PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Stefania Zinno

XXX Cycle

Training and Research Activities Report – Second Year

Tutor: Giorgio Ventre - co-Tutor: Stefano Avallone

1. Information

My name is Stefania Zinno and I was awarded the master Science degree in "Ingegneria delle Telecomunicazioni" at University of Naples Federico II. I am a PhD Student in Information Technology and Electrical Engineering, XXX Cycle, Università degli Studi di Napoli Federico II. I completed the industrial master "SIRIO-FORM Servizi per l'Infrastruttura di Rete wIreless Oltre il 3G" held by CNIT - Consorzio Nazionale Interuniversitario per le Telecomunicazioni in partnership with VoiSmart srl and Seconda Università degli Studi di Napoli – Dipartimento di Ingegneria Industriale e dell'Informazione. I work under the supervision of Prof. Giorgio Ventre and Prof. Stefano Avallone.

2. Study and Training Activities

- ***Test and Diagnosis of Integrated Circuits*** - Alberto Bosio 2.4 CFU
- ***Hardware Security and Trust*** - Giorgio Di Natale - 2.4 CFU
- ***Model based pattern and base GUI testing*** - Ana Paiva - 1.6 CFU
- ***La sintesi sonora dell'ingegner Laurens Hammonds*** - Riccardo de Asmundis - 0.8 CFU
- ***Memory technology for Android based System*** - Romano - 0.40 CFU
- ***Predictable real time embedded control system*** - Giorgio Buttazzo - 1,2 CFU
- ***Security Operations in una Telco esperienze e riflessioni dal*** *campo* - Fabio Zamparelli - 0.40 CFU
- ***Perception Based Surround Sound Recording and Reproduction*** - Enzo De Sena - 0.2 CFU
- ***1st Workshop of the Project Cluster on Data Protection Security and Privacy in the Cloud*** - Valentina Casola - 1.2
- ***Programmable network conjunction*** - Roberto Bifulco - 0.4
- ***Speech technology at Trinity*** College - Dublin - Loredana Cerrato - 0.2
- ***Challenging real time measurement system for immersive life-size augmented environment*** - Giovanni Caturano - 0.5
- ***An overview on image forensics with emphasis on physics-based scene verification*** - Christian Riess - 0.20
- ***Internet: la dimensione immateriale dell'esistenza*** - Stefano Quintarelli - 0.40

B) MODULES:
- ***Scientific Writing*** - Chie Shin Fraser - 3 CFU
- ***The Entrepreneurial Analysis of Engineering Research Projects*** - Iandoli - 3 CFU
- ***SecureCI: Securing Critical Infrastructure*** - 6 CFU
- ***Communicating and disseminating your research work*** - Mansouri - 3 CFU

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TYPE	CFU	ACTIVITY	LECTURER	DATE
S	2,4	Test and Diagnosis of Integrated Circuits	Alberto Bosio	17/11/2016
S	2,4	Hardware Security and Trust	Giorgio Di Natale	19/11/2015
S	1,6	Model based pattern and base GUI testing	Ana Paiva	23/11/2015
S	0.8	La sintesi sonora dell'ingegner Laurens Hammonds	Riccardo de Asmundis	09/11/2015
S	0.40	Memory technology for Android based System	Romano	10/11/2015
S	1,2	Predictable real time embedded control system	Giorgio Buttazzo	16/11/2015
S	0.40	Security Operations in una Telco esperienze e riflessioni dal campo	Fabio Zamparelli	4/12/12015
M	6	SecureCI: Securing Critical Infrastructure		01/2016
S	0.20	Perception Based Surround Sound Recording and Reproduction	Enzo De Sena	22/02/2015
S	1.2	1st Workshop of the Project Cluster on Data ProtectionSecurity and Privacy in the Cloud	Valentina Casola	23/2/2016
S	0.40	Programmable network conjunction	Roberto Bifulco	26/02/2016
M	3	The Entrepreneurial Analysis of Engineering Research Projects	Iandoli	02/2016
S	0.20	Speech technology at Trinity College - Dublin	Loredana Cerrato	2/3/2016
M	3	Communicating and disseminating your research work	Mansouri	03/2016
S	0.50	Challenging real time measurement system for immersive life-size augmented environment	Giovanni Caturano	29/04/2016
S	0.20	An overview on image forensics with emphasis on physics-based scene verification	Christian Riess	18/05/206
S	0.40	Internet: la dimensione immateriale dell'esistenza	Stefano Quintarelli	19/05/206
M	3	Scientific Writing	Chie Shin Fraser	05/2016-06/2016

