ICT-257422

# CHANGE

**CHANGE: Enabling Innovation in the Internet Architecture through Flexible Flow-Processing Extensions**

Specific Targeted Research Project

FP7 ICT Objective 1.1 The Network of the Future

# D6.4 - Industrial Workshop Report

Due date of deliverable: December 1st, 2013

Actual submission date: December 22, 2013

| | |
|---|---|
| Start date of project | 1 October 2010 |
| Duration | 36 months |
| Lead contractor for this deliverable | NEC Europe Ltd. |
| Version | 1.0 |
| Confidentiality status | Public, Confidential to CHANGE project and Commission Services, Restricted to bodies determined by the CHANGE project |

**Abstract**

This deliverable presents a report of the CHANGE industrial workshop, co-organized with the EU FP7 OFELIA project. Beyond actually organizing the project, several CHANGE members participated by presenting technical papers as well as invited technical and industry talks. This document provides a summary of these activities, as well as the workshop's call for papers, program committee, and technical program. The workshop was a success, drawing over 100 people on both days from a large range of academic and industry players ranging from vendors, operators and service providers.

**Target Audience**

The General Public.



**Impressum**

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| Full project title | CHANGE: Enabling Innovation in the Internet Architecture through Flexible Flow-Processing Extensions |
| Title of the workpackage | D6.4, Industrial Workshop Report |
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| Work-package | WP6 - Dissemination, Exploitation and Standardization |
| Security | Public (PU) |
| Nature | P |
| Version | 1.0 |
| Total number of pages | 17 |

# Contents

# 1 Introduction

The CHANGE industrial workshop was co-hosted in collaboration with the EU FP7 OFELIA project. More specifically, members of CHANGE and OFELIA set up the Second European Workshop on Software Defined Networks. On the CHANGE side, the effort was led by the two main industrial partners, NEC and Deutsche Telekom, with help from Olivier Bonaventure from UCL-BE.

The workshop took place on October 10th and 11th, 2013, in Berlin, Germany, at the Berliner Congress Center, in the heart of the city. The rest of this document represents a thorough report of the workshop. We begin by covering the participation of CHANGE members in the event, beyond its organization. Then, in section 2.3, we list the workshop's call for papers. Section 3.3 then discusses the configuration of the technical program committee which took care of producing paper reviews and coming up with the program; finally, section 4.2 lists the program itself. In all, the workshop was quite successful, with over 100 participants attending both days.

More information about the workshop can be found online at http://ewsdn.org.

## 1.1 CHANGE Member Participation

Beyond co-organizing the workshop, several CHANGE members from different partners formed part of the technical program committee (TPC). Saverio Niccolini, for example, acted as one of the workshop's TPC co-chairs, while Nicola Ciulli (Nextworks), Peter Feil (Deutsche Telekom), Costin Raiciu (Universitatea Politehnica Bucuresti) and Georgios Smaragdakis (Deutsche Telekom Lab / TUB, Germany) were part of the TPC itself. The full description of the TPC can be found in section 3.3.

In addition, several CHANGE members participated in the event itself by attending and giving talks. Roberto Bifulco (NEC), for instance, contributed by presenting a technical talk on high performance software BRASes. Further, Michio Honda (NEC), gave an invited industry talk on high speed software switches. Finally, Felipe Huici (NEC) gave an invited talk describing the main results of the CHANGE project, including netmap, VALE, and ClickOS, to name a few. The rest of this section gives the abstracts for these three talks.

### 1.1.1 Paper: Rethinking Access Networks with High Performance Virtual Software BRASes

Broadband Remote Access Servers (BRASes) play a crucial role in todays networks, handling all traffic coming from access networks (e.g., DSL traffic), applying operator policies and providing the first IP point in the network. It is perhaps unsurprising then, that these are expensive, proprietary, difficult-to-upgrade boxes. They also represent a large, single point of failure, making operators even more reticent to deploy new functionality for fear it might seriously disrupt day-to-day operations. In order to remove some of these barriers to innovation, we advocate for turning BRASes from the monolithic hardware boxes they are today into flexible, virtualized, software-based devices running on inexpensive commodity hardware. As a

proof- of-concept, we present the implementation and performance of a software BRAS based on ClickOS, a tiny Xen virtual machine designed specifically for network processing. Our software BRAS prototype can establish subscriber sessions at rates above 1,000 per second; requires only 1MB of memory per 1,000 established sessions; can boot in milliseconds; and can handle traffic at 10Gb/s for almost all packet sizes.

