



**PhD in Information Technology and Electrical Engineering**  
Università degli Studi di Napoli Federico II

**PhD Student: Daniele Lombardi**

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Cycle: XXXVII

**Training and Research Activities Report**

**Year: First**

*Daniele Lombardi*

**Tutor: prof.ssa Valentina Casola**

*Valentina Casola*

**Co-Tutor: -**

**Date: December 12, 2022**

# Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXVII

Author: Daniele Lombardi

## 1. Information:

- **PhD student:** Daniele Lombardi
- **DR number:** DR996240
- **Date of birth:** 19/07/89
- **Master Science degree:** Computer Engineering
- **University:** University of Naples “Federico II”
- **Doctoral Cycle:** XXXVII
- **Scholarship type:** (*no scholarship*)
- **Tutor:** prof.ssa Valentina Casola
- **Co-tutor:**

## 2. Study and training activities:

| Activity  | Type <sup>1</sup> | Hours | Credits | Dates                         | Organizer                   | Certificate <sup>2</sup> |
|---|-------------------|-------|---------|-------------------------------|-----------------------------|--------------------------|
| “Seeqc: the digital quantum computing company”  | Seminar           | 1     | 0.2     | 24.02.22                      | UniNa                       | N                        |
| “Can a Text-to-Speech Engine Generate Human Sentiments?”  | Seminar           | 1     | 0.2     | 28.02.22                      | UniNa                       | N                        |
| Activity 1 CINI-RFI<br>“Integration and testing of SCSC library for the control and sorting of communications between railway logic applications over Linux”<br>“Activity 1 CINI-RFI Drafting of “Manuale d’uso di SCSC e configurazione del sistema” | Research          | -     | 4.8     | 28.02.22                      | -                           | N                        |
| Virtualization technologies and their applications  | Course            |       | 5.0     | 17.01.2022<br>/<br>04.03.2022 | UniNa                       | Y                        |
| “Malware reverse engineering: foundations”  | Seminar           | 2     | 0.4     | 16.03.2022                    | University of Rome Sapienza | Y                        |
| “IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published from IEEE Editors”   | Seminar           | 1,5   | 0.3     | 30.03.2022                    | IEEE                        | Y                        |
| “Ciberconflitti e   | Seminar           | 2     | 0.4     | 05.04.2022                    | RUniPace                    | N                        |

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|  |          |     |     |            |                             |   |
|--|----------|-----|-----|------------|-----------------------------|---|
| minacce per la pace e la stabilità internazionale”   |          |     |     |            |                             |   |
| “Potential and challenges of next generation railway signaling systems: Moving Block and Virtual Coupling”                         | Seminar  | 1   | 0.2 | 06.04.2022 | UniNa                       | Y |
| “Springer Nature Author Workshop: Open Access and Transformative Agreements in Italy”  | Seminar  | 1,5 | 0.3 | 12.04.2022 | Springer Nature             | Y |
| “Explainable Natural Language Inference”   | Seminar  | 1,5 | 0.3 | 13.04.2022 | UniNa                       | N |
| “Avanzamento delle attività per la Piattaforma ACC”  | Research |     | 1,3 | 17.03.2022 | RFI                         | Y |
| “Research and experimentation activities on interrupt-latency measurement  | Research |     | 4.5 | 30.03.2022 |                             | N |
| “Statistical data analysis for science and engineering research”   | Course   |     | 4.0 | 10.06.2022 | UniNa                       | Y |
| “The role of the Italian National Cybersecurity Agency”  | Seminar  | 2   | 0.4 | 04.05.2022 | University of Rome Sapienza | Y |
| “International cooperation on cybercrime – The criminal justice perspective”   | Seminar  | 2   | 0.4 | 11.05.2022 | University of Rome Sapienza | Y |
| “Blockchain in Business”   | Seminar  | 1,5 | 0.3 | 26.05.2022 | UniNa                       | N |
| MAIA project - Cyber and physical threat intelligence solution, within an architecture for monitoring railway infrastructure.      | Research |     | 3   | 30.06.2022 |                             | N |
| Statistical analysis on the execution traces of a real time system, in the safety critical domain, in order to detect timing bugs. | Research |     | 2.4 | 30.06.2022 |                             | N |
| “Data Science for Patient Record Analysis”   | Course   |     | 3   | 27.07.2022 | UniNa                       | Y |
| MAIA project - Cyber and physical threat   | Research |     | 6   | 31.07.2022 |                             | N |

