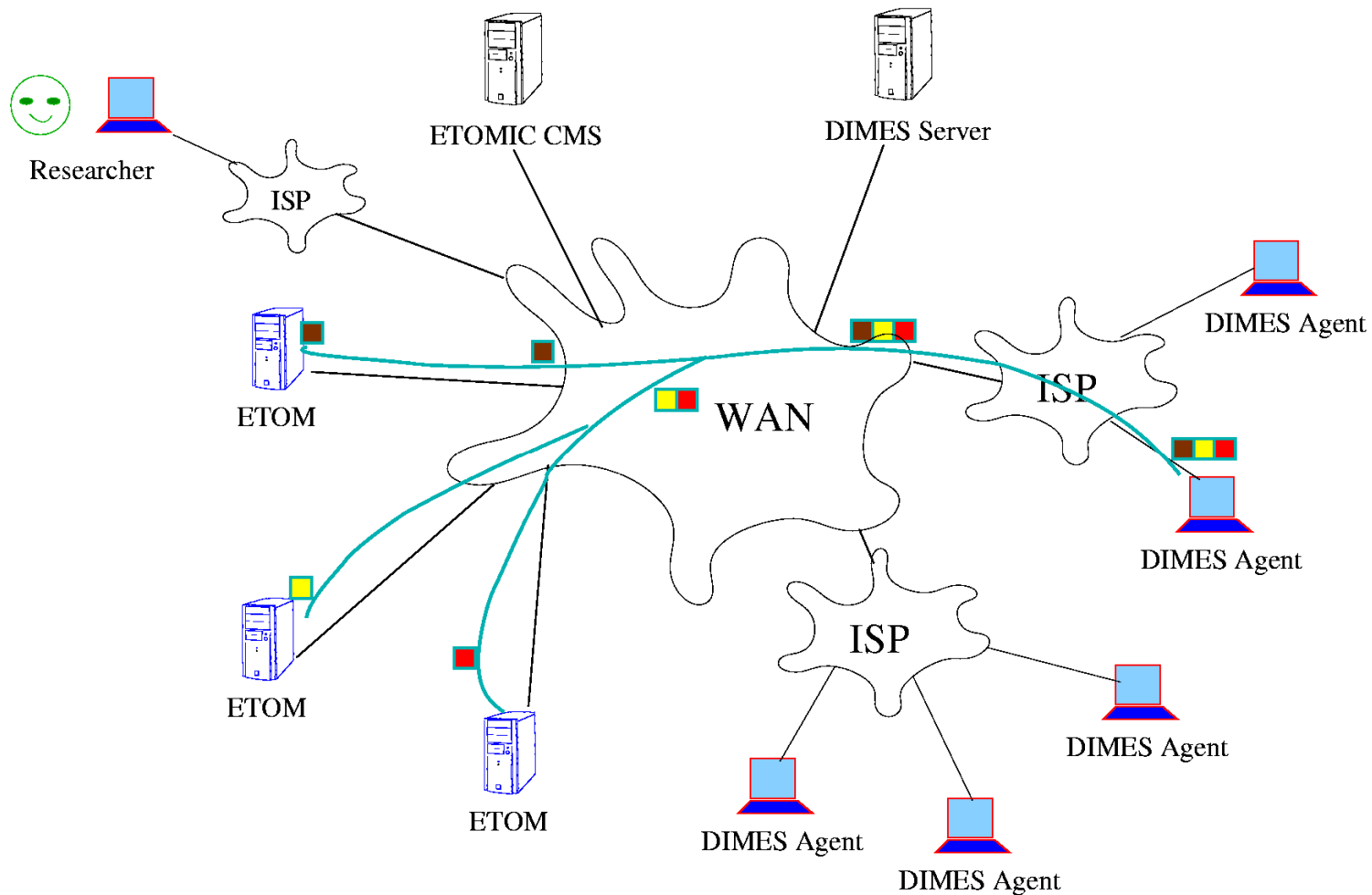
Large Scale Internet Queuing Delay Tomography