### 1.1.2 Talk: Enabling Innovation in the Internet: Main achievements of the CHANGE Project

The CHANGE project seeks to re-enable innovation in the Internet by shifting network processing from a proprietary, hard-to-program hardware world to one made of software functions running on commodity hardware, all while achieving high performance. To do so, CHANGE builds so-called network processing platforms and an architecture to construct network processing in a network made up of several of these platforms.

This talk describes several technologies developed to build such platforms. First, I will describe netmap, a high performance packet I/O framework that is able to achieve 10Gb/s rates for all packet sizes even when using a single, downclocked CPU. Second, I will cover VALE, a high performance software switch that we use as a back-end for the platform in order to demux packets from NICs to the virtual machines that actually do the network processing. VALE yields high throughput (up to hundreds of Gigabits per second) and low delay of only tens of microseconds.

In the final part of the talk I will discuss ClickOS, a high-performance, virtualized software middlebox platform. ClickOS virtual machines are small (5MB), boot quickly (about 30 milliseconds), add little delay (45 microseconds) and over one hundred of them can be concurrently run while saturating a 10Gb pipe on a commodity server. We further implement a wide range of middleboxes including a firewall, a carrier-grade NAT and a load balancer and show that ClickOS can handle packets in the millions per second.

### 1.1.3 Talk: Accelerating software switches with Netmap

The use of software switches has become prominent in a wide variety of systems and scenarios, from standard ones (back-end packet mux/demux for virtualization technologies, replacements for hardware switches) to novel ones such as providing switching planes for consolidated middlebox platforms and software defined networks.

This wide range of use cases would greatly benefit from the availability of an extensible software switch that can provide modularity and high performance. Unfortunately, no existing software switches match both requirements.

In this paper we present mSwitch, a modular software switch with a strong emphasis on performance, scalability, and extensibility. mSwitch is based on the netmap API and extends the VALE software switch in various ways. Scalability comes by restructuring VALE's internals to support much larger number of ports and increase parallelism among senders. Extensibility is achieved by decoupling the high speed switching fabric from the implementation of the switching logic. The latter can be dynamically reconfigured by loading

 

a kernel module, without having to deal with the complexity of an efficient dataplane implementation.

These changes allow mSwitch to scale to hundreds of ports (as opposed to VALE's 64), and outperform VALE's throughput by as much as 3.6 times, reaching rates of up to 283 Gbit/s for maximum-sized packets and 72 Mpps for minimum-sized ones.

In order to show the flexibility of our approach, we use mSwitch to build three distinct modules: a learning bridge consisting of 45 lines of code that outperforms FreeBSD's bridge by 6 times; an accelerated Open vSwitch module requiring small changes to the code and boosting performance by 2.6 times; and a protocol demultiplexer for user-space protocol stacks.

# 2 Call for Papers

This section provides the text for the workshop's call for papers.

## 2.1 SDN Evolution and Current Trends

Software Defined Networking is undoubtedly one of the chief trends in the ICT area. In the past year we have seen all big players in the networking arena starting to ride the SDN wave one way or another. The standardization work is actively ongoing in ONF with its 7 working groups, in the IETF where several working groups are somehow related to SDN (e.g. FORCES, NETMOD, NETCONF, ALTO, NVO3 and the recently formed I2RS), while the recent initiative of ETSI on Network Functions Virtualization (NFV) is also tightly related to SDN. On top of the several existing Open Source SDN controllers, tools and development environments, the recently launched Open Daylight project is backed up by several players and it is receiving a lot of attention. In parallel to this activity which is now largely driven by industry, the academia is also actively pursuing the SDN topic, both following the mainstream and using the SDN concepts in many innovative areas of applications or with disruptive approaches.

