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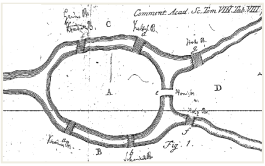

The EULER Newsletter

In this issue

The benefits and role of measurements in Internet

Imagine an internet measurement question, like estimating the length of longest routes, how many users share a given end-host, or how frequent are router failures, for instance. Now, ask to a networking expert his/her best guess on the answer to this question, and conduct the measurement. In most cases, you will observe something dramatically different from the expert's intuition.

This is a very general fact when measuring the internet: results from real-world observation are often in sharp contrast, or at least in contradiction, with intuition. This has been demonstrated many contexts, ranging from network traffic to topology,overlays, mobility, user behaviors, and many others. It turns out that counter-intuitive results in internet measurements are the rule rather than the exception.

As a consequence, measuring the internet is a crucial task. Indeed, in the absence of insights from such measurements, our understanding of this key object would only rely on so-called expertise, or more generally intuition. Models used to predict the internet behavior, to design protocols and evaluate their performance would then poorly fit the true features of the internet, and so would be doomed to failure.

However, as Willinger et al say [1], "A very general but largely ignored fact about Internet-related measurements is that what we can measure in an Internet-like environment is typically not the same as what we really want to measure (or what we think we actually measure)." Indeed, obtaining rigorous insights from measurements in a challenging task. Current state-of-the-art remains very frustrating: although observations are crucial and deviate much from intuition, they are often not accurate enough to be reliable. There is for instance a lively controversy regarding the degree distribution of the internet topology, at various levels [2,3,4].

These difficulties must not hide what should be the baseline in the field: knowledge of the true internet is crucial for both fundamental and applied reasons, and a true knowledge should reconcile intuition with observations. The situation we face is not very different from the ones usually faced by natural sciences: when one studies living organisms or the universe, for instance, measurement is a key component of the scientific approach, both for collecting information and for testing hypotheses.

In the context of the internet and more generally in computer sciences, however, there is a big difference: the objects under study have been built by engineers and researchers. The internet is indeed composed of routers built by a few companies, protocols documented thoroughly, and various kinds of manufactured connections and devices. In principle, all these elements are well known and understood.

For this reason, the classical natural sciences approach relying on measurements coexists with (and actually was developed much later than) a bottom-approach which aims at understanding the internet as a huge combination of these key elements. And yet, just like understanding atoms and their interactions is not sufficient to understand living organisms, this precise knowledge of building elements of the internet is not sufficient to understand it as a whole.

As a consequence, internet research faces a situation where two very different approaches coexist and provide complementary insights: a bottom-up approach starting from accurate knowledge of key elements of the internet and their interactions, and a top-down approach envisioning the internet as a complex system and relying on probes to measure it. Both approaches have their own strengths and weaknesses. The future of the field certainly is in a combination of these approaches, which currently often are in contradiction but should eventually lead to a unified vision of the internet.

In conclusion, the benefits of measuring the internet are countless. They root our understanding of both internet traffic, its topologies, protocols and users. In turn, this knowledge is crucial for designing efficient architectures and protocols. As a consequence, the effort for making measurements more accurate and reliable, and further for designing models in accordance with real-world observation, must be continued with the same energy. This is the price to pay for having deployed and using daily a network at such a scale that understanding it from its design only became out of reach.

[1] W. Willinger, D. Alderson, J. C. Doyle, “Mathematics and the Internet: A Source of Enormous Confusion and Great Potential”, *Notices of the American Mathematical Society* 56 (5), 2009.
[2] M. Faloutsos, P. Faloutsos, C. Faloutsos, “On Power-law Relationships of the Internet Topology”, *Proc. ACM SIGCOMM*, 1999.
[3] A. Lakhina, J. Byers, M. Crovella, P. Xie, “Sampling Biases in IP Topology Measurements”, *Proc. IEEE INFOCOM*, 2003.
[4] J.-L. Guillaume, M. Latapy, “Relevance of massively distributed explorations of the internet topology: Simulation results”, *Proc. IEEE INFOCOM*, 2005.

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Information on last main EULER publications

During the last period, several papers have been published in the framework of the EULER activities. In this section we summarise the content and the main outcomes of selected papers.

In [1], D. Papadimitriou et al. presents the new concept of Geometric Information Routing (GIF). This technique operates by associating to content identifiers (names) a content locator taken out of a geometric coordinate space from which a routing path (more precisely, a geodesic) can be derived without requiring non-local information. Upon querying specific content multiple locators can be received enabling the receiver to select the (geometrically) closest locator. Since it is based on local information only, routing on such locator space is less memory consuming than non-local information dependent routing.

In [2], D. Papadimitriou et al. provide a theoretical performance analysis of different classes of multicast routing algorithms, namely the Shortest Path Tree, the Steiner Tree, compact routing and greedy routing. The motivation is to determine the routing scheme which would yield the best trade-off between the stretch of the multicast routing paths, the memory space required to store the routing information and routing table as well as the communication cost. For this purpose, these results have been compared to those obtained by simulation on the CAIDA map of the Internet topology comprising 32k nodes.

