



**ERCIM "ALAIN BENSOUSSAN"  
FELLOWSHIP PROGRAMME**



## Scientific Report

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Name of the <i>Host Organisation</i>	NTNU
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Period of the fellowship	23/10/2014 to 22/10/2015

## I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

My research work during my fellowship period at the Department of Telematics in the Norwegian University of Science and Technology were in the following aspects.

First, many applications of wireless sensor networks (WSNs) need to balance multiple yet often conflicting performance requirements such as high energy efficiency, high throughput, low delay and low loss. Finding appropriate WSN parameter configuration to achieve the best trade-off requires indepth understanding of the joint effect of key parameters residing at different layers on the performance. In this work, we present an extensive experimental study on the data delivery performance of a WSN link, where 4 major performance metrics, namely energy, throughput, delay and loss, were measured over 6 months under around 50 thousand parameter configurations of 7 key stack parameters. Different from existing work, rich observations are made out of the extensive measurement data, with the focus on the joint effect of these parameters on the performance. Specifically, for each of the four performance metrics, a set of guidelines is derived for parameter optimization. In addition, we propose empirical models for each performance metric to quantify the joint effects, which enable finding optimal settings for parameters such as payload size or retransmissions, in consideration of link quality and other parameter settings, to achieve better performance trade-offs. To demonstrate the potential of this work, the obtained joint parameter optimization results are applied to an example. The outcome is compared with those achieved by following representative single-parameter tuning guidelines from the literature. The comparison reveals that by considering the joint effect of multi-layer parameters together, a WSN ap

Second, the de facto implementation of Software Defined Networking (SDN), i.e., OpenFlow, only parses L2-L4 headers, which limits the use of SDN to employ control intelligence in application layer. In this work, we advocate content parsing to empower SDN with finer grained control ability over traffic. Specifically, we propose a scalable content parser, called COPY, to identify and parse application layer protocols. COPY creates a distinguishable counting context free grammar (DCCFG) to specify the

protocol's semantics in application layer, and translates multiple DCCFGs into one distinguishable counting automaton (DCA). DCA is generated without semantic loss from the single DCCFG, and thus provides accurate and scalable parsing ability. Our experiments show that COPY precisely identifies every packet in a labelled trace. When comparing with other six approaches on the real traces, COPY performs 4.2Gb/s and 24.7Gb/s with single- and eight-thread models, respectively, which improves 20%–860% than others, and consumes acceptable off- line overhead in time and space.

Third, in order to deep understand the big network data on the fly, we advocate Deep Semantic Inspection (DSI) to re- veal the semantic of user behaviors instead of only identifying the protocols or applications from network traffic. DSI contains a standard description to unify the various formats of different applications, and finally purifies user semantics. To enable it, we design and implement a Semantic On-Line Intent Detection (SOLID) system. In the kernel space of SOLID, we propose a semantic parser obtaining the application semantic from the raw protocol data unit, and a matching engine converting the application semantic to the user behavior sketch for flexible high-level data analyses. The kernel space achieves 17.2Gbps throughput with 709MB memory in a 12-core x86 platform in our evaluations. In addition, SOLID shows its effectiveness in the user space with four practical cases in the scenarios of service provider, content provider and large Intranet with their real traffic.

## **II – PUBLICATION(S) DURING YOUR FELLOWSHIP**

1. Songwei Fu, Yan Zhang, Yuming Jiang, Chengchen Hu, Chia-Yen Shih, and Pedro Jose Marron, Experiment study for multi-layer parameter configuration of WSN links, 35th IEEE International Conference on Distributed Computing Systems (**ICDCS**), Columbus, Ohio, USA on June 29 – July 2, 2015.
2. Hao Li, Chengchen Hu, Junkai Hong, Xiyu Chen, Yuming Jiang, Parsing Application Layer Protocol with Commodity Hardware for SDN, in the proceeding of **ACM/IEEE ANCS** 2015, Oakland, USA, May 7-8, 2015.
3. Di Chen, Peng Zhang, Chengchen Hu, Huanzhao Wang, Shun Wu, Ningzhe Xing, PAPERS: Private and Precise Range Search for Location Based Services, in the

proceeding of **IEEE ICC 2015**, London, Jun., 2015

4. Kai Chen, Xitao Wen, Xingyu Ma, Yan Chen, Yong Xia, Chengchen Hu, Qunfeng Dong, Yongqiang Liu, WaveCube: A Scalable, Fault-Tolerant, High-Performance Optical Data Center Architecture, in the proceedings of **INFOCOM 2015**, Hong Kong, Apr. 26- May 1, 2015
5. Chengchen Hu, Yuming Jiang, Online Semantic Analysis over Big Network Data. **ERCIM News**, Vol .101, 2015
6. Chengchen Hu, Hao Li, Yuming Jiang, Yu Cheng, Poul Heegaard, Deep Semantics Inspection over Big Network Data at Wire-Speed, **IEEE Networks**, in press, 2016

### **III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES**

1. SDN/NFV seminar, NTNU, Trondheim, Mar. 19, 2015
2. USENIX, NSDI 2015, Oakland, USA, May 4-6, 2015.
3. ACM/IEEE ANCS 2015, Oakland, USA, May 7-8, 2015.
4. SDN seminar, Dublin City University, Dublin, Aug. 25, 2015
5. Next generation networking workshop, University of Goettingen, Goettingen, r, Sep. 4, 2015

### **IV – RESEARCH EXCHANGE PROGRAMME (REP)**

I visited Fraunhofer SIT, Darmstadt, Germany from Aug. 26 - Sep. 2. My host was Michael Kasper, who is the Vice Head of Department Cyber Physical Systems Security at Fraunhofer SIT. During the visit, we organized several discussions and meetings with the researchers (Michael Kasper, Frank Gerd Weber, Rahamatullah Khondoker) at the institute, aiming at exchanging research ideas, proposing joint studies / publications, kick-starting ideas for project proposals related to the topics of SDN and security. I also gave a presentation at the institute titled as “flexibility vs. scalability in SDN data plane”.