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Trilogy

Trilogy: Re-Architecting the Internet.

An Hourglass Control Architecture for the Internet, Supporting Extremes of Commercial, Social and Technical Control

Large Scale Integrating Project

FP7 ICT Objective 1.1 – The Network of the Future

Deliverable 11

Public record of the Summer School hosted during Year 2: Trilogy Future Internet Summer School'09

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Abstract

This document contains the report on the summer school organized by the Trilogy project. The Trilogy Future Internet Summer School 2009 was held in Louvain la Neuve (Belgium) during August 2009. In particular, this report contains the detailed program of tutorials and demos presented by renowned international experts during the summer school. It also contains information about the participants and poster sessions. The tutorial sessions, all slides and papers presented are available from:

http://inl.info.ucl.ac.be/TFISS09

Target audience: the general public.

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Table of contents

1 Executive Summary 4
2 List of Authors 5
3 Introduction 6
4 The organization committee 7
5 The Summer School program 8
6 The poster sessions 11
7 The attendees 14

1 Executive Summary

This document describes the Trilogy Future Internet Summer School, which was organized by the Trilogy project and the Grascomp doctoral school. The summer school was held in Louvain la Neuve, Belgium, and was hosted by Université catholique de Louvain during the last week of August 2009 (24th - 29th August 2009). The summer school was a great success, attracting more than 60 participants (59 attendees plus 7 speakers) from all over the world. This success is mainly due to the quality of the program which attracted a lot of students. The tutorial sessions, all slides and papers presented are available from:

http://inl.info.ucl.ac.be/TFISS09

2 List of Authors

Pascal Mérindol Université catholique de Louvain, Belgium (UCL-BE).

Olivier Bonaventure Université catholique de Louvain, Belgium (UCL-BE).

3 Introduction

The FP7 Trilogy project promised to realise a summer school during the second year of the project.

Hence, the Trilogy project and the GRASCOMP doctoral school has organised in August 2009 the Trilogy Future Internet Summer School in Louvain-la-Neuve, Belgium. The objective of the summer school was to gather PhD students and researchers who are actively working on the development of tomorrow's Internet.

The program consisted to two main parts:

- presentations by renowned international experts on the design of a new Internet architecture
- poster sessions to allow PhD students to present their work, discuss with other students and researchers and receive feedback.

All student participants could submit a short paper on their research, and present it during the poster sessions. They also were asked to review several of the short papers. This gave the students experience of writing, reviewing and presenting, as well as enabling them to make contacts with fellow researchers.

The Internet architecture has been remarkably successful in allowing a planet-scale internetwork to form. However, this architecture is losing its original simplicity and transparency as new classes of applications, business models, security mechanisms, scalability enablers and operational and management requirements give rise to solutions that extend the architecture without regards to its original design principles. Several substantial Future Internet initiatives are underway in Europe, the Americas and Asia.

The topics related to the Trilogy summer school are listed here:

- New networking paradigms
- New routing architectures
- New traffic engineering and congestion control mechanisms
- Measurements and analyses that characterize and quantify architectural limitations
- New protocols to address specific architectural limitations
- Principles of evolving future architectures
- Discussions on interworking with the existing Internet and deployability

The slides of all the presentations and short papers proceedings related to poster sessions are available online at: http://inl.info.ucl.ac.be/TFISS09. In addition, we have recorded all presentations and setup a web streaming server for accessing the videos. All videos are available in various formats (flash, ipod and mpeg4) from the same website link. The Trilogy project website also contains a dedicated page for the summer school: http://trilogy-project.org/Summer-school.

The summer school was a complete success and all details are given below.

4 The organization committee

The members of the summer school organization committee were:

- Olivier Bonaventure (UCL-BE)
- Pascal Mérindol (UCL-BE)
- Pierre François (UCL-BE)
- Benoit Donnet (UCL-BE)
- Bruno Quoitin (UCL-BE)
- Virginie Van den Schrieck (UCL-BE)
- Sébastien Barré (UCL-BE)
- Wolfgang Muhlbauer (DTAG/TUB)
- Luigi Iannone (DTAG)
- Marcelo Bargnelo Braun (UC3M)
- Rolf Winter (NEC)
- Louise Burness (BT)
- Alan Readhead (BT)
- Philip Eardley (BT)

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5 The Summer School program

Based on the feedback received from the students and the presenters, it seems that the summer school was a great success. Indeed, the quality and the diversity of the presentations attracted many peoples from varied horizons. The summer school was even more successful because it managed to achieve a interesting mix of topics such as new routing architectures, Internet measurements, new models of layer-4 connected transport protocols and so on...