Considering the hot SDN research areas, a lot of interest is now focused on forwarding abstractions, "Northbound" APIs towards applications, SDN high level languages and tools for improving the software robustness like compilers and debuggers. Inter-domain aspects and inter-controller orchestration policies draw the attention of researchers as well. The idea of abstraction layers toward switching equipment has been proposed for new "Southbound" interfaces in order to manage the coexistence of different solutions besides the canonical OpenFlow approach (e.g., I2RS). New switch architectures supporting SDN are considered a hot topic. The application of SDN in the domain of optical networks is paving the way toward a unified control plane framework to integrate the packet and the optical domain, promoting a better coordination with higher network layers and applications. In mobile networks, the introduction of SDN will enable to program base stations' wireless data plane and to enhance the functionalities of the Evolved Packet Core, thus giving Mobile Operators greater control over their equipment and an opportunity to introduce novel value-added services. WLANs and WPANs can also benefit by the introduction of SDN concepts by improving resource utilization and facilitating their programmability.

Considering the strategic side of the SDN adoption, if SDN will progress to offer Carriers' Class solutions, which will be the impact on the telecom ecosystem? Which innovative services and business models will emerge out of the technology improvements?

## 2.2 European?

What makes an SDN workshop "European"? Traditional strengths of European research and development have been in optical transmission and wireless, especially cellular networks. The workshop emphasizes aspects of Software Defined Networks that come up when extending SDN 'beyond Ethernet'. In this regard, "European" does not mean that we restrict to a geographic scope, we welcome contribution and participation

 

from all over the world. One goal of the workshop is to bring together industry and academia on the topics of SDN; in particular the workshop will feature an “industry forum”, i.e. a session with presentations of key industrial players.

Contributions to the workshop We are interested in both papers showing consolidated results and in position papers bringing up innovative ideas. We welcome contributions including, but not limited to, the following topics:

- Forwarding abstractions, APIs, object models
- Network Function Virtualization and SDN, Network Virtualization techniques based on SDN
- Optical extensions to OpenFlow, SDN
- Wireless integration, characterization of wireless interfaces, flows, handover support
- Evolved packet core, LTE support for OpenFlow
- New controller architectures, Application Programmer’s Interfaces, SDN “north-bound” interfaces
- Interoperation of cloud architectures and SDN
- New switch architectures supporting SDN
- New networking paradigms like Content or Information Centric Networks (CCN/ICN) and their relation with SDN
- Carrier-grade SDN architectures and equipment
- Practical experiments on OpenFlow / SDN based testbeds
- Identification of use cases for SDN, SDN related business models, strategic role of SDN in network evolution
- SDN frameworks and tools, SDN based equipment: controllers, switches, integrated development environment, testing and debugging environment

## 2.3 Important Information

- Format: up to 6 pages, double column 10pt font
- Acceptance notification: July 29th, 2013
- Camera ready: Sept 15, 2013
- Please submit via the EasyChair submission system
- Contact: ewsdn13@easychair.org

- We plan to have the EWSDN Workshop proceedings submitted to IEEE Xplore, as we did for EWSDN 2012.

# 3 Program Committee

This section describes the structure of the technical program committee (TPC) which was in charge of reviewing and picking papers for inclusion in the program. The industrial workshop was chaired by Hagen Woesner, EICT, Berlin, Germany, from the EU FP7 OFELIA project. From the CHANGE project, Saverio Niccolini was one of TPC co-chairs, and several other members were part of the TCP itself (Nicola Ciulli from Nextworks, Costin Raiciu from University of Bucharest, Peter Feil from Deutsche Telekom and Georgios Smaragdakis from Deutsche Telekom Lab / TUB, Germany).

## 3.1 Technical Program Committee Co-Chairs

- **Saverio Niccolini, NEC, Heidelberg, Germany**
- Stefano Salsano, Univ. Tor Vergata, Roma, Italy
- Elio Salvadori, CREATE-NET, Trento, Italy

## 3.2 Sponsors

The workshop was sponsored by the SCOPE Alliance and by Telekom Innovation Laboratories.

