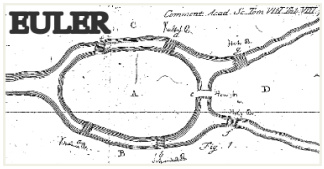


THE EULER NEWSLETTER

SEVENTH FRAMEWORK PROGRAMME

In this issue

Exploitation of the BGP stability metrics

Understanding the dynamics of the Internet routing system is fundamental to ensuring its stability and improving the mechanisms of the BGP routing protocol. Investigations on the Internet routing system dynamics involve investigations on routing engine resource consumption. Although current routing engines could potentially support up to O(1M) routing table entries instabilities resulting from i) routing protocol behaviour, ii) routing protocol information exchanges, and iii) changes in network topology that may adversely affect the network's ability to remain in a useable state for extended periods of time.

The overall goal of this activity part of the EULER project is to identify a set of stability criteria and to develop a method to provide a better understanding of the Internet routing system's stability by analyzing data collected from operational networks.

The stability of a routing system is characterized by its response (in terms of processing routing information) to inputs of finite amplitude. These inputs may be classified as either internal system events, such as routing protocol configuration changes, or as external system events, such as routing information updates. A routing system when disturbed by an external or internal event is qualified as: 1) stable if it returns to its initial equilibrium state; 2) marginally stable if it transits to a new equilibrium state; 3) unstable if it remains in an unending condition of transition from one state to another. The degree to which a routing system, or components thereof, can function correctly in the presence of input events is a measure of the **robustness** of the system.

The mechanism developed to determine the stability properties consists of the following procedures. More details are available in **http://tools.ietf.org/html/draft-ietf-grow-rss-00.**

Let RT be the Routing Table, RT(n) represent the routing table at some time n, and |RT(n)| its number of routes. At time n+1, the routing table can be expressed as the sum of two components:

$$RT(n+1) = RT_o(n) + \delta_{RT}(n+1) \quad \text{where } \delta_{RT}(n+1) = RT_c(n+1) + RT_n(n+1)$$

$RT_o(n)$ is the set of routes that experience no change between n and n+1, and $\delta_{RT}(n+1)$ accounts for all route changes between n and n+1, i.e. it is the stability metric of the entire RT at time t=n+1. It considers both network topology changes (new routes appearing, changes to existing routes, etc.), and routing protocol changes (session failure, route attribute changes, changes to filtering policies, etc.).

In order to compute $|\delta_{RT}(n+1)|$, a stability metric for an individual route has to be calculated. A route $rt_i(n+1)$, a component of RT(n+1), consists of {destination, AS path, attributes}. Let the stability metric associated with a route rt_i be called ϕ_i whose initially value is set to 0. Whenever rt_i does experience a change, then **Procedure 1** is executed.

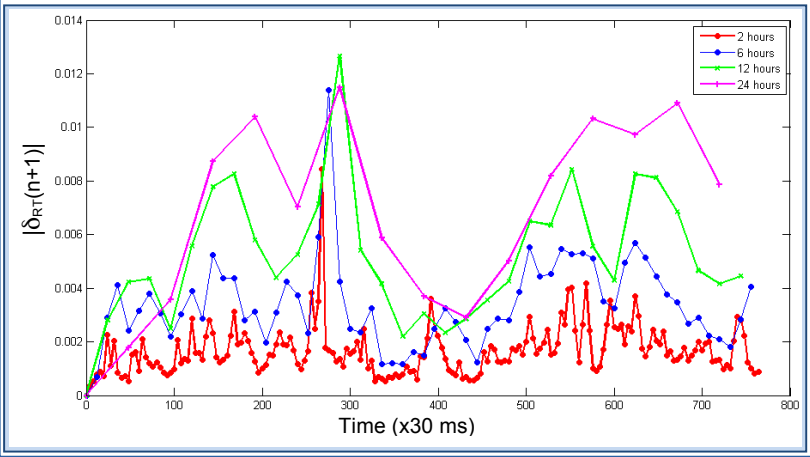
Let $|\delta rt_i(n+1)|$ be the change in stability metric associated with a single route, rt_i, from t=n to t=n+1. Then **Procedure 2** is executed to evaluate $|\delta_{RT}(n+1)|$. A resulting value 0 implies perfect stability, while 1 indicates complete instability.

