Prof. Laurent Vanbever
Networked Systems

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Mission

In less than 30 years, the Internet has completely revolutionized our society: from the very way we communicate, access and exchange information, shop, pay, move, entertain or even maintain friendship. At the same time, the Internet never stopped to grow, connecting more users and devices every day, increasingly wirelessly and at faster speed.
By 2015, there will be more than 3 billion of Internet users, more than 40% of the world's population.

Each success comes with its own set of challenges. And the Internet is no exception. One of the main challenges the Internet is facing is that it was not designed to be used this way. As a matter of fact, the Internet runs on technologies that are more than two decades old and did not change much since its inception. The huge gap between the network design and the usages made of it creates many issues ranging from scalability, security and efficiency to Internet governance. As an illustration, the explosive growth of the Internet puts tremendous stress on the devices responsible for forwarding user traffic. Also, the lack of built-in security mechanisms makes it possible for hackers to divert and eavesdrop on almost any traffic.

The goal of the Networked Systems Group (NSG) is to modernize computer networks such as the Internet, making them more efficient, flexible and reliable. Rather than developing a series of ad-hoc solutions, we believe in the value of building theoretical foundations allowing for a rigorous understanding of the issues before finding creative ways to apply these theoretical results back to the real world. As such, we always strive to develop solutions that either work today or offer significant benefits in the early stages of their deployments.

Curriculum Vitae

Prof. Laurent Vanbever
Professor of Networked Systems

Degrees/Higher Education
2012: PhD in Computer Sciences Engineering, University of Louvain, Louvain-la-Neuve, Belgium
2010: MS in Management, Solvay Brussels School of Economics and Management, Brussels, Belgium
2008: MS in Computer Sciences Engineering, University of Louvain, Louvain-la-Neuve, Belgium
2005: BS in Engineering, University of Louvain, Louvain-la-Neuve, Belgium

Professional Career
2015-present: Assistant Professor, Networked Systems Group, Computer Engineering and Networks Laboratory, D-ITET, ETH Zurich
2012-2014: Postdoctoral Research Associate, Princeton University, New Jersey, USA
2008-2012: Research and Teaching assistant, University of Louvain, Louvain-la-Neuve, Belgium

Honors and Awards
2015: IETF/IRTF Applied Networking Research Prize
2013: Best Paper Award, IEEE International Conference on Network Protocols (ICNP)
2013: IETF/IRTF Applied Networking Research Prize
2012: ACM SIGCOMM Doctoral Dissertation Award (runner-up)
2012: University of Louvain/ICTEAM Best PhD Thesis Award
2008-2012: Graduate Scholarship, Belgian scientific research foundation
2010: CeFiP Academic Award Belgium
2008: Alcatel-Lucent Innovation Award
2007: Belgium's BEST Engineering Competition (winner)

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Research Activities and Achievements

Improving Network Management

A big problem in today's networks is that they are managed indirectly. To implement a high-level objective (e.g., forward web traffic along a given set of links), network operators have to fine tune the behavior of potentially each device in their network, using low-level and arcane configuration languages. In a sense, configuring a network could be seen as programming a large distributed application in assembly language. Because of this, the majority of the costs associated to a network usually comes from the people managing it, rather than from the network devices themselves. Even worse, studies have shown that most of the network downtimes are caused by humans, rather than equipment failures. In a world where pervasive connectivity is often considered as granted, relative network fragility is still a surprising reality.

Building on these observations, a good part of our research focuses on developing novel management primitives and abstractions to enable declarative network operations. In a declarative network, operators only specify the high-level objectives and then a software program (i.e., a Network Operating System) takes care of translating it to low-level rules, automatically. In the last few years, we published several papers in top-level conferences aimed at building this software program. More specifically, we studied the fundamental problem of modifying the network behavior, while it is running, without incurring any losses (SIGCOMM 2011, INFOCOM 2012, TON 2012, ICNP 2013, TON 2013, INFOCOM 2013, INFOCOM 2014).

Impact: Our work receives multiple awards: the 2012 ACM SIGCOMM Doctoral Dissertation Award (runner-up); the 2012 University of Louvain/ICTEAM best thesis award; the 2013 IETF/IRTF Applied Networking Research Prize; and the 2013 Best Paper Award at ICNP 2013.

