PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Stefano Rosiello

XXXI Cycle

Training and Research Activities Report – First Year

Tutor: prof. Domenico Cotroneo

1. Information

PhD candidate: Stefano Rosiello
MS title: Computer Engineering – Univ. of Naples Federico II
PhD cycle: XXXI (year I)
Fellowship type: PhD student grant
Tutor: prof. Domenico Cotroneo

This report is on the training and activities of Stefano Rosiello during his first year of the PhD course "Information Technologies and Electrical Engineering" (ITEE), XXXI cycle, at University of Naples Federico II.

Stefano received his Master's degree cum laude in Computer Engineering in 2015 from the University of Naples Federico II, working on reliability evaluation for Network Function Virtualization infrastructures.

Stefano works within the DIETI DESSERT (Dependable System and Software Engineering Research Team) group, under the supervision of Prof. Domenico Cotroneo. His main research activity focuses on overload control in carrier-grade network function virtualization and cloud infrastructures. His research interests also include experimental reliability evaluation, dependability benchmarking and fault-injection testing.

2. Study and Training activities

In his first year, Stefano attended the following courses and seminars:

Courses

(1) Msc course: "Metodi Formali", prof. Valeria Vittorini Mar-2015 (3 CFU)
(2) Msc course: "Analisi e Prestazioni di Internet", prof. Antonio Pescapè Mar-2015 (6 CFU)
(3) Ad hoc course: "Scientific Writing", May-2015 (3 CFU)
(4) Ad hoc course: "Complementi di analisi funzionale", prof. A. Fiorenza, May-2015 (7 *CFU)
*(to be acquired during the second year)

Seminars

(1) Adversarial Testing of Protocol Implementations, Prof. Cristina Nita Notaru – (Northeastern University), 23 Feb 2016 (0.4 CFU)
(2) Programmable network conjugation, PhD Roberto Bifulco (Neclabs) 26 Feb 2016 (0.4 CFU)
(3) Netflow ed IPFix, dalla teoria alla pratica, Maurizio Molina, 11 Apr 2016 (0.8 CFU)
(4) Misure di qualità dell'accesso ad Internet – Misura Internet, Agcom – Fond. Ugo Bordoni, 9 May 2016 (0.8 CFU)
(5) Monitoraggio di qualità del servizio oltre gli indicatori standard: l'esperienza sulla rete mobile di Telecom Italia, Telecom Italia, 16 May 2016 (0.4 CFU)
(6) La protezione brevettuale – opportunità, procedure e casi di studio. Bogdan Bojoila, Michele Maremonti (European Patent Office), 30 Sep 2016 (0.5 CFU)

External courses

(1) PhD school: "Securing Critical Infrastructures 2016", Cortina d'Ampezzo, Italy 17-24 Jan 2016, organized by Prof. Roberto Baldoni (University of Rome, Sapienza) and Prof. Andrea Bondavalli (University of Florence). (7 CFU)

CS Summary

	year 1								year2	year3	
		1	2	3	4	5	6				
	Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	Estimated	Estimated	Check
Modules	20	0	7	0	3	0	9	**19**	15	0	30-70
Seminars	5	0	0,8	0,8	1,2	0	0,5	**3,3**	5	5	10-30
Research	35	10	2	9	6	10	1	**38**	40	55	80-140
	60	10	9,8	9,8	10	10	11	**60**	60	60	180

3. Research activity

Title: Overload Management in Network Function Virtualization

Description and study

(1) Motivation

Network services experience an overload condition when they work with traffic flows greater than their engineered capacity, causing the disruption of resources and/or unavailability of services. This condition violates SLAs, by potentially compromising customers' contracts [1]. Overload and congestion control has been a key research topic in Telecom network appliances [8]; most of proposed techniques are well assessed and are today part of networking industry standards and commercial products [2].

More recently, the **Network Function Virtualization** (**NFV**) [4] paradigm is rapidly changing telecom services, to cut costs and energy consumption, to improve manageability, and to reduce time-to-market. To pursue these objectives, we are witnessing a shift of Telecom network functions from hardware appliances to software, by leveraging on virtualization and cloud computing technologies [5].

In this new context, traditional overload control techniques are unable to provide the strict high-availability and performance requirements of carrier-grade Telecom services [7], because they assume that the system has a fixed, or, at least, predictable capacity in terms of amount of service requests that it can correctly handle. These techniques are not effective in a virtualized cloud environment [6] since the actual capacity is time-varying because of

- a dynamic amount of resources allocated to a service according to the cloud elasticity paradigm [9-11],
- contention on the physical resources (such as CPU, memory, storage and network) [12, 13],
- faults that can occur in any layer of the infrastructure [14, 15],

For these reasons, NFV requires additional solutions for mitigating overloads in the short-term (i.e., within few tens of seconds), by rejecting or dropping the traffic in excess with respect to the capacity of the network.