## 3.3 Technical Program Committee

- Rui Aguiar, Universidade de Aveiro, Portugal
- Achim Autenrieth, ADVA AG Optical Networking, Germany
- Siamak Azodolmolky, GWDG, Germany
- Leonardo Bergesio, i2CAT Foundation, Spain
- Dean Bogdanovic, Juniper Networks, USA
- Marco Canini, TU Berlin / T-Labs, Germany
- Ramon Casellas, CTTC, Spain
- **Nicola Ciulli, Nextworks, Italy**
- Richard Clegg, University College London, UK
- Didier Colle, Ghent University - iMinds, Belgium
- Daniel Corujo, Instituto de Telecomunicaes, Portugal
- Panagiotis Demestichas, University of Piraeus, Greece
- Francesco De Pellegrini, CREATE-NET, Italy

- Alisa Devlic, Ericsson Research, Sweden
- Thomas Dietz, NEC Eurolabs, Germany
- Diego Lopez, Telefonica I+D, Spain
- **Peter Feil, Deutsche Telekom AG, Germany**
- Panagiotis Georgopoulos, Lancaster University, UK
- Stefano Giordano, University of Pisa, Italy
- Ken Gray, Juniper Networks, USA
- Eduardo Jacob, University of the Basque Country, Spain
- Wolfgang John, Ericsson Research, Sweden
- Pawel Kaczmarek, ADVA, Poland
- Holger Karl, University Paderborn, Germany
- Eiji Kawai, NICT, Japan
- Eric Keller, University of Colorado, USA
- Wolfgang Kellerer, Technische Universitt Mnchen, Germany
- Teemu Koponen, Nicira, USA
- Marc Krner, TU Berlin, Germany
- Alessandro Leonardi, AGT Group /R&D GmbH, Germany
- Li Erran Li, Bell Labs, Alcatel-Lucent, USA
- Dante Malagrino, Embrane, USA
- Antonio Manzalini, Telecom Italia Lab, Italy
- Jon Matias, University of the Basque Country, Spain
- Ruben Merz, Swisscom, Switzerland
- Giacomo Morabito, DIIT - University of Catania, Italy
- Reza Nejabati, University of Bristol, UK
- Konstantinos Pentikousis, EICT GmbH, Germany

- Luca Prete, Consortium GARR, Italy
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- **Georgios Smaragdakis, Deutsche Telekom Lab / TUB, Germany**
- Marc Sune, BISDN, Germany
- Bill Snow, ON.Lab, USA
- Vincenzo Suraci, Universit degli Studi eCampus, Italy
- Attila Takacs, Ericsson Research, Hungary
- Kostas Tsagkaris, University of Piraeus, Greece
- Zoltan Turanyi, Ericsson Hungary Ltd.
- Steve Uhlig, Queen Mary, University of London
- Luca Veltri, University of Parma, Italy
- Cedric Westphal, Huawei, USA
- Minan Yu, USC, USA

# 4 Technical Program

This section gives a full listing of the workshop's program over the course of the two days. Names in bold denote CHANGE participants.

## 4.1 Thursday, October 10th, 2013

**9:30 Welcome and Logistics**

Hagen Woesner

**9:45 Keynote**

Rdiger Martin (European Commission): The role of SDN in the research funding landscape of Europe

Andreas Gladisch (Deutsche Telekom Laboratories): SDN beyond the hype: Where are we?

10:30 Coffee Break

**11:00 Technical session I: Performance and QoS**

Performance Evaluation of a Scalable Software-Defined Networking Deployment Siamak Azodolmolky, Philipp Wieder and Ramin Yahyapour

Implementation and Evaluation of a carrier-grade OpenFlow Virtualization Scheme Pontus Skldstrm and Wolfgang John.

Control of Multiple Packet Schedulers for Improving QoS on OpenFlow/SDN Networking Airton Ishimori, Fernando Farias, Eduardo Cerqueira and Antnio Abelm.

12:15 Lunch

**13:00 Technical session II: Virtual appliances and virtual networks**

Virtual Public Networks Arjuna Sathiaseelan, Charalampos Rotsos, Sriram C S, Dirk Trossen, Panagiotis Papadimitriou and Jon Crowcroft.