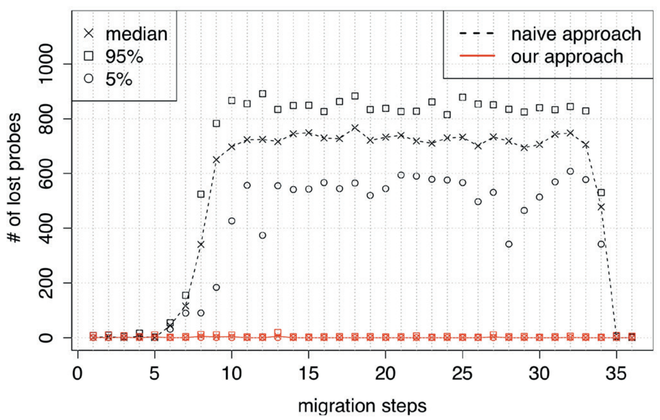

Figure 1: Our reconfiguration framework guarantees that no data is lost during a network update. In contrast, long-lasting data losses can happen when updating a network naively.

Software-Defined Networking

In addition to improving the operations of current networks, the NSG is also actively developing the next generation of computer networks based on Software-Defined Networking (SDN). SDN is an exciting new networking technology that has gained significant traction in both the research and the industry community. SDN is predicated around the separation between the control-plane (which decides how to handle traffic) and the data-plane (which forwards traffic according to the control-plane decisions).

While powerful, SDN does not remove the need for management abstractions. However, it gives us (network researchers) a tremendous opportunity to do things right, right from the beginning. Currently, our efforts focus on building the right management interface and have already led to a series of papers (HotSDN 2013, ICNP 2014, INFOCOM 2015). We also aim at applying SDN to new network settings. In that context, we already showed that SDN can bring significant benefits to cellular core networks (ONS 2013, CoNEXT 2013) and can solve some of the fundamental problems in inter-domain routing (SIGCOMM 2014).

As with any disruptive technology, SDN will not be deployed in one day. Instead, there will be quite a long period in which both legacy technologies and SDN will coexist. Understanding how different networking technologies and mechanisms interact is a hard problem that we are also studying, with some success already (CCR 2014, ONS 2014, HotNets 2014).

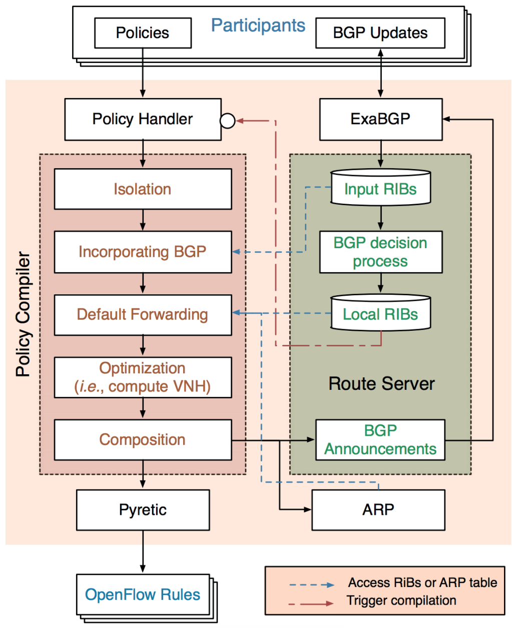

Figure 2: Block diagram of our SDX framework which enables Software-Defined Networking (SDN) capabilities at Internet eXchange Points (IXP). The SDX is the first succesfull application of the SDN principles to inter-domain routing.

Network scalability

Today's inter-domain routing protocol (BGP) mandates all the devices in the Internet to maintain detailed reachability information about all the destinations (IP prefixes), putting a lot of stress on the routing and forwarding infrastructures. Recently, the number of destinations surpassed 512,000 which caused many routers to crash, creating Internet-wide instabilities.

Exchanging detailed information about every destination is not necessary because a lot of it is redundant. Yet, filtering redundant information is hard as it can impact how data is forwarded in unpredicted ways. In a recent paper (CoNEXT 2014), we developed a distributed filtering and aggregation technique which provably preserves the forwarding paths after filtering. Our technique reduces the amount of information maintained by up to 80%, in the majority of the Internet.