Student: Name Surname   Tutor: Name Surname   Cycle XXX
stefania.zinno@unina.it   giorgio.ventre@unina.it

	Credits year 1								Credits year 2								Credits year 3								Total	Check
	Estimated	bimonth 1	bimonth 2	bimonth 3	bimonth 4	bimonth 5	bimonth 6	Summary	Estimated	bimonth 1	bimonth 2	bimonth 3	bimonth 4	bimonth 5	bimonth 6	Summary	Estimated	bimonth 1	bimonth 2	bimonth 3	bimonth 4	bimonth 5	bimonth 6	Summary	Total	Check
Modules	20		2		3		12	17	15		9	3	3			15	21							0	32	30-70
Seminars	8				1,8		1,8	3,6	6	9,2	1,8	0,7	0,6			12	12							0	16	10-30
Research	32	10	8	10		10		38	39			10	10	10	10	40	30							0	78	80-140
	60	10	10	10	4,8	10	14	59	60	9,2	11	14	3,6	10	10	67	63	0	0	0	0	0	0	0	126	180

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3. Research Activity

A) Research Description

- On a Fair Coexistence of LTE and Wi-Fi in the Unlicensed Spectrum
To overcome the lack of spectrum resources the proposal of extending LTE (Long Term Evolution) to the readily available unlicensed spectrum is receiving much attention.

As LTE was not originally designed to encompass any mechanism for the sharing of a channel (as it assumes to operate alone on the licensed bands), solutions are being devised for allowing it to share the unlicensed spectrum with other wireless technologies.

Most proposals are based on one of the following mechanisms: *Listen-Before-Talk* (LBT) and the *Almost Blank Subframe* (ABS) techniques. In addition to those, other techniques will be presented that can be used in conjunction with the first two to further improve the way LTE can coexist as a good neighbour with Wi-Fi.

o *Listen-Before-Talk Mechanism*

Listen-Before-Talk (LBT) is a mechanism that, at its basis, consists in the assessment of the channel state before transmitting, mainly by means of detection of electromagnetic energy. Such a detection allows to decrease the collision probability with other devices' transmissions in the same frequencies. It is important to note that a form of LBT, loosely specified, is required both by the European and Japanese legislations in order to operate in the ISM (Industrial, Scientific and Medical) band; for that reason an LTE solution operating in such areas is bound to adopt the LBT approach.

LBT mechanisms are divided in different categories and adopt features like random back off procedures or a contention windows mechanism both fixed or dynamically setup. One of the most efficient out of these is called LBT CAT 4 and its features are well described.

o *Almost Blank Subframes*

In the time domain, when ABS is in place, data transmissions of the macro cell, e.g. a eNodeB, is restricted to happen only in certain sub-frames. Small cells, e.g. pico cells or femto cells, can therefore transmit in the remaining sub-frames (which are called ABSs) and experience very little interference. The interference is not null in such ABS because the main cell is still allowed to transmit for control and signal purposes.

In other words, LTE transmission are almost "blanked out" in certain periods of time giving birth to what is called a "duty cycle"; it is during the duty cycles that other networks, such as Wi-Fi are allowed to transmit. It is important to note that the basic ABS mechanism, as defined in LTE Release 10 does not perform any sensing of the channel whatsoever,

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therefore a solution employing merely ABS is not compatible with some jurisdictions, such as the European and Japanese.

In order to coordinate the scheduling of ABSs on a certain area by the involved cells, signalling messages related are exchanged through the *X2 interface*, i.e. a mandatory interface supplied by LTE cells for control and signalling purposes.

In addition to the LBT and ABS techniques, other proposals have had considerable attention in literature. Most of them can in fact be used in conjunction with LBT and ABS to further enhance the capability of LTE networks to behave as good neighbours with Wi-Fi networks: Transmit Power Control, Carrier selection, Automatic Gain Control and Minimum channel occupancy.

Many different standards were brought on the market in these years for LTE access in unlicensed bandwidth:

LTE-Unlicensed

The original proposal for LTE in the unlicensed spectrum has come from Qualcomm, which presented a working prototype of an LTE cell in the unlicensed band based on LTE Release 11 LTE PHY/MAC.

In 2014 the LTE-U Forum was created by Verizon in collaboration with Alcatel-Lucent, Ericsson, Samsung and QUALCOMM Technologies. The forum developed several standards with the aim of developing LTE potentiality in the unlicensed band. A multitude of technical specifications were produced regarding fair coexistence with Wi-Fi systems and good performances for LTE cells.