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



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

Measurement scheme



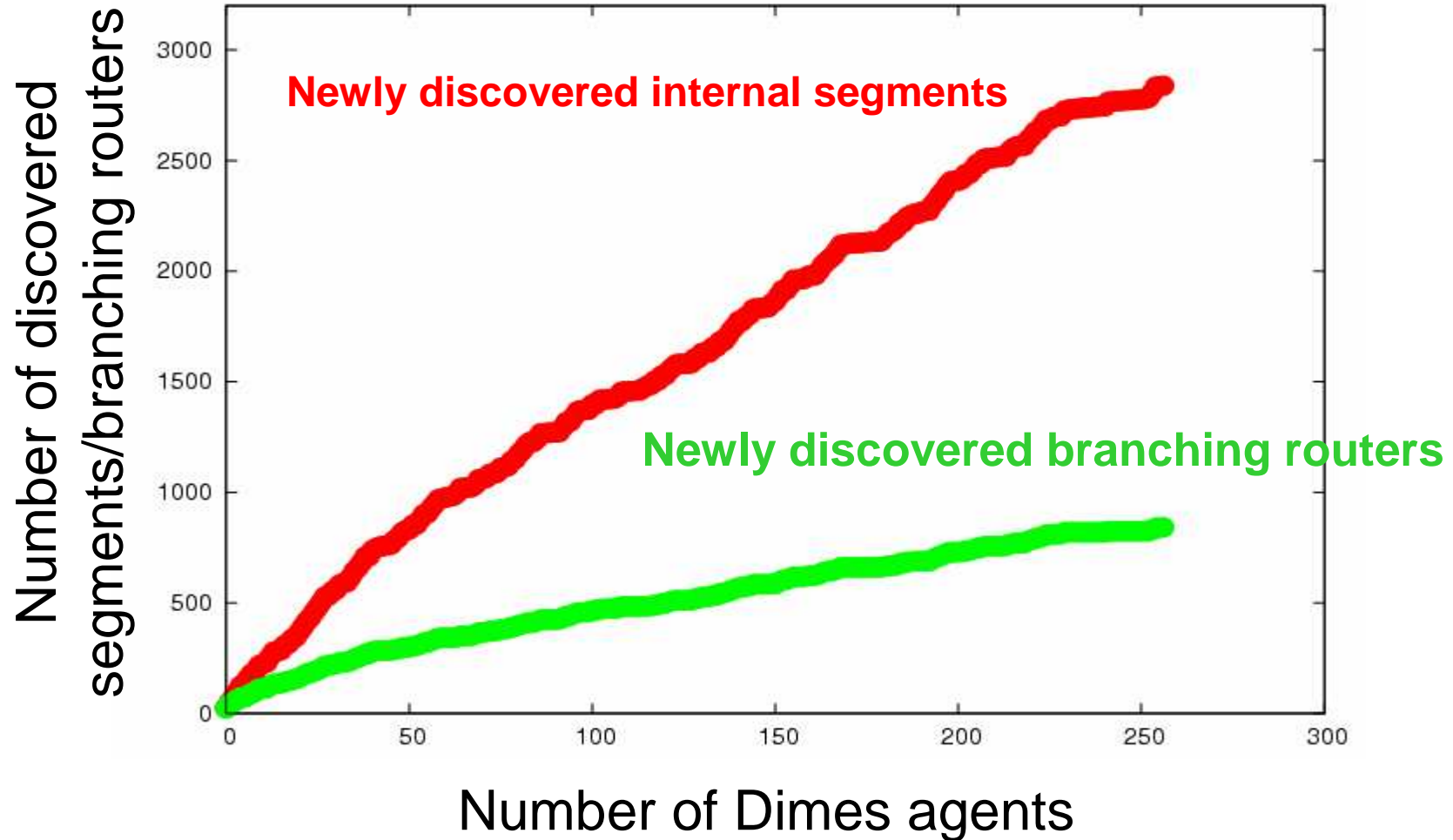
Large Scale Internet Queuing Delay Tomography