In [3] and [4], D. Careglio et al. report the development experience and experimentation studies of two multicast routing schemes for the Internet, namely, Protocol Independent Multicast (PIM)-Source Specific Multicast (SSM) and Greedy Compact Multicast Routing (GCMR). In particular [3] details their implementation over the Quagga open source routing suite, as well as their experimentation tests over a large-scale topology that reproduces the Internet characteristics and provides some results that show the goodness of GCMR compared to PIM-SSM. In [4], the authors present a demo proposal for the Infocom 2014 demo session. The details of this demo are discussed in the next section.

In [5], E. Rotenberg et al. present the UDP ping tool. The argument that motivates the development of this tool is the fact that the most basic function of an Internet router is to decide, for a given packet, which of its interfaces it will use to forward it to its next hop. To do so, routers maintain a routing table, in which they look up for a prefix of the destination address. The routing table associates an interface of the router to this prefix, and this interface is used to forward the packet. We explore here a new measurement method based upon distributed UDP probing to estimate this routing table for Internet routers.

EULER selected publications

[1] D. Papadimitriou, D. Colle, P. Audenaert, P. Demeester, "Geometric Information Routing", 7th IEEE ANTS, Chennai, India, Dec. 2013.

[2] D. Papadimitriou, D. Careglio, P. Demeester, "Performance analysis of multicast routing algorithms", ICNC, Honolulu, USA, Feb. 2014.

[3] D. Careglio, D. Papadimitriou, F. Agraz, S. Sahhaf, J. Perelló, W. Tavernier, S. Spadaro, D. Colle, "Development and experimentation towards a multicast-enabled Internet", 17th IEEE Global Internet Symposium (IEEE Infocom 2014), Toronto, Canada, April 2014.

[4] D. Careglio, D. Papadimitriou, F. Agraz, S. Sahhaf, J. Perelló, W. Tavernier, "On the experimentation of the novel GCMR multicast routing in a large-scale testbed", 33rd IEEE Infocom 2014 (Demo session,) Toronto, Canada, April 2014.

[5] E. Rotenberg, C. Crespelle, M. Latap, "Measuring Routing Tables in the Internet", 6th IEEE NetSciCom (IEEE Infocom 2014), Toronto, Canada, April 2014.

GCMR demo at Infocom 2014

As part of the work conducted in the EULER FP7-project, we designed the Greedy Compact Multicast Routing (GCMR) scheme (see newsletter No.3). The proposal of demonstrating the execution of the prototype of the GCMR multicast scheme has been recently accepted to be presented at the upcoming IEEE Infocom 2014, which will be celebreted in Toronto, Canada on April 27-May 2, 2014. In this demonstration, we will exhibit the successful operation of GCMR in the context of inter-domain routing over a large-scale network topology and compare its performance with the standard PIM protocol.

The prototypes of the GCMR and the PIM routing engines have been developed using the libraries of the Quagga open source routing suite (see Newsletters No. 10 for the details).

The configuration of the demo will consist of two parts, the iLab.t Virtual Wall (VW) and the local setup at the conference booth. The iLab.t VW is a large-scale experimental Linux machine-based emulation testbed located in iMinds, Ghent, Belgium (see Newsletter No. 7). A large-scale topology mimic a realistic portion of the Internet will be setup in the iLab.t VW. The aim is to reach an experimental facility that can emulate O(10k) routers each one running a Debian 6 Linux distribution, the Quagga routing suite and the considered multicast routing protocols (GCMR and PIM). In additional, a video server and several clients will be configured in the iLab.T. The local setup will consist of a Linux router and two clients connected to the iLab.t VW by means of an openvpn tunnel.

The final goal of the demo is to demonstrate that that, using more than one order of magnitude smaller routing tables, GCMR creates and maintains multicast distribution trees with better stretch and very quick recovery time in case of link failure than PIM at the expense of higher communication cost.

Forthcoming EC and FIRE events

1st Fed4FIRE competitive call for SME — **02/04/2014**
http://www.fed4fire.eu/open-calls/1st-call-for-sme.html

FI-PPP – 1st Eur. Conf. on Future Internet — **02-03/04/2014**
http://www.fi-ppp.eu/ai1ec_event/1st-european-conference-on-the-future-internet-ecfi/
Brussels, Belgium

Celtic-Plus event — **23-24/04/2014**
http://www.celticplus.eu/
Montecarlo, Monaco

IoT week 2014 — **16-20/06/2014**
http://iot-forum.eu/iot-week-2014
London, UK

EuCNC'2014 — **23-26/06/2014**
http://www.eucnc.eu/
Bologna, Italy

Call for papers

33rd Int. Symp. SRDS — **13/04/2014**
http://www-nishio.ist.osaka-u.ac.jp/conf/srds2014/
October 6-9, 2014, Nara, Japan

39th Int. Symp. MFCS — **18/04/2014**
http://www.inf.u-szeged.hu/mfcs2014/
August 25-29, 2014, Budapest, Hungary

22nd Eur. Symp. Algorithms (ESA) — **18/04/2014**
http://algo2014.ii.uni.wroc.pl/esa/
September 8-10, 2014, Wroclaw, Poland

20th Int. Col. SIROCCO — **25/04/2014**
https://sites.google.com/site/sirocco2014japan/home/call-for-papers
July 23-25, 2014, Hida Takayama, Japan

Internet Measurement Conference (IMC) — **07/05/2014**
http://conferences2.sigcomm.org/imc/2014/
November 5-7, 2014, Vancouver, Canada