Procedure 1: update ϕ_i value

```
if rt_i(n+1) ≠ rt_i(n) then
     φ_i(n+1) = φ_i(n)+1
else if φ_i(n) = 0 then
     φ_i(n+1) = 0
else
     φ_i(n+1) = φ_i(n)-1
end ifs
```

Procedure 2: evaluation of $|\delta_{RT}(n+1)|$

```
for i = 1 to |RT(n+1)|
     if rt_i(n+1) is a new route then
          |δrt_i(n+1)| = 0
     else if φ_i(n) = 0 and φ_i(n+1) = 0 then
          |δrt_i(n+1)| = 0
     else if φ_i(n+1) > φ_i(n)  then
          |δrt_i(n+1)| = [φ_i(n) + 1] / [φ_i(n+1) + 1]
     else
          |δrt_i(n+1)| = φ_i(n+1) / φ_i(n)
     end ifs
end i loop
|δ_RT(n+1)| = Σ(δrt_i(n+1)) / |RT(n+1)|
```



A preliminary result has been obtained applying these procedures to a BGP feed of a DFZ router having roughly 340k entries (FIB). The router has around 30 peers, mainly academic networks and ISP. Using the data collected after the BGP decision process, the values of $|\delta_{RT}(n+1)|$ over a span period between 25/12/10 and 9/1/11 have been determined. The figure on the left-hand side illustrates the results. It can be observed that the stability metric assumes values between 0.001 and 0.014. As well, the higher the sampling period (i.e. 10 hours vs. 2 hours), the higher the value of $|\delta_{RT}(n+1)|$. Further studies will determine how this local stability measure could be exploited as part of the BGP route selection process.

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How the EULER project is progressing?

The EULER project, started on October 1st, 2010, completed the first quarter of the 3-year project duration and the following activities were conducted.

The project kick-off meeting took place on 6-8 October 2010 at Alcatel-Lucent Bell offices. It included a one-day seminar with one session (half day) on "Internet topology & routing: models, algorithms, and analysis" by Dimitri Papadimitriou (ALB) and one session (half day) on "Topics in large networks theory" by Jean-Charles Delvenne (UCL). The two other days were dedicated to the technical work with presentations by WP leaders and leaders of Tasks starting at M01 (T3.1, T3.2, T4.1, T5.1). The Project Officer (Mr. Jean-Pierre Euzen) attended the third day with a presentation on the activities lead by the DG-INFSO/Unit F4 to which the EULER project belongs.

In T3.1 "Graph-based topology modelling, and graph analysis/mining", topology models and properties survey have been investigated. UCL has already explored the feasibility of testing some properties (like node centrality and graph similarity) on Internet-like graphs of 100.000 nodes. INRIA has studied the treeness of the Internet according to two graph parameters: the treewidth and the hyperbolicity. ALB is investigating topological properties useful for distance decreasing path routing/greedy routing on hyperbolic space. RACTI has considered existing game-theoretic scenarios to model network routing in antagonistic settings where decisions depend on the user/router strategies. IBBT focused on the little known auto-similarity based CAP generator of random scale-free graphs with a strong hierarchy and community structure.

Concerning T3.2 "Measurement-based topology modelling and data analysis/mining", a novel approach has been defined consisting in isolating a set of properties and then design a specific method to accurately estimate each one. UPMC has developed a distributed tool for the measurement of Internet core router degrees and performed event detection in radar measurements. To characterize the behaviour and dynamics of BGP routing paths, ALB has defined an initial set of stability metrics for AS paths (see front page) that will be further validated by experimentation on BGP datasets. These sets will be obtained by means of the data collection tool currently under development at UPC. This data collection tool will gather a dataset of BGP feeds during a significant amount of time.

Concerning T4.1 "Performance objectives, evaluation criteria, and metrics", ALB structured the definition of objectives, criteria and metrics into the following units: 1) Functional analysis of routing system architectures, 2) Performance analysis of the routing algorithms, 3) Experimentation of routing model/protocol components, 4) Sensitivity analysis, 5) Properties and characteristics (criteria) that shall be met by the experimental results and corresponding metrics.