Impact: Our work on route aggregation received the 2015 IETF/IRTF Applied Networking Research Prize. More information can be found on http://www.route-aggregation.net

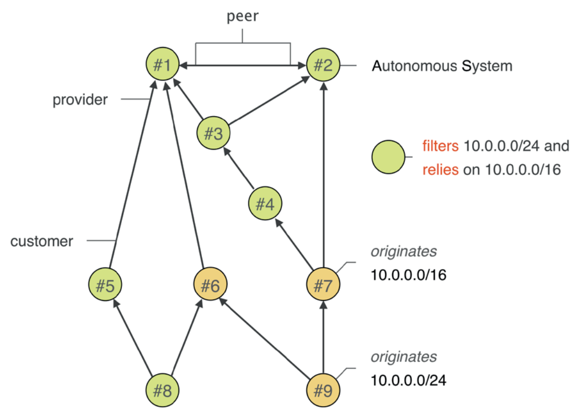

Figure 3: DRAGON is a distributed algorithm that enables Internet to automatically filter routing information, without impacting forwarding. In this simple example, only 3 nodes out of 9 end up not filtering. Find out more about DRAGON on: www.route-aggregation.net

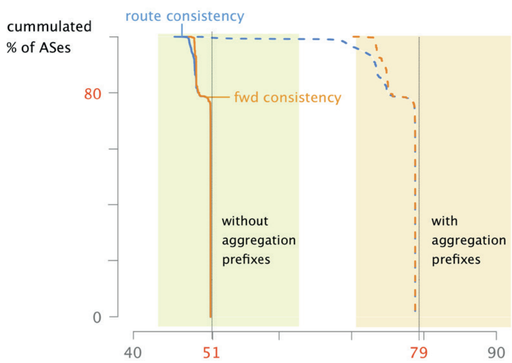

Figure 4: DRAGON enables 80% of the Internet devices to filter 80% of the routing information, not only improving the scalability but also the speed at which the Internet converges after a failure. Find out more about DRAGON on: www.route-aggregation.net

Network security

New attacks on the Internet infrastructure are reported literally every day leading to loss of connectivity, reduced performance or violation of privacy. At the NSG, we are interested in hardening the security of the Internet routing protocol (BGP) without requiring a complete overhaul of the Internet architecture. Recently, we improved the security offered by Tor, a widely used anonymity system, making it less vulnerable to routing attacks (HotNets 2014).

Impact: Our work on Tor received considerable media coverage: ACM TechNews, The Register, Computer Business Review and Help Net Security.

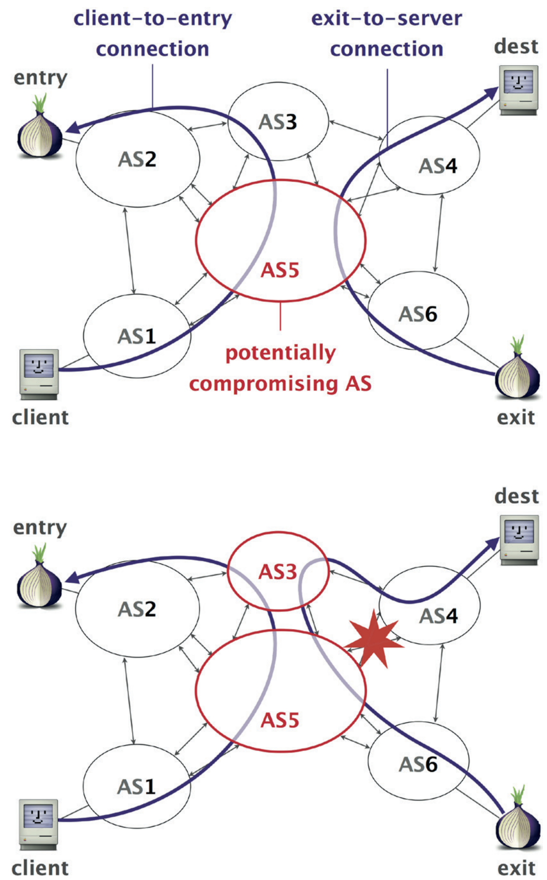

Figure 5: Internet routing tends to decrease Tor users' anonymity over time. In this example, a single network (AS5) can readily de-anonymize the Tor client by seeing both direction of its traffic (see above). After the failure of the link between AS5 and AS4 and the corresponding Internet convergence, AS3 can also de-anonymize the Tor client.