Topology discovery (2006 January)

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

Traceroute between 257 Dimes agents and 15 EtoMic nodes



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

Dimes application

Java/C interface

packettrain.dll

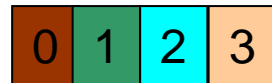
UDP header

Local timestamp

Packet id: #robin

Packet id: #sequence

Robin 1



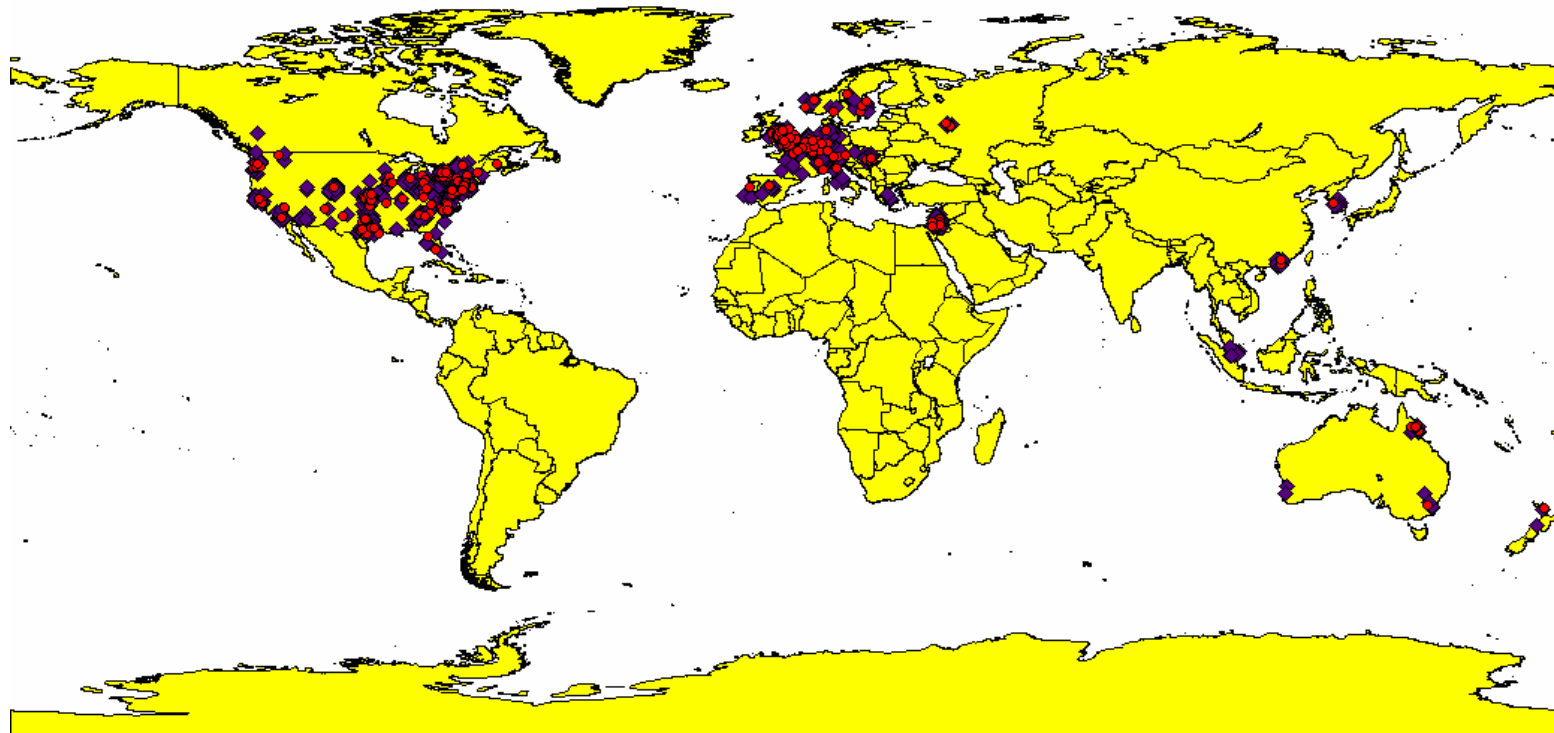
Robin 2



Robin 3



Network



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

An example 1.



