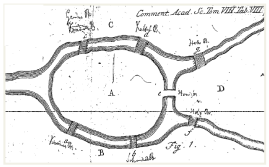


THE EULER NEWSLETTER

SEVENTH FRAMEWORK PROGRAMME

In this issue

EULER experimental platform

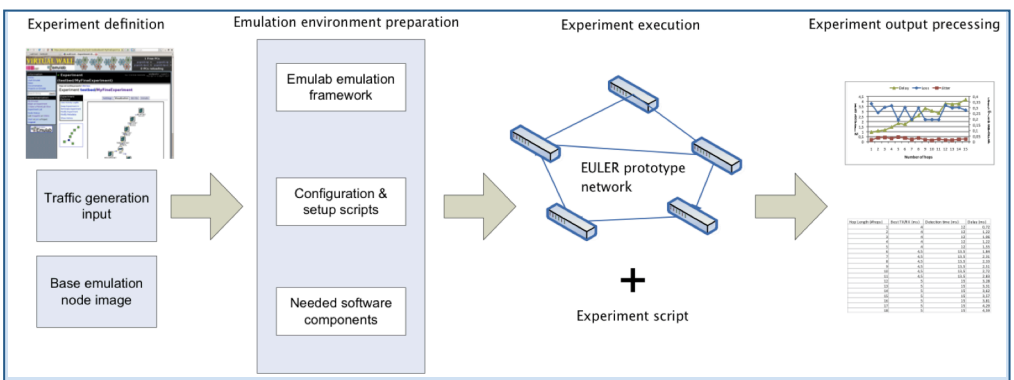
The research efforts of the EULER project focus on the **design and evaluation of novel routing schemes** for inter-domain routing in the Internet. Current BGP-based (Border Gatewy Protocol) Internet routing architecture suffers from a number of scalability and performance issues which drive the EULER research. Because of the large scale and massive impact of this routing architecture, experimentation is crucial in this research. Indeed, Internet routing relies on IP addressing and BGP routing to interconnect roughly 40K domains or ASes (Autonomous Systems), owned by different administrative parties. Careful analysis of the interactions between these domains, their policies, their scaling properties and the resulting performance can only succeed when supported by thorough experimentation, involving an adequate mix of simulation experiments and emulation (prototyping) experiments. The latter is supported by the extensive experimentation platform provided by IBBT (Interdisciplinary institute for BroadBand Technology).

The IBBT technology centre iLab.t offers the experimentation environments, the hardware, the measurement equipment and the software tools needed to evaluate a wide range of state-of-the-art network innovations, and/or test their performance and service quality. iLab.t plays a prominent role in several European FIRE (Future Internet Research & Experimentation) projects involved in research and experimental evaluation of cutting edge network technologies. The **iLab.t Virtual Wall facility** (**http://www.ibbt.be/en/develop-test/ilab-t/virtual-wall**) is a generic test and emulation environment for advanced network, distributed software and service evaluation, and supports large-scale experiments. It has around 100 nodes (dual CPU, dual core, over 500 x 1 Gb/s Ethernet network interfaces), interconnected via a non-blocking central switch (Force 10 networks: 576 x 1 Gb/s port; 8 x 10 Gb/s port; 1.6 Tb/s backplanes), and a display wall of 20 monitors for experiment visualization. Virtual Wall nodes can assume different functionalities: terminal, server, network, impairment node. They can be connected to test boxes for wireless terminals, generic test equipment, simulation nodes (for combined emulation and simulation), etc. The facility relies on the use of Virtual LAN technology (VLAN) implemented by the Force10 switch to arbitrary logical topologies between these nodes. However, for the user of the platform, this is entirely transparent, as experimental topologies can be set up using the user-friendly web-interface of the Emulab control-software. When virtualization technology is used on top of this platform, large dedicated experimental setups of **up to thousands of network nodes** (e.g., 100 machines x 100 emulated nodes = 10k) can be set up very fast. Because of the well-controlled environment, experiment setups enable to produce repeatable and verifiable results, ideal for scientific research.

IBBT ilab.t virtual wall facility

The ilab.t virtual wall facility has been **successfully used in a large number of Belgian and European research projects**. In the context of the CELTIC TIGER project, the facility was successfully used to benchmark prototyped Carrier Ethernet technology making use of GMPLS (Generalized Multi-Protocol Label Switching) controllers. Cutting-edge OpenFlow-based routing and forwarding has been experimented on the virtual wall in the context of the European FP7 projects SPARC (**http://www.fp7-sparc.eu/**) and OFELIA (**http://www.fp7-ofelia.eu/**), and the platform has served the FP7 ECODE project (**http://www.ecode-project.eu/**) to evaluate novel cognitive routing mechanisms on top of the Internet routing infrastructure.

The availability of the above experimentation platform allows to evaluate the designed routing schemes **in very realistic network environments**, enabling scientific benchmarking and assessment of the router software implementing novel schemes such as compact routing, greedy routing or extensions of existing path-vector routing. In this context the project will rely, on and extend the Quagga routing software suite, which contains open-source, implementations of commonly used routing protocols, including BGPv4. This routing platform is able to transform a UNIX-based PC into a production-level software router, perfectly suited for scientific experimentation in the context of the EULER project.