The presentations were very interesting and the students were able to present their ongoing research during three poster sessions. We noticed a lot of interactions among students and renowned experts during the poster sessions. We organized a best poster award to congratulate the best poster presenter.

The detailed program content and agenda is given here:

- Speaker **: Paul Francis (MPI-SWS)**
- Title: **Dirty-slate approaches to scaling global Internet routing**
- **Date:** 24/08 14h-17h (2h)

  Abstract: The Internet research community has in recent years taken a renowned interest in the long-standing global Internet routing scaling problem. Much of this research has taken the form of much-needed "clean-slate" research, where ideas are pursued unconstrained by the installed base. Our research group takes an opposite but complementary approach. We look for solutions that are economically motivated and therefore have a decent chance of actually being deployed. One such solution is Virtual Aggregation, an approach that exploits tunnelling and aggregation to reduce the size of hardware routing tables (the FIB) easily by an order of magnitude. This work is being pursued in the IETF. More recently, we are working on adapting Virtual Aggregation to shrinking software routing tables (the RIB) as well. In this session, we will discuss the root causes of scaling problems in the Internet, review the history of scaling solutions, and present Virtual Aggregation in detail.

- Speaker **: Lars Eggert (NOKIA)**
- Title: **Future Internet Standardization Activities in the IETF/IRTF**
- **Date:** 25/08 8h-11h (2h)

  Abstract: The Internet Engineering Task Force (IETF) and its research arm, the Internet Research Task Force (IRTF) have been developing and standardizing the majority of the core Internet protocols over the last 25 years. This talk will give an overview of the two bodies, highlight Future-Internet-related activities that are already underway or are likely to kick off in the near future, as well as describe how new research results can be brought forward for standards consideration.

- Speaker **: Janardhan Iyengar (Franklin & Marshall College)**
- Title: Rethinking Transport Layering
- **Date:** 25/08 13h30-15h30 (2h)

  Abstract: Current Internet transports conflate functions driven by underlying network requirements, such as endpoint naming and congestion control, with functions driven by application requirements, such as retransmission and reordering. Dividing these function areas into layers separated by a clean interface addresses several limitations of the Internet's architecture, enabling middle boxes such as firewalls, network address translators, and performance enhancing proxies to operate without interfering with end-to-end semantics or security mechanisms such as IPsec and HIP. We explore two

alternative instantiations of this architectural principle: one in a ground-up redesign of the Internet's transport suite, the other a mere reorganization of existing transport protocols. The former approach offers efficiency advantages such as smaller headers and fewer round-trips to initiate a connection, while the latter approach may be easier to deploy quickly.

- Speaker**: Bruno Quoitin (UCL-BE) and Christel Pellser (IIJ - Japan)**
- Title: **Realistic inter-domain routing simulations with C-BGP**
- **Date:** 25/08 16h-18h (2h)

  Abstract: C-BGP is a BGP routing solver. It was developed as an alternative to traditional packet-level simulators for playing with BGP on large scale topologies. C-BGP computes the outcome of the BGP routing decisions based on a fairly detailed description of the layer-3 topology, the interconnection of BGP routers and the BGP routing policies. In this session, we will first briefly describe the design of C-BGP, its recent evolution and the kind of experiments it can be used for. In a second time, we will present two different applications of C-BGP: modelling an Internet-like topology and modelling an ISP's backbone network.