Licensed Assisted Access

LAA was recently presented by the 3rd Generation Partnership Project (3GPP). 3GPP is a consortium of enterprises and research entities that provides their members with a stable environment to produce a complete system specification covering cellular telecommunications networking technologies. 3GPP started the work on LTE in unlicensed bands with a workshop in June 2014, to which followed a formal study in September 2014.

MuLTEfire

MuLTEfire is the only LTE version able to work in the unlicensed spectrum without any simultaneous channel open in the licenced spectrum.

In other words, MuLTEfire is designed to operate in the unlicensed spectrum exclusively and to adopt similar spectrum sharing mechanisms similar to Wi-Fi to share the spectrum with other networks.

Gaining capacity in a band where Wi-Fi technology is widely used and guaranteeing

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fairness between systems is not an easy to address issue. Wi-Fi and LTE coexistence is analyzed and it is shown that LTE with no fair mechanism of coexistence isn't a good neighbour to Wi-Fi. Giving an overview of LTE and Wi- Fi MACs is noticeable why a fair coexistence isn't achievable without additional mechanisms. The centralized scheduling of LTE eNodeBs saturates all the channel resources while Wi-Fi Access Points refrain from transmission sensing the channel busy because of LTE transmissions.

- Measurements and Statistical Analysis of LTE Network Performance
Long Term Evolution (LTE) technology gives access to higher bandwidth and assures efficiency at network level for telecommunication operators, providing a reliable and continuous data traffic flow allowing transmission of extremely high bit-rate data streams. The use of statistical methods shows how standard expectations are too high with respect to real life users' experience. An analysis is carried out with reference to key parameters for radio optimization that are not defined in standards so that each vendor implements and evaluates them differently.

Results are collected with a smartphone-based measurement device during a car ride. The software AZQ suite is installed on the test device to this purpose.
The main focus was on network indicator strictly related to user's experience, therefore throughput was chosen. We tried to evaluate the relationship between KPI and network SINR. In particular, for the estimation of channel condition from a user prospective SINR was explored, since it is the most useful of all available parameters when dealing with real-case scenarios. The goal of this analysis is to understand how downlink throughput is affected by SINR. In the bottom figure the relationship between the SINR and downlink throughput at the physical layer for the Primary Component Carrier is shown.
One of the obtained results shows a proportional relationship SINR and throughput.
As shown, 10 Mbps throughput can be reached by a minimum SINR of -6.53 dB.
Under good channel conditions, a small increase in SINR can result in a great increase in throughput. It is interesting to notice that, in our experiment, a great increase in SINR is necessary to step up from 45 Mbps to 50 Mbps and beyond. This is easily explained by the implementation of higher rate modulation such (64QAM).
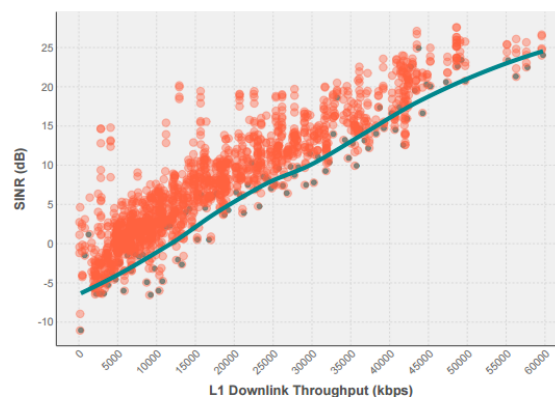
B) Collaborations:

1) Progetto per la Ricerca di Ateneo: *"Radio Optimization and Human Exposure Assessment for "LTE Advanced" Networks"*

Given the larger and larger spread expected for LTE mobile system, efforts are required to fully characterize its propagation characteristics, and more specifically how propagation impacts on signal strength, which in turn affects the system's quality of service (QoS) indicators and the human exposure to electromagnetic fields.

The proposed research project has two main purposes, both involving an extensive experimental activity and pertaining the physical layer (i.e., the propagation channel) and the radio optimization in LTE: on the *physical* side, it will focus on investigating the methodologies for the measurement of the human exposure to the electromagnetic field generated by the system in order to determine the one resulting in the lowest uncertainty level, also on evaluating the best approach to estimate the covered area by identifying which spatial interpolation algorithm best matches propagation. On the optimization side, we will use the assessment made to coverage shaping, load balancing procedure and interference reduction algorithms. Coverage and capacity requirements between busy hours and quiet periods of the day are also to take into account. In a cellular network coverage and capacity determine largely the grade and QoS of a given service on a given set of radio spectrum. To efficiently use network resources there is a need to configure o configure cell resources according to the actual radio conditions, propagation environment and traffic needs.