Experimental platform workflow

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The typical **experimental workflow** on the iLab.t Virtual Wall facility is depicted above. The process consists of 4 phases. In the **experiment definition** stage, a topology description and node software image is uploaded to the Emulab platform using either the depicted web interface or a scriptable batch interface. EULER will experiment on both synthetic scale-free and power-law degree topologies as well as on measurement-based topologies obtained from the CAIDA initiative. The software image will be based on Debian Linux in combination with the earlier mentioned Quagga routing suite.The second phase (**emulation environment preparation**) involves the activation of the configuration topology by the Emulab environment (swap-in), and the preparation of the configuration of nodes and the runtime environment involved in the experiment. This includes the activation of virtualization technology, for example relying on lightweight Linux Containers, as well as detailed configuration of individual routers (configuration of interfaces, addresses, neighboring relationships, etc.).

The third phase consists of the **experiment execution** itself, which is guided by an experimentation script which executes the low-level scenario to benchmark the deployed routing components. This typically involves the evaluation of performance metrics related to, e.g., routing protocol convergence time and resource consumption as a result of the introduction of network failure and growth scenario's.

The last phase of the emulation-based experimentation is concerned with the processing of experiment output. This involves **post-processing and interpreting** of the obtained measurement data from the previous phase, resulting into graphs, tables, allowing for scientific analysis a scientific analysis of the conducted experiment.

The unique combination of a cutting-edge experimentation platform and state-of-the-art routing scheme experimentation provided by the EULER project is of significant interest of, and value for the scientific networking community. The EULER experimentation setup enables the assessment of novel Internet routing schemes with highly realistic emulation experiments in previously unseen (large-scale) topologies.

Call for papers

32nd IEEE Infocom **27/07/2012**
http://infocom.dico.unimi.it/
April 14-19, 2013, Turin, Italy

IEEE J. Selected Areas in Communications **01/08/2012**
Network Science

Analytic Algorithms & Combinatorics **01/08/2012**
http://www.siam.org/meetings/analco13/
January 6, 2013, New Orleans, USA

IFIP/IEEE Int. Symp. Integrated Network Mngt. **16/08/2012**
http://www.ieee-im.org/
May 27-31, 2013, Ghent, Belgium

Int. Conf. Network Games, Control & Optimization **21/08/2012**
https://sites.google.com/site/netgcoop2012/
November 28-30, 2012, Avignon, France

IEEE ICC 2013 **16/09/2012**
http://www.ieee-icc.org/2013/
June 9-13, 2013, Budapest, Hungary

30th STACS **21/09/2012**
http://www.stacs2013.uni-kiel.de/
February 27-March 2, 2013, Kiel, Germany

ACM-SIAM W. Algorithm Engineering & Exper. **25/09/2012**
http://www.siam.org/meetings/alenex13/
January 7, 2013, New Orleans, USA

27th IEEE IPDPS **01/10/2012**
http://www.ipdps.org/
May 20-24, 2013, Boston, USA

How the EULER project is progressing?

The EULER project, started on October 1st, 2010, completed the seven quarter of the 3-year project duration.

The first Techical Advisory Board (TAB) meeting has been organized on June 8, 2012 at IBBT, Ghent, Belgium with invited members Antonio Manzalini (Telecom Italia) and Nicolai Leymann (Deutsche Telecom). The goals of this first meeting were to present the project motivations, objectives and orientations in terms of Internet routing research. In order to steer discussions a set of open questions were proposed to gather feedback. Distributed routing functionality that are essential include in order of priority: adaptivity, policing, and security that BGP offers today (if we would include security considerations as developed in SIDR). Incentive for migration shall justified by at least one of order of magnitude of improvement, e.g., memory size, compared to the current BGP situation without deteriorating other functionality and/or performance currently provided by BGP -- this statement corroborates the current position taken in the project. Indeed, core/edge routers today can accommodate O(1M) IPv4 active routes (in Loc_RIB), which leaves sufficient headroom at current deployment rate.

Moreover, if the replacing routing scheme would induce the use of a different current locator space (compared to the current IPv4 space) deep operational impact would follow that should be further justified in terms of reduction operational complexity and cost (beside the cost of migration). Such migration would be justified when the new protocol offers new business opportunities and not only improves the cost of scale of the Internet routing system. Though invited participants see value in long-term routing research, they remain convinced that triggers for changing the Internet routing protocol would be "problem-driven" and not exclusively driven by protocol performance aspects. For this purpose, investigation of the IPv6 routing table growth (compared to IPv4), stability of routing paths and heterogeneity of the environments were BGP can be deployed and perform (assuming extension in data centers for instance) as well as more specific BGP policing operational such as in/out filter (re-)configuration upon node failure, seems to be of interest for participants.

FIRE/EC events