- Speaker**: Bob Briscoe (BT - Network Research Centre)**
- Title: **Practical Microeconomics and Internet Resource Sharing Protocols**
- **Date**: 26/08 9h-12h (3h)

  Abstract: This tutorial gives a primer on the microeconomics of sharing a pooled resource like Internet bandwidth. This knowledge is then used in 2 ways:

  1. assess how the economics has led to unintended consequence, given today's resource sharing protocols: TCP, weighted fair queuing, volume capping and deep packet inspection (and similar problems with the recent proposals XCP & RCP).
  2. motivate an approach to resource sharing based on understanding of the economic drivers and pitfalls. Kelly's proposal to use Floyd's Explicit Congestion Notification (ECN) for pricing will be explained, as well as the recent re-ECN proposal. Further unintended consequences of these approaches will be outlined, including potential market failures.

- Speaker**: Mathieu Lacage (INRIA)**
- Title: **Network experimentation and simulation with ns-3**
- **Date:** 27/08 14h-17h (3h)

  Abstract: Intended to eventually replace the popular ns-2 simulator,ns-3 aims to retain the successful features of ns-2, while remedying some complaints about it. In this presentation, we will describe the design of ns-3 and how it relates to some of its long-term goals, such as improving the integration of simulation tools with real-world applications and experimentation testbeds.

- Speaker**: Timothy G. Griffin (Cambridge University)**
- Title: **From Semirings to Metarouting**
- **Date:** 28/08 9h-12h (3h)

  Abstract: The metarouting project is developing a system for the declarative specification of routing protocols. A metalanguage is used to specify "routing algebras", structures related to semi-rings. Algebraic properties, such as monotonicity,

are automatically inferred from metalanguage specifications. Code is generated and linked with algorithms selected from our library, which includes generalized versions of standard Internet routing protocols that we have extracted from the Quagga code base. The inferred properties are used to ensure that only a correct matching of an algebra and an algorithm can take place.

- Speaker**: Dimitri Papadimitriou (Alcatel-Lucent)**
- Title: **Compact Routing: Challenges, Perspectives, and Beyond**
- **Date:** 28/08 13h30-15h30 (2h)

Abstract: Compact routing schemes were until recently considered as the main alternative to overcome the fundamental scaling limitations of the Internet routing system. Such schemes have been introduced to address the fundamental and unavoidable trade-off between the stretch of a routing scheme and the routing table size it produces. Recent studies have shown that static routing on topology-dependent identifiers (that includes "some" topological information) scales (poly) logarithmically on the number of nodes in scale-free graphs such as the Internet. Nevertheless, evolution of the Internet routing system also demonstrates that i) topology-independence of the numbering scheme becomes a fundamental requirement for e.g. multi-homing, nomadicity, and mobility, and ii) "static" routing is unable to handle dynamic graphs, i.e., routing update messages (triggered by topology-driven, policy-driven, and other protocol-driven events) must be exchanged to timely inform remote routers such that each router maintains a consistent view of the non-local topology. This tutorial starts by reviewing the fundamental dimensions of routing schemes. It then introduces the compact routing theory and its application to scale-free graphs. Next, it describes and analyses the consequences resulting from i) routing on topology-independent numbering space and ii) dynamic routing information exchanges and resulting costs. This tutorial will conclude by outlining the open research coupled-challenges (stretch x routing table size x dynamics) and possible direction(s) to address them.

6 The poster sessions

We organized a call for papers to encourage students to present their works through poster sessions. The authors were required to submit a two page paper as an extended abstract of their current research results. We received more than 30 submissions, and we decided to accept all papers whose authors were able to come in the summer school.

After having submitted their abstracts, all the PhD students have been asked to comment, discuss and review between two and four extended abstracts submitted by other PhD students. This process encourages the PhD students to discuss and explain their research with other PhD students before the summer school. By starting this process before the summer school, we ensured that the discussion and cooperation when they arrived at the summer school "hit the ground running". Furthermore, this is a good way for the PhD students to discover the standard paper reviewing process and it was the first reviewing experience for many of the students. According to the feedback we received from the participants, this process was successful and PhD students benefited from this kind of experience.