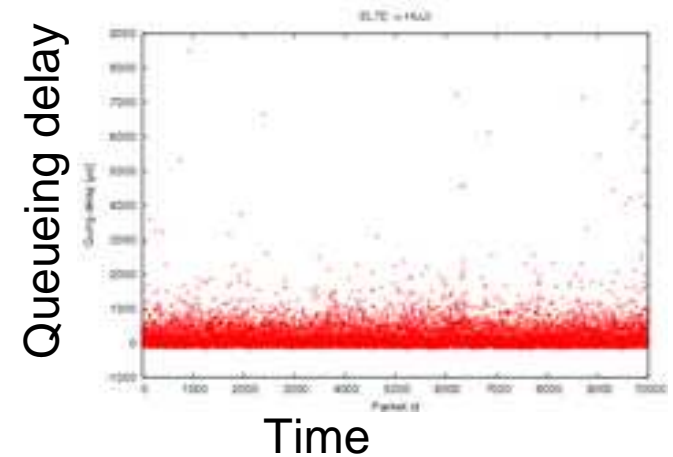
Test experiment

- 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.

1. Step

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

ELTE -> HUJI



An example 2.

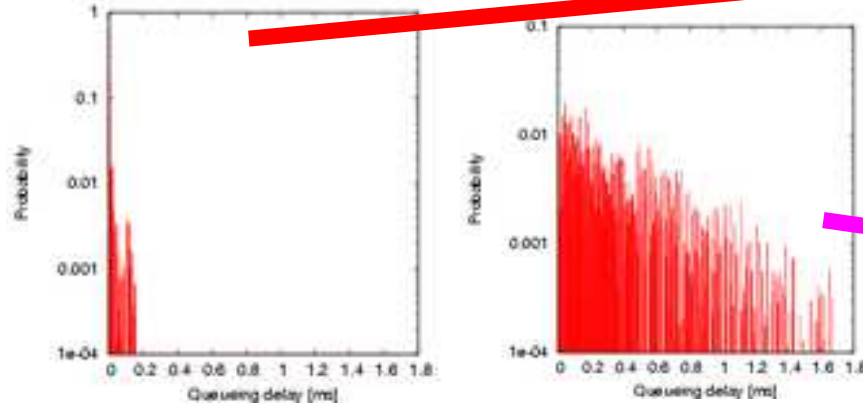


