Scientific Report

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Nationality	Cypriot
Name of the *Host Organisation*	INRIA Rennes-Bretagne Atlantique
First Name / family name of the *Scientific Coordinator*	Gerardo Rubino
Period of the fellowship	01/10/2012 to 30/09/2013

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

In this section, an overview of my research activities during the tenure of my ERCIM postdoctoral fellowship at INRIA Rennes (DIONYSOS team) is presented, organized by research theme.

Network clock synchronization[1]

The main focus of my work was on the area of network clock synchronization protocols, and in particular on the application of the Precision Time Protocol v2 (PTPv2) for delay-based network load estimation. PTPv2, specified in the IEEE 1588-2008 standard, is a protocol which aims at achieving sub-microsecond-level synchronization accuracy between network clocks, operating typically in a master-slave fashion.

A measurement-driven methodology was proposed, which allows for the derivation of empirical models of network delay as a function of the traffic load introduced in the path between two network clocks. Based on these models, an algorithm for real-time load estimation was built, which operates on path delay measurements inherently carried out during the operation of the PTPv2 protocol. To validate our approach, we performed extensive measurements on a testbed which included a hardware implementation of the protocol, "training" our estimation algorithm on synthetic workloads for various types of realistic traffic. For ease of integration, we implemented our load estimation algorithm as a service accessible over an HTTP API. As a use case, we designed and implemented in a popular open source media player a load-aware rate adaptation mechanism for DASH[2] video streaming. In our design, the client application periodically queries our load estimation service and adapts to network load variations by appropriately adjusting the requested video bitrate.

My work in this area then focused on the design of mechanisms to control the operation of PTP slave clocks. Typically, based on the exchange of timestamped PTPv2 messages, the slave calculates its phase and frequency offset from the master clock. A servo control mechanism uses the calculated offsets as a feedback signal and corrects the slave clock to accurately and smoothly track the master clock. As part of our ongoing work, we apply tools from control theory (a Kalman filter for clock state estimation and Proportional-Integral controllers or Linear-Quadratic Regulators for calculating adjustments) to improve synchronization accuracy for PTPv2 slave clocks and study how network conditions affect the robustness of the proposed control schemes.

Quality-of-Experience (QoE) for Cloud services[3]

In a different line of research, we studied the issue of the optimal selection among a set of available Service Level Agreements (SLAs) for the deployment of a multimedia service to the cloud, adopting a QoE-driven approach and operating under budget constraints.

[1] Joint work with Dr. Adlen Ksentini, Dr. Yassine Hadjadj-Aoul (INRIA Rennes), and Gilles Boime (Spectracom-Orolia France).
[2] Dynamic Adaptive Streaming over HTTP.
[3] Joint work with Dr. Gerardo Rubino (INRIA Rennes), Dr. Martin Varela, and Dr. Aggeliki Sgora (VTT Finland).

User-centric wireless networking

During my fellowship, I concluded a part of my research work that I had been carrying out before joining INRIA Rennes, which resulted in the submission of two journal articles. The focus was, on the one hand, on the security vs. performance trade-off for VoIP services over user-centric, community-based wireless access networks and, in another direction, on the security and robustness aspects of crowdsourced Wi-Fi topology discovery.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

Accepted

P.A. Frangoudis, A. Ksentini, Y. Hadjadj-Aoul, and G. Boime, "PTPv2-Based Network Load Estimation," Proc. 2013 International IEEE Symposium on Precision Clock Synchronization for Measurement, Control and Communication (ISPCS'13), Lemgo, Germany, 25-27 Sept. 2013.

Abstract—We make the case for utilizing the recently standardized IEEE 1588-2008 Precision Time Protocol (PTPv2) to achieve real-time, delay-based, network load estimation. We design and implement a load estimation service which builds upon our measurement-driven scheme for correlating path delay and network load, showing it to minimize estimation error to less than 11% for realistic traffic workloads. Such a service has multiple applications; we demonstrate how it can be utilized to achieve rate-adaptive delivery of multimedia content.

Submitted

Two articles, mainly based on my research on user-centric wireless networking which I carried out before joining INRIA, were prepared and submitted for journal publication.

In preparation

A demo paper where we demonstrate a prototype system for PTPv2-based network load estimation and its application to Dynamic Adaptive Streaming over HTTP has been prepared and is to be submitted.

A paper in the area of QoE for cloud-based services is also in preparation, and a paper submission based on early results from our work on PTP slave clock control mechanisms is planned.

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

- ERCIM ABCDE Seminar, Sophia-Antipolis, France, 24-26 Oct. 2012.
- 2013 Int'l IEEE Symposium on Precision Clock Synchronization for Measurement, Control and Communication (ISPCS'13), Lemgo, Germany, 25-27 Sept. 2013.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

REP Visit 1
Institute: Swedish Institute of Computer Science (SICS), Stockholm, Sweden
Date: 23/6/2013-1/7/2013

I visited the SICS Centre for Networked Systems, where I had meetings with members of the Computer Systems Laboratory (CSL), led by Dr. Sverker Janson and the Communication Networks and Systems Laboratory (NETS), led by Dr. Bengt Ahlgren, on research issues of mutual interest in the generic area of Computer Networks. Also, being hosted at the Mobile Life Centre premises, I had the chance to interact with researchers from various different disciplines. Furthermore, I took the time to visit the Laboratory for Communication Networks (LCN), led by Prof. Gunnar Karlsson, at the Royal Institute of Technology (KTH).

REP Visit 2
Institute: VTT Technical Research Centre, Oulu, Finland
Date: 26/8/2013-1/9/2013

During my visit at VTT, I collaborated with the Quality of Service Technologies team, led by Jukka-Pekka Laulajainen. Our discussions focused on QoE issues for Cloud-based applications.