We organized three poster sessions, the title of the papers and their authors are listed here:

- An Evolvable Network Architecture for Embedded Devices Ariane Keller (ETH Zurich)
- A modular architecture for Multipath Exposure to networking stacks Sebastien Barre (UCLouvain)
- Recent Advances in Multi-Constrained Routing for Multi-Domain Networks Gilles Bertrand (Institut Telecom, Telecom Bretagne)
- Robust Self-Stabilizing ad hoc network managementFouzi Mekhaldi (LRI, university of Paris-Sud 11), Colette Johnen (LaBRI, University of Bordeaux)
- BGP churn evolution: A perspective from the core Ahmed Elmokashfi (Simula Research Laboratory), Amund Kvalbein (Simula Research Laboratory), Constantine Dovrolis (Georgia Tech)
- Aggregating Noisy and Unsynchronized Measurements for Network Tomography Italo Cunha (Thomson and UPMC Paris Universitas), Renata Teixeira (CNRS and UPMC Paris Universitas), Nick Feamster (Georgia Tech), Christophe Diot (Thomson)
- Connecting Cloud Applications to the Internet Vytautas Valancius (Georgia Tech)
- CAT - Content-aware Transport ProtocolLong Nguyen Hoang (Helsinki University of Technology)
- Enabling a forwarding plane for future data-centric networks Christian Esteve Rothenberg (University of Campinas)
- CoreSim: A Simulator for Evaluating Locator/ID Separation Protocol Mapping Systems Florin Coras (Technical University of Cluj-Napoca), Lorand Jakab (Universitat Politecnica de Catalunya), Albert Cabellos-Aparicio (Universitat Politecnica de Catalunya), Jordi Domingo-

Pascual (Universitat Politecnica de Catalunya), Virgil Dobrota (Technical University of Cluj-Napoca)

- Multipath Transport on the Internet Sebastian Siikavirta (Helsinki University of Technology, Department of Communications and Networking)
- Trafic engineering optimization methods to provide multiple IP services on a shared infrastructure HO Trong Viet (UCLouvain)
- Transport Layer Enhancements for Deployable Resource Pooling Michio Honda (Keio University)
- Randomness for Reduced-State Inter-Domain Forwarding Stephen D. Strowes (University of Glasgow), Colin Perkins (University of Glasgow)
- Secure Multipath Transport for Legacy Internet Applications Tatiana Polishchuk (HIIT), Andrei Gurtov (HIIT)
- Choosing paths to advertise in a Multiple Paths Advertisement environment Virginie Van den Schrieck (UCLouvain)
- Unleashing Network Testing and Troubleshooting Laurent Vanbever (UCLouvain)
- Congestion Balancing using re-ECN Joao Taveira Araujo (University College London), Miguel Rio (University College London), George Pavlou (University College London)
- How to mitigate the effect of scans on mapping systems Damien Saucez (UCLouvain), Luigi Iannone (Deutsche Telekom AG Laboratories)
- Triangle Inequality Violation Avoidance in Internet Coordinate Systems Yongjun Liao (Research Unit in Networking (RUN), University of Liege, Belgium), Guy Leduc (Research Unit in Networking (RUN), University of Liege, Belgium)
- NGN model with heterogeneous mobile customers Jose Moura (Computing Department - Lancaster University), Martin Dunmore (Computing Department - Lancaster University), Christopher Edwards(Computing Department - Lancaster University)
- Supporting the Mobile Internet Using GSE/8+8 Avinash Mungur (Lancaster University), Martin Dunmore (Computing Department - Lancaster University), Christopher Edwards(Computing Department - Lancaster University) ***Best poster award***
- Segment Level Authentication: Combating TCP-based Misbehaving Traffic Ming Li (Helsinki University of Technology, Department of Computer Science and Engineering)
- Source Route Capabilities Vamsi Kambhampati (Colorado State University, Fort Collins, CO, USA), Christos Papadopoulos (Colorado State University, Fort Collins, CO, USA), Dan Massey (Colorado State University, Fort Collins, CO, USA)

