Relazione Scientifica Finale sull’attività svolta nell’ambito dell’assegno di ricerca

Nominativo dell’assegnista di ricerca: Christian Quadri

Titolo dell’assegno di ricerca: Mobile Edge Computing and emerging network services

Specificare se si tratta di assegno di ricerca di tipo A o di tipo B: A

Docente referente: Gian Paolo Rossi

Durata del contratto da 01/08/2018 a 31/07/2020

Obiettivi della ricerca:
The research aims at designing and evaluating novel network services by leveraging both network virtualization and softwareisation paradigms which are driving the today’s transformation of the mobile network towards 5G and beyond. To pursue this goal, we have been focusing on three main research directions:

- **Behavioral analysis of the mobile users:** the activity leads to understand the spatio-temporal dynamics of the mobile users, e.g. mobility patterns, social interactions, social groups formation. This is an essential milestone to drive resources provisioning and allocation.
- **Study of emergent network solutions and technologies:** the next generation of mobile network leverages new technologies and paradigms, such as Fog Computing/Mobile Edge Computing (MEC), Software Defined Networking (SDN), Network Function Virtualization (NFV) and Network Slicing. My research in this field aims to provide solutions for the dynamic orchestration of the resources pursuing two goals: (i) optimal placement of virtualized resources in order to increase the Quality of Experience (QoE) and respecting the Service Level Agreement (SLA), and (ii) optimal utilization of the physical resources (CPU, Memory, I/O, and Bandwidth)
- **Design and evaluation of vertical services in a sliced network:** to analyze costs/benefits, Quality of Service (QoS) and Quality of Experience (QoE) by means of network emulator/simulator and testbed.

Risultati della ricerca intermedi e conclusivi:

**Behavioral analysis of the mobile users:**

- Analysis of the behavior of cohesive groups of mobile users in urban space. We have shown the strict bond between the on-phone interactions and the off-line interaction. In particular, the group of users built on top of the on-phone interactions are also very likely to meet each other in different locations of the city space. The results of this research are published in [1].
- Analysis of the behavior of single users moving in the city space. In particular, we focus on the non-routine places, that the user occasionally visits and we perform a comprehensive analysis of the user’s attitude to become explorer of the city’s space. This happens to be during leisure time and, unlikely frequently visited places, far from home and workplace. The results of this research are published in [4,7].
• Analysis of the social behavior of mobile users. We analyzed the mobility and the sociality of the mobile users to characterize ties in the ego-network of the users. We validated the Dunbar’s hypothesis and we found that distinct types of relationship (e.g. family members, colleagues, friends) lie in different Dunbar circles. The results of this research are published in [3].

Study of emergent network solutions and technologies
• We developed and evaluated an optimization model for Virtual Network Function (VNF) placement in a multi-slice scenario. We have performed an extensive analysis on the VNF placement algorithm showing that the multi-slice version outperforms the single slice one in terms of QoS parameters. The results of this research are published in [2].
• We are performing a preliminary study on the provisioning and managing of virtualized resources to support MEC services shared by multiple mobile users, e.g. video conference, online gaming, etc. which require stringent latency requirements. We are defining the offline optimization model to obtain an upper-bound of the QoE offered to the users. As a next step in this research, we will develop an online algorithm to manage the initial placement and the life-cycle of the shared services taking into account the users mobility and the network load.

Design and evaluation of vertical services in a sliced network
• This activity initiated during my internship at IMDEA Networks in Madrid where we studied the feasibility of a MEC assisted platooning control. The result of this research is a simulator for platooning that enabled us to show, through extensive simulations, that the MEC assisted platooning control is a viable, safe, effective and more scalable alternative to the traditional distributed V2V approach. The results of this research are reported in [8]
• The research is now extending the MEC controller to multiple platoons which are coordinated by a controller deployed in the MEC. The preliminary results show that it is possible to coordinate multiple platoons by guaranteeing the stability of single platoons. Besides, the proposed controller is flexible and scales in terms of RAN utilization.

Attività svolte:
• Teacher Assistant:
  o Reti di Calcolatori (bachelor course) 2019/2020
  o Reti wireless e Mobili (master course) 2018/2019 – 2019/2020
• Co-supervision of master thesis (completed):
  1. Giuseppe Carnà 867749 - “Architettura di Mobile Edge Computing a supporto di gruppi di utenti mobili”
  2. Andi Breshanaj 868274 – “Studio e analisi della mobilità di gruppi sociali in contesto urbano”
• Co-supervision of bachelor thesis (completed):
  3. Luca Leporini 871397 - “Caratterizzazione funzionale delle aree di una città mediante una piattaforma di geo-localizzazione”
  6. Ledia Prifti 893507- “Implementazione di scenari di Mobile Edge Computing con tecniche SDN”
  7. Andrea Minotti 828420 – “Analisi del protocollo di comunicazione IEEE 802.11p a supporto della mobilità di plontoni di veicoli”
  8. Matteo Carlo Giavarini 896141- “Studio e analisi delle prestazioni del protocollo 802.11p per la guida autonoma di platoon di veicoli”
Co-supervision of master thesis (on-going):
1. Francesca Bassi 921900 - "Migrazione di virtual network function in uno scenario di mobile EDGE computing."

Co-supervision of bachelor thesis (on-going):
1. Leonardo Menti 908947 - "Progettazione e sviluppo dell’orchestrazore dell’architettura ETSI MEC nel simulatore Omnet++"
2. Valerio Cislagli 909682 - "Sviluppo di un multi-platoon manager in ambiente di edge computing"

TCP member of the 8th International Workshop on Complex Networks and their Applications (Complex Networks 2019)
TCP member of the 7th International Workshop on Complex Networks and their Applications (Complex Networks 2018)
TPC member of IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM 2019)
Reviewer for IEEE Transaction on Wireless Communications
Reviewer for Elsevier Pervasive and Mobile Computing
Reviewer for the MDPI Electronics
Reviewer for the MDPI Symmetry
Reviewer for the MDPI Applied Science
Reviewer for the MDPI Future Internet
Reviewer for Scientific Reports
Guest Editor for MDPI - Future Internet - Special Issue "Selected papers from The 7th International Conference on Complex Networks and Their Applications"

Descrizione dell’attività di ricerca svolta all’estero:
Periodo: 1 June – 31 July and 1 September – 4 October 2019
Affiliazione: IMDEA Networks
Luogo: Avda. del Mar Mediterraneo, 22 - 28918 Leganes (Madrid) Spain
Research: Joint research on Mobile Edge Computing focused on the optimization of resources allocation at the edge of the mobile network

Prodotti della ricerca conseguiti:

Journals

Conference Proceedings:


7. M. L. Damiani, F. Hachem, C. Quadri, S. Gaito, “Location relevance and diversity in symbolic trajectories with application to telco data”, accepted for publication in the proceedings of 16th International Symposium on Spatial and Temporal Databases (SSTD), 2019

Submitted

8. C. Quadri, V. Mancuso, M. Ajmone Marsan, G. P. Rossi, “Platooning on the edge”, submitted to 23rd ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWiM 2020) — This paper is the result of the research internship at IMDEA Networks - Madrid

La presente relazione, non contiene dati sensibili e dati giudiziari di cui all’art. 4, comma 1, lettere d) ed e) del D.Lgs. 30.6.2003 n. 196. Si autorizza la pubblicazione della relazione annuale sul sito web del Dipartimento.

Firmato (In Stampatello) CHRISTIAN QUADRI

Data 07/07/2020

Il Responsabile Scientifico

(Firma)

L’ Assegnista di Ricerca

(Firma)