Concerning T5.1 "Implementation of the IT and knowledge management tools", the development and setup of the IT tools such as mailing lists, public website, private Wiki, shared file repository, newsletter, etc have been carried.

For more information: **http://www.euler-fire-project.eu.**

Upcoming EU events

1st FIRE Open Calls Information Day **09/02/2011**
http://www.ict-fire.eu/events/meetings/1st-fire-open-calls-information-day.html
Brussels, Belgium

FutureNetworks FP7 Concertation Meeting **10/02 - 11/02/2011**
http://ec.europa.eu/information_society/events/future_networks/concertation
Brussels, Belgium

Future Internet Conference Week **16/05 - 20/05/2011**
*** Internet of Things** **16/05/2011**
*** Future Internet Assembly** **17/05 - 19/05/2011**
*** ICT Proposers' Day** **19/05 - 20/05/2011**
http://ec.europa.eu/information_society/activities/foi/events/index_en.htm
Budapest, Hungary

FIRE Week report

Four different sessions composed the last FIRE Week Conference held in Ghent, Belgium on 15 December 2010: An introductory session with a summary of the current ongoing projects and the perspective of incoming initiatives and calls; The second session was dedicated to the presentation of the FIRE experimental facilities and the methods the project will adopt to stimulate the use and populate the testbeds; In the first afternoon session, a set of examples of concrete uses cases were presented; The last session focused on the sustainability beyond 2015 as major challenge for Call8 and future FPx.

From a general point of view, three major challenges have been highlighted in all discussions: 1) the utilisation of the testbeds because the experimental facilities are currently scarcely used; 2) the sustainability of the experimental facilities because, once an experimental facility project ends, its associated testbed(s) usually becomes inoperative; 3) the federation of the facilities in collaboration with the FIRE architecture board, which is making progress on methods of federation, joint portal, as well as benchmarking and measurements.

From this event, EULER has identified the following action points.

As an experimental-driven research project, EULER is closely looking at the evolution of the capabilities and properties of the available FIRE experimental facilities. Ensuring an adequate match between experimental needs and experimental facilities offer would enable production of tangible results taking benefit of these facilities. Among the available facilities, OFELIA (**http://www.fp7-ofelia.eu**) may offer additional features that could be used in combination with the iLab-t Virtual Wall, the EULER default experimental facility that offers full control of experimental parameters and running conditions. The Virtual Wall (**http://www.ibbt.be/en/ilabs/ilab-t**), located at IBBT premises, is one of the five islands that will be available in OFELIA.

The visibility of EULER as experimental-driven research project in FIRE conferences is limited. With the current organization of these events, the focus is mainly put on the IP projects where the STREP projects are only used as examples of testbed use cases. A novel research forum initiative has been proposed by the EULER project together with FIREStation Support Action to help all FIRE projects (**http://wiki.ict-fire.eu**). It aims to improve the visibility and the involvement of the experimental-driven research projects as well as increase researcher attendance and their active participation to these events. However, more initiatives are needed to promote the scientific and technical nature of FIRE projects.

Call for Papers

13th Rencontres AlgoTel '11 **04/02/2011**
http://www-sop.inria.fr/mascotte/AlgoTel2011/
May 23-26, 2011, Cap Estérel, France

38th International Colloquium ICALP **15/02/2011**
http://icalp11.inf.ethz.ch/
July 4-8, 2011, Zurich, Switzerland

Computer Networks journal **18/02/2011**
Complex Dynamic Networks: Tools and Methods

2011 IEEE Globecom Conference **01/03/2011**
http://www.ieee-globecom.org/2011/
December 5-9, 2011, Houston, Texas, USA

18th International Colloquium SIROCCO **10/03/2011**
http://www.sirocco2011.org/
June 26-29, 2011, Gdańsk, Poland

19th IEEE International Symposium MASCOTS **18/03/2011**
http://pdcc.ntu.edu.sg/mascots2011/
July 25-27, 2011, Singapore, Singapore

IEEE Network magazine **01/04/2011**
Managing an Autonomic Future Internet

25th International Symposium DISC 2011 **20/04/2011**
http://disc2011.dis.uniroma1.it/
September 20-22, 2011, Rome, Italy