2. Step

- Topology reconstructed
- Branching routers determined

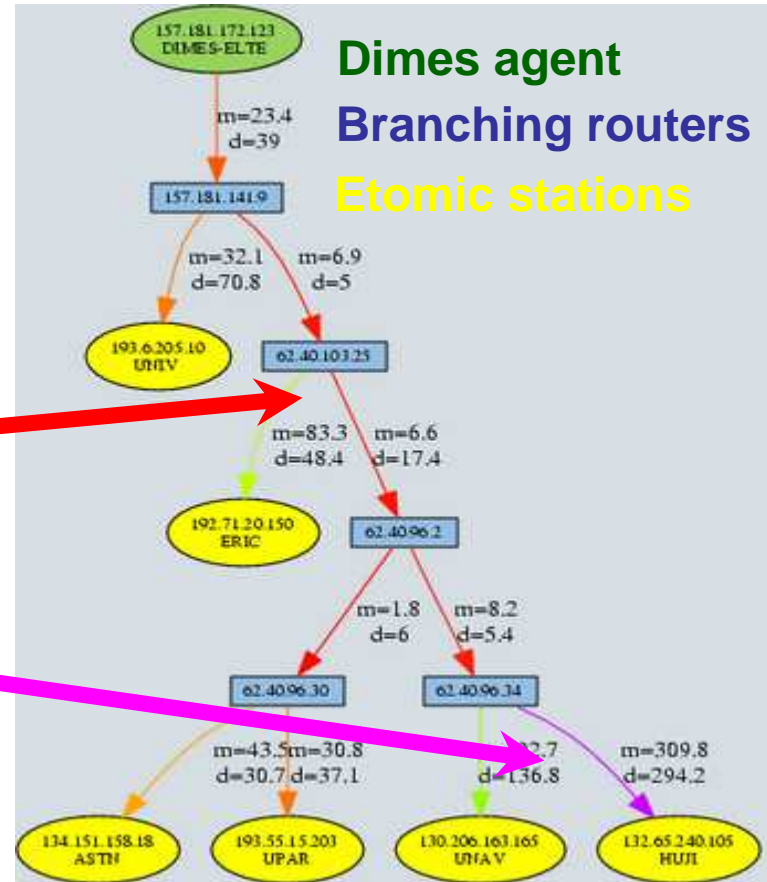
3. Step

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



Backbone link

Access link

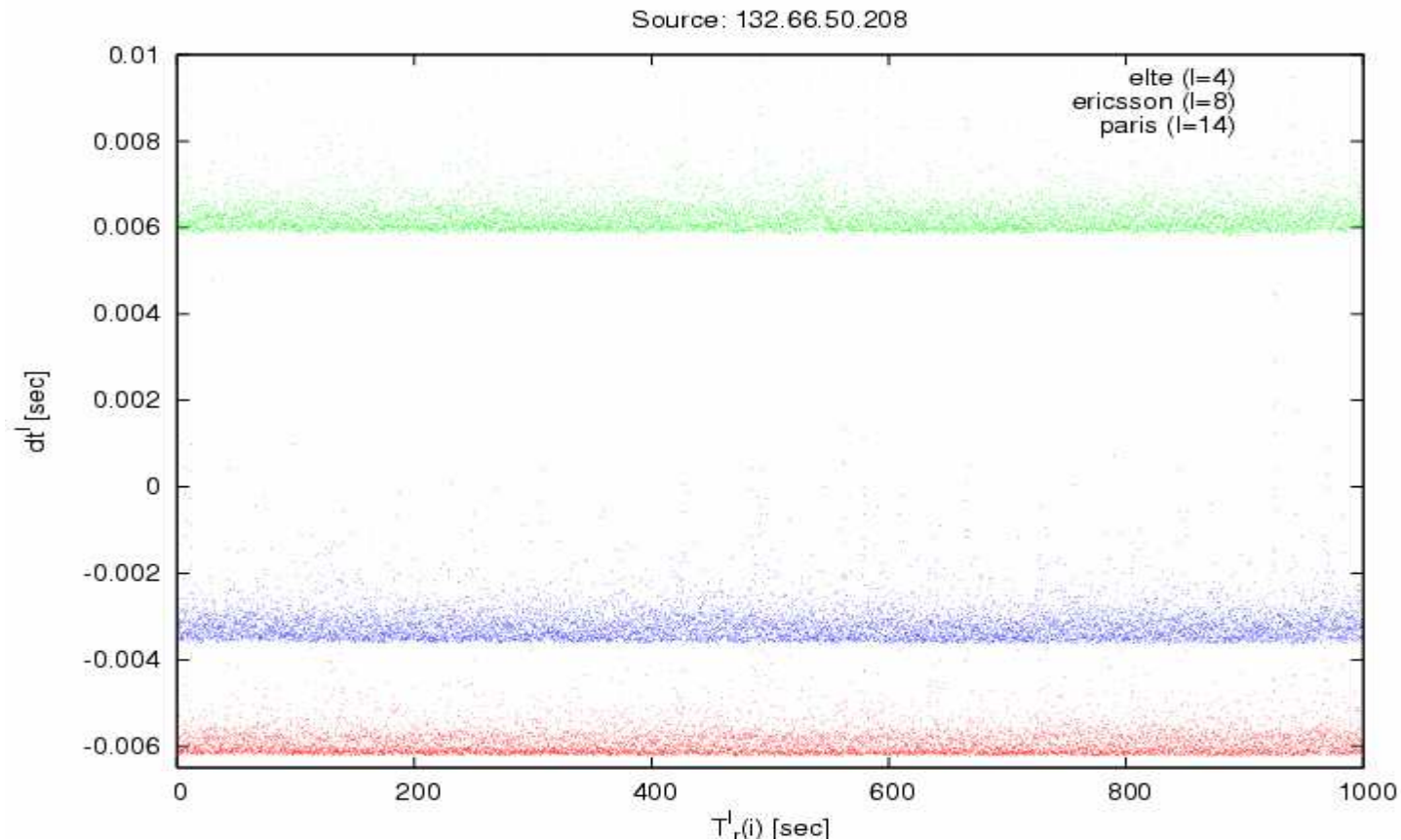


An example 3.