2) Nuovi Approcci per PrOteggere Le InFrastrUTtUre cRitiche da Attacchi cibernetici NAPOLI FUTURA - CINI Conosorzio Interuniversitario Nazionale per l'Informatica
Analisi delle prestazioni della piattaforma per la migrazione di risorse virtuali basata sul paradigma Software Defined Networks (SDN).

3) Nuovi Approcci per PrOteggere Le InFrastrUTtUre cRitiche da Attacchi cibernetici NAPOLI FUTURA - Conosorzio Interuniversitario Nazionale per l'Informatica
"Attività di ricerca scientifica necessarie alla definizione e realizzazione degli esperimenti, installazione della piattaforma per la migrazione di risorse virtuali basata sul paradigma Software Defined Networks (SDN), analisi dei risultati e validazione della piattaforma stessa. Le attività oggetto del presente Bando andranno sviluppate conformemente a quanto specificato dal Piano di Azione Coesione (PAC)."

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4) BORSA DI STUDIO ATTIVITÀ DI RICERCA CENTRO DI ATENEO FEDERICA WEBLEARNING** - **Centro di Ateneo per l'innovazione, la sperimentazione e la diffusione della didattica multimediale dell'università degli studi di Napoli Federico II
"Con riferimento al progetto "Percorsi formativi per la prevenzione della corruzione", nell'ambito dell'Accordo attuativo sottoscritto dal Centro Federica Web learning - Centro di Ateneo per l'innovazione, la sperimentazione e la diffusione della didattica multimediale dell'Università degli Studi di Napoli Federico II e dalla Scuola Nazionale dell'Amministrazione (SNA) per lo Sviluppo di modelli informatici finalizzati alla gestione di risorse didattiche attraverso formati innovativi e multimediali e la Pianificazione e organizzazione delle attività di help desk."

4. Products

- *"On a Fair Coexistence of LTE and Wi-Fi in the Unlicensed Spectrum"* - Stefania Zinno, Giovanni Di Stasi, Stefano Avallone, Giorgio Ventre
Preparing to be submitted to Elsevier Computer Communications

- *"Measurements and Statistical Analysis of LTE Network Performance"*- Stefano Avallone, Senior Member, IEEE, Nicola Pasquino, Senior Member, IEEE, Stefania Zinno and Domenico Casillo
Submitted to I2MTC 2017

5. Conference and Seminars

6. Activity Abroad

WWDC 16 - Worldwide Developers Conference di Apple
http://www.apple.com/newsroom/2016/06/hello--from-wwdc16.html

7. Tutorship

1. I am teaching assistant for the courses of: ***"Reti di Calcolatori I"***, Bachelor's degree in Computer Engineering, and ***"Computer Networks II"***, Master's degree in Computer Engineering, Scuola Politecnica delle Scienze di Base, Università degli

Studi di Napoli Federico II. In particular I wrote the lesson: *"Correlazione QoS - QoE"* for Computer Networks II.

2. I was involved in writing for **Federica Web Learning** *(*Centro di Ateneo per l'innovazione, la sperimentazione e la diffusione della didattica multimediale dell'università degli studi di Napoli Federico II) for the course **"Web e tecnologie digitali"** - Prof. Ventre

3. I was involved in *"***Laboratori territoriali *FabLabCond***"** promoted by *"Istituto superiore Grottaminarda I.T.I.S – I.T.C. – L.A- L.U- L.S.U."* together with CINI and Prof. Ventre

4. *I was a Correlator with* Prof. Pasquino and Prof. Ventre for the bachelor Thesis: *"Analisi della Letteratura sull'Esposizione ai Campi Elettromagnetici Generati da Dispositivi WI-FI"*

5. I was teaching three afternoon laboratories about Scratch programming for *"Web e Nuove Tecnologie" UniSob* - Prof. Ventre

6. I was teaching *"Didattica delle applicazioni dell'informatica"- Percorsi Abilitanti Speciali (PAS)* per il conseguimento dell'abilitazione all'insegnamento per le scuole secondarie Sessione suppletiva - Anno Accademico 2015/2016 - Classi aggregate A042-C300

7. Programma per il finanziamento della ricerca di Ateneo**:** *"Radio Optimization and Human Exposure Assessment for "LTE Advanced" Networks"* with Prof. Stefano Avallone and Prof. Nicola Pasquino.

8. **ELIS BE DIGITAL** - HACKATON BE DIGITAL 2°class.
9. **ELIS BE DIGITAL** – BEST IDEA CHALLENG FOR ENEL