Rethinking Access Networks with High Performance Virtual Software BRASes **Roberto Bifulco, Thomas Dietz, Felipe Huici, Mohamed Ahmed, Joao Martins, Saverio Niccolini and Hans-Joerg Kolbe.**

Dynamic VPN Optimization by ALTO Guidance Michael Scharf, Vijay Gurbani, Thomas Voith, Manuel Stein, W. Roome, Greg Soprovich and Volker Hilt.

14:15 Coffee Break

**14:30 Technical session III: SDN Architectures and APIs**

On the feasibility of a consistent and fault-tolerant data store for SDNs Fbio Botelho, Fernando M. V. Ramos, Diego Kreutz and Alysson Bessani.

OpenFlow Needs you! A Call for a Discussion About a Cleaner OpenFlow API Peter Peresini, Maciej Kuzniar and Dejan Kostic.

Taming SDN Controllers in Heterogeneous Hardware Environments Zdravko Bozakov and Amr Rizk.

Virtual Aggregation using SDN Pontus Skldstrm and Belgis Chial Sanchez.

16:10 Coffee Break

**16:30 Technical session IV: Access and Home networks**

Enabling service market in metro and access networks - the ADDONAS project Artur Binczewski, Wojbor Bogacki, ukasz Dolata, John Dunne, Lukasz Lechert, Andre Oehlschlaeger, Lukasz Podleski, Milosz Przywecki, Bijan Rofoee, Dimitra Simeonidou and Georgios Zervas.

CROWD: An SDN Approach for DenseNets Hassan Ali-Ahmad, Claudio Cicconetti, Antonio de La Oliva, Martin Draexler, Rohit Gupta, Vincenzo Mancuso, Laurent Roullet and Vincenzo Sciancalepore

HomeVisor: Adapting Home Network Environments Tomasz Fratczak, Matthew Broadbent, Panagiotis Georgopoulos and Nicholas Race.

18:00 End of Day One

20:00 Food and Drinks at RIVABAR

## 4.2 Friday, October 11th, 2013

**09:00 Technical session V: Open Session**

SDN-based Application-Aware Networking on the Example of YouTube Video Streaming Michael Jarschel, Florian Wamser, Thomas Hhn, Thomas Zinner and Phuoc Tran-Gia.

Exploiting OpenFlow resources towards a Content-Centric LAN Kostas Choumas, Nikos Makris, Thanasis Korakis, Leandros Tassiulas and Max Ott.

Datacenter in a box: test your SDN cloud-datacenter controller at home Gianni Antichi, Davide Adami, Jos Teixeira, Alessio Del Chiaro, Stefano Giordano and Alexandre Santos.

NetIDE: First steps towards an integrated development environment for portable network apps Federico Michele Facca, Elio Salvadori, Holger Karl, Diego R. Lopez, Pedro Andres Aranda Gutierrez, Dejan Kostic and Roberto Riggio.

10:40 Coffee Break

**11:00 Invited Speakers Sessions**

**Felipe Huici (NEC Laboratories Europe)**: Enabling innovation in the Internet: main achievements of the CHANGE project

**11:30 Industry session I: Accelerating SDN switches: hardware and software approaches**

Gergely Pongracz, Lszl Molnr and Zoltn Lajos Kis: Removing Roadblocks from SDN: OpenFlow Software Switch Performance on Intel DPDK

**Michio Honda (NEC Laboratories Europe)**: Accelerating software switches with Netmap

Marc Sune (BISDN GmbH): xDPd: eXtensible DataPath Daemon

13:00 Lunch

**13:40 Industry session II: Network Function Virtualization, Network Service Chaining**

Diego Lopez (Telefonica): The Virtual Brick Road. Achievements and Challenges in NFV Space

Nic Leymann (Deutsche Telekom): Flexible Service Chaining: Requirements and Architectures

Antonio Manzalini (Telecom Italia): SDN: in track vs. disruptive adoption

Igor Marty (IBM): OpenDove as a Chaining Platform for NFV Appliances

16:00 Coffee Break

**16:30 Industry session III: Testing of SDN and OpenFlow**

Steve Jarman (SPIRENT): The Migration of Test Equipment Architectures to Support SDN and NFV - Benefits and Challenges

17:45 End of Day 2