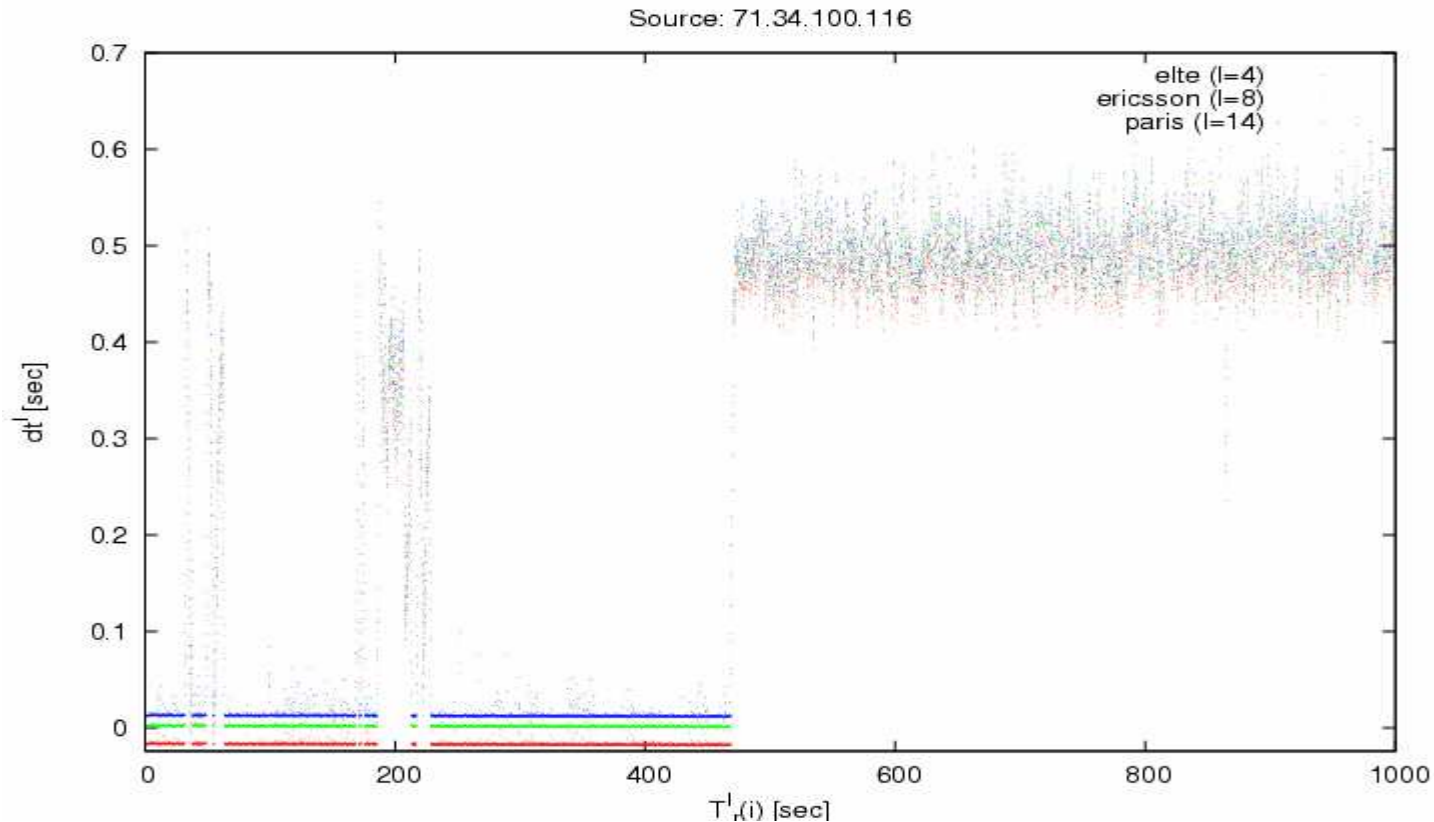


Link	Avg. q.d.(μ s)	Error	Std dev. (μ s)	Error
1	23.446	2.738	35.044	4.652
2	6.976	3.883	3.883	2.048
3	32.196	2.779	70.856	2.678
4	6.693	4.016	17.467	10.557
5	83.373	5.730	48.426	1.373