(2) Activity

During the first year, Stefano collaborates with **Huawei Technologies Co. Ltd.**, within an industrial research project with the aim to propose efficient methodologies and tools to detect and mitigate overload conditions of Network Function Virtualization systems.

Within his research group, firstly he studied how the overload phenomena affects the performance of NFV-oriented technologies. Towards this goal, he considered a virtualized IP Multimedia Subsystem (IMS) [16] (the Clearwater IMS Project) as a testbed, as suggested by his industrial partners. Within his research group, he conducted the following activities:

- **Characterization of NFV overload issues**

  The first phase of this task was to assess the metrics that are representative of overload conditions to reliably detect overload problems. To this purpose, we reproduced in the IMS testbed a wide range of possible scenarios causing overload (such as unpredictable increase in service demand, poor capacity planning, physical resource contention and hardware and software faults).

  The data traces obtained from the experiments helped us to identify criteria to detect the overload. We used part of the data to tune the algorithms and the other part to assess the detection coverage and its accuracy.

- **Identification of the NFV architectural points of action, detection and mitigation algorithms**

  From the study of the NFV framework [4], and the NFV use cases [5] we identified 3 point of action: (1) at VNF (node) level, (2) at NFV network (service) level and (3) at infrastructure level. However, in each of this level there are a different set of metrics that can be observed and controlled.

  In each of those points, we added an overload detector module and an overload mitigation module (both software components) and we assessed the performance of the different overload control solutions.

In the next year, Stefano will focus on the **overload management in distributed multi-tier software architectures**, on which complex NFV services are implemented. In those architectures, there are dynamic dependencies between the nodes of the system (e.g., the required resource is stored in a specific database node). Therefore, the load cannot be balanced equally among different nodes and this will cause more subtle overload scenarios.

(3) Other activities

During his first year, Stefano had the opportunity to review the following papers:

1. "JURY: Validating Controller Actions in Software-Defined Networks" – submitted to the 46th annual IEEE/IFIP International Conference on Dependable Systems and Network (DSN), 2016
2. "Assessing the Performance of Elastic Cloud Systems using Combinatorial Interaction Testing" – submitted to the 27th International Symposium on Software Reliability Engineering (ISSRE), 2016

4. Products

(1) Domenico Cotroneo, Roberto Natella, Stefano Rosiello – "NFV Throttle: An Overload Control Framework for Network Function Virtualization" – IEEE Transaction on Network and Service Management (**In submission**)

5. Conferences and Seminars

During his first year, he attended the winter school “Securing Critical Infrastructures” (Cortina D’Ampezzo, January 14-23, 2016) where he presented a work titled “cloud opportunities to discourage overload caused by DDoS attacks: an attack vs defence cost-based analysis”.

Moreover, he presented in a seminar titled “Capacity Management in NFV”, during the Ms.Sc. “Impianti di Elaborazione”, University of Naples Federico II.

6. Activity abroad

No activity abroad has been carried out during his first year.

7. Tutorship

During his first year, he has been MSc thesis co-advisor on topic about performance analysis of NFV-oriented IMS infrastructures (Giovanni Di Fiore).

References

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[3] J. Sherry, S. Hasan, C. Scott, A. Krishnamurthy, S. Ratnasamy, and V. Sekar, “Making middleboxes someone else’s problem,” in Proc. SIGCOMM, 2012, pp. 13–24.

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[6] NFV ISG, “Network Function Virtualisation Infrastructure Architecture - Overview,” Tech. Rep., 2014. [Online]. Available: http://docbox.etsi.org/ISG/NFV/Open/Latest\ Drafts/ nfv-inf001v036-InfrastructureOverview.pdf

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[13] L. Wang, R. A. Hosn and C. Tang, "Remediating Overload in Over-Subscribed Computing Environments," Cloud Computing (CLOUD), 2012 IEEE 5th International Conference on, Honolulu, HI, 2012, pp. 860-867.

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[15] D. Cotroneo et al., "Network Function Virtualization: Challenges and Directions for Reliability Assurance," Software Reliability Engineering Workshops (ISSREW), 2014 IEEE International Symposium on, Naples, 2014, pp. 37-42.

[16] Project Clearwater. Project Clearwater - IMS in the Cloud. http://www.projectclearwater.org.