- A Dynamic Trust Federation for Business Layers Alexandre Matos (Cisuc-University of Coimbra), Paulo Simoes (Cisuc-University of Coimbra), Edmundo Monteiro (Cisuc-University of Coimbra)
- Bandwidth Aggregation over Heterogeneous Wireless Links Kristian Evensen (Simula), Dominik Kaspar (Simula)
- Service Platform for On-demand Optical Network Services Aldo Campi (University of Bologna), Franco Callegati (University of Bologna)
- On Opportunistic Networking Security Bernhard Distl (ETH Zurich), Franck Legendre (ETH Zurich)
- An Approach for Mobile User's IP-Connectivity Management in Next Generation Wireless NetworksRoberto Rigolin Ferreira Lopes (University of Sao Paulo), Bert-Jan van Beijnum (University of Twente), Edson dos Santos Moreira (University of Sao Paulo)
- Provider Information Diffusion in Multihomed Sites Etienne Gallet de Santerre (Telecom Bretagne)
- Reliable Internetworking using publish/subscribe paradigm Nikolaos Fotiou (AUEB)
- QoS Models for Business Layers Fernando Matos (University of Coimbra), Paulo Simoes (Cisuc-University of Coimbra), Edmundo Monteiro (Cisuc-University of Coimbra)

7 The attendees

The summer school was also a success in the number of attendees with more than 60 students coming from diverse countries, universities and institutions. Note that most of the registered peoples are not related to the Trilogy project.

The complete list is given here:

Luiz Gustavo	Zuliani	University of Pisa
Gilles	Bertrand	Telecom Bretagne
Etienne	Gallet de Santerre	Telecom Bretagne
Christopher	Reason	BT Innovate & Design
Aruna Prem	Bianzino	Telecom-ParisTech
Samo	Grasic	LTU
Ariane	Keller	ETH Zurich, Switzerland
Fouzi	Mekhaldi	LRI
Italo	Cunha	Thomson / LIP6
Ivan	Pepelnjak	NIL Data Communications
Tatiana	Polishchuk	HIIT, Finland
Ho	Trong Viet	INGI – UCL
Long	Nguyen Hoang	TKK, Finland
Long	Nguyen Hoang	TKK, Finland
Andreas	Voellmy	Yale University, USA
Bruno	Sousa	CISUC - University of Coimbra
Sergio	Labeaga	Aalborg University, Denmark
Alexandre	Matos	CISUC - University of Coimbra
Fernando	Matos	CISUC - University of Coimbra
Stephen	Strowes	University of Glasgow, Scotland
Christophe	Feltus	CRP Henri Tudor, Luxembourg
Vytautas	Valancius	Georgia Institute of Technology
João	Araújo	UCLouvain
Radoslaw	Ruchala	WSB-NLU, Poland
Amir	Mehmood	TU Berlin / T-Labs
Nadi	Sarrar	TU Berlin / T-Labs
Bernhard	Distl	ETH Zurich, Switzerland
Avinash	Mungur	Lancaster University
Ingmar	Poese	TU-Berlin / T-Labs
Gregory	Detal	UCL – INGI
Zhihua	Jin	TKK, Finland

Ming	Li	TKK, Finland
Simon	van der Linden	UCLouvain
Wolfgang	Mühlbauer	TU Berlin / T-Labs
Eilidh	McAdam	Abertay University, Scotland
Wang	Yang	Tsinghua University, China
Sofiane	Hassayoun	TELECOM-Bretagne
Christoph	Paasch	UCLouvain
Andreas	Ripke	NEC Europe Ltd.
Clarence	Filsfils	Cisco Systems, Inc.
Panayiotis	Kolios	King's College London
Oluwasoji	Omiwade	University of Houston, USA
EL KAED	Charbel	France Telecom & LIG
Joerg	Wagner	NEC Europe Ltd.
Christian	Esteve Rothenberg	Unicamp, Brazil
Jose	Moura	Lancaster University
Michio	Honda	Keio University, Japan
Yongjun	Liao	Universite de Liege
David	Hock	University of Würzburg
Matthias	Hartmann	University of Würzburg
Pengfei	Di	TU Munich
Dominik	Kaspar	Simula Research Laboratory
Sebastian	Siikavirta	TKK, Finland
Ahmed	Elmokashfi	Simula Research Laboratory
Vamsi	Kambhampati	Colorado State University
Cristel	Pelsser	UCLouvain
Laurent	Schumacher	UCLouvain
Uwe	Metz	Eurescom GmbH
Seweryn	Dynerowicz	FUNDP (University of Namur)