6	1.802	0.707	6.059	4.215
7	8.273	1.452	5.441	0.981
8	43.575		30.752	
9	30.866		37.188	
10	309.853		294.230	
11	92.723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

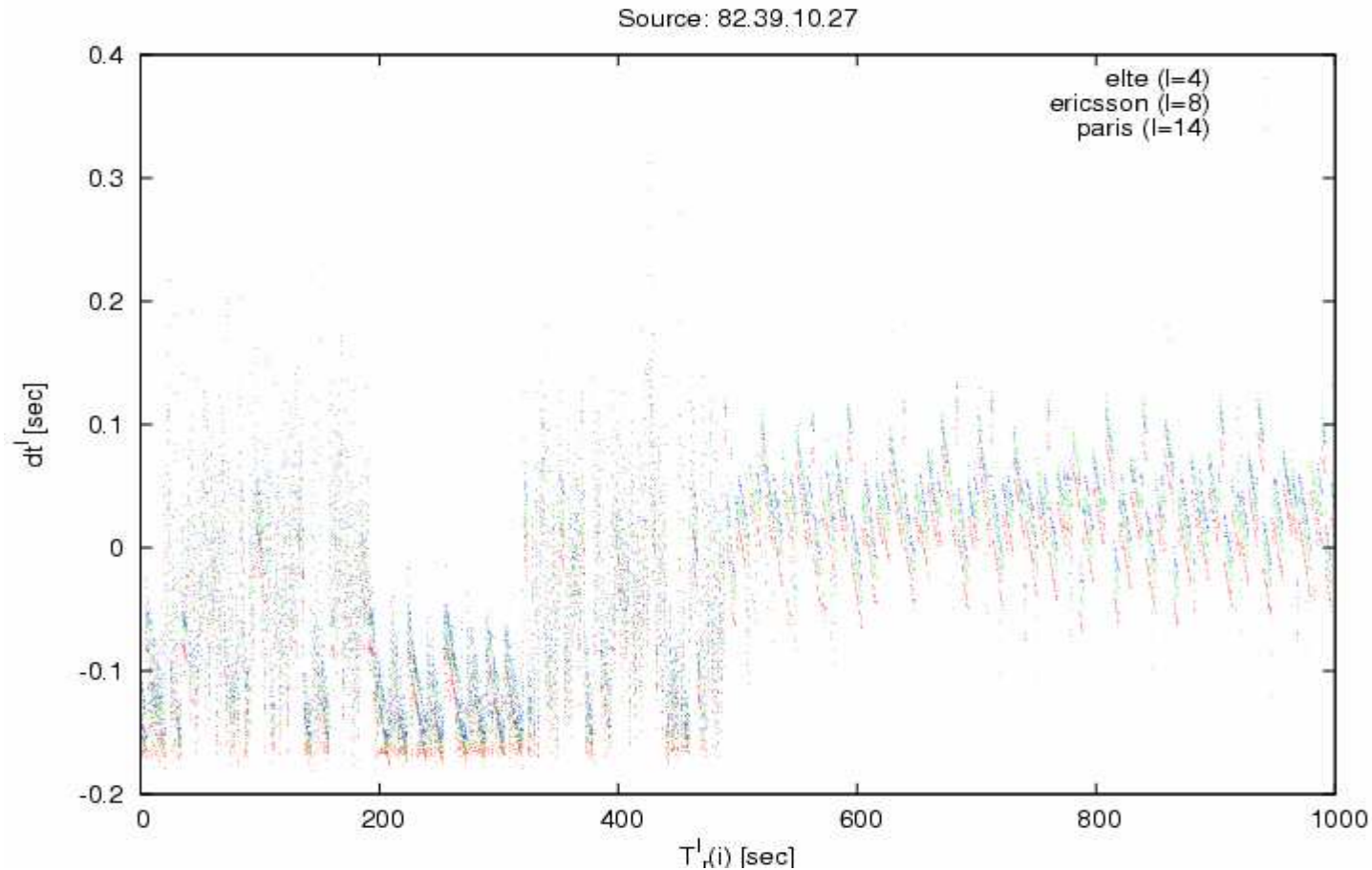
Timeseries 1.



Dimes agent probably connected to a high bandwidth access link
similar oneway delay series experienced like within internal Etomic
measurements



Dimes agent probably connected to a high bandwidth 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

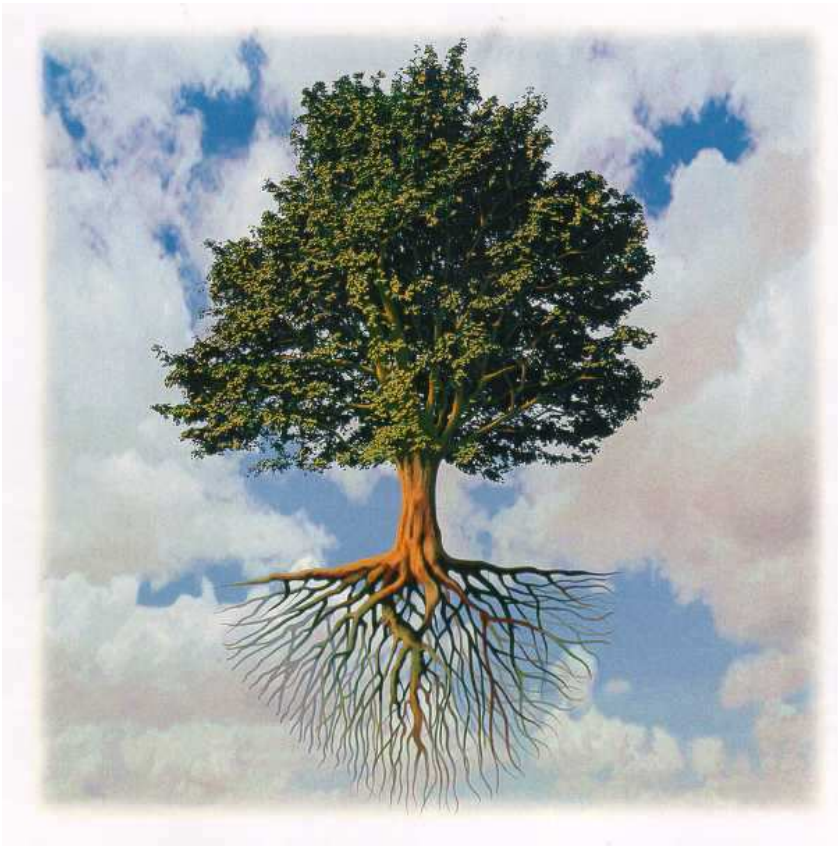


Dimes agent probably connected to a low bandwidth access link
heavy cross traffic causes large fluctuations in queueing delay

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.



Thanks!



IST Future and Emerging Technologies