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|   |            |   |     |            |           |   |
|---|------------|---|-----|------------|-----------|---|
| intelligence solution, within an architecture for monitoring railway infrastructure.  |            |   |     |            |           |   |
| Summer School on Security Testing and Verification  | PhD School |   | 4.8 | 23.09.2022 | KU Leuven | Y |
| “PRIVACY-PRESERVING MACHINE LEARNING”   | Seminar    | 2 | 0.4 | 14.10.2022 | UniNa     | Y |
| MAIA project - Cyber and physical threat intelligence solution, within an architecture for monitoring railway infrastructure.<br><br>Measurement techniques in real time safety critical systems<br><br>Non-intrusive Testing techniques in real-time safety-critical systems | Research   |   | 4.6 | 31.10.2022 |           | N |
| MAIA project - Cyber and physical threat intelligence solution, within an architecture for monitoring railway infrastructure.<br><br>Measurement techniques in real time safety critical systems<br><br>Non-intrusive Testing techniques in real-time safety-critical systems | Research   |   | 6   | 05.12.2022 |           | N |

- 1) Courses, Seminar, Doctoral School, Research, Tutorship
- 2) Choose: Y or N

## 2.1. Study and training activities - credits earned

|           | Courses | Seminars | Research | Tutorship | Total |
|-----------|---------|----------|----------|-----------|-------|
| Bimonth 1 | 0       | 0        | 6        | 0         | 6     |
| Bimonth 2 | 0       | 0,4      | 4,8      | 0         | 5,2   |
| Bimonth 3 | 5       | 1,9      | 5,8      | 0         | 12,7  |
| Bimonth 4 | 4       | 1,1      | 5,4      | 0         | 10,5  |
| Bimonth 5 | 3       | 0        | 6        | 0         | 9     |

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|                 |           |            |             |          |             |
|-----------------|-----------|------------|-------------|----------|-------------|
| Bimonth 6       | 0         | 5,2        | 4,6         | 0        | 9,8         |
| <b>Total</b>    | <b>12</b> | <b>8,6</b> | <b>32,6</b> | <b>0</b> | <b>53,2</b> |
| <b>Expected</b> | <b>20</b> | <b>10</b>  | <b>30</b>   | <b>0</b> | <b>60</b>   |

### 3. Research activities:

Currently, my research activity focuses on three main themes: the design, development and testing of safety-critical applications in the railway domain; the predictability of real-time systems; cyber and physical threat intelligence. In the following, they will be discussed in detail.

#### The railway domain

Regarding the railway domain, I continued the activities started during my thesis period studying an innovative architecture for railway traffic signaling and control. In that respect, there are several projects in which I have taken part, all born from the collaboration between Rete Ferroviaria Italiana, a company of the Ferrovie dello Stato group, and DIETI of the University of Naples Federico II. In particular, I studied and applied model-based design for the development of applications in safety critical environment. As part of the same project, I applied model-based testing in accordance with the constraints of software development standards in safety-critical environment. In another project, I studied how to be able to non-intrusively test code in critical domains, applying this knowledge to the testing of complex systems, i.e., a hard-real-time operating system.

#### Predictability of real-time systems

Critical systems, i.e., those systems for which the failures or malfunctions can cause serious injuries, or even the death, to people, environmental harm or severe economic losses, are increasingly common in many application fields, e.g., heavy industries, transportations, or the medicine field, just to mention. Depending on the actual application field, the development of such systems may have to comply with strict regulations, e.g., the IEC 61511 for the process industry, or the CENELEC 50128 for the railway domain. The latter aim at guaranteeing that systems exhibit a given Safety Integrity Level (SIL), that, albeit inconsistently defined among all the functional safety standards, is usually defined in terms of probability of dangerous failure per hour. Besides, such systems have to behave correctly both from the functional and timing perspective. There may be several causes that undermine the predictability of these kinds of systems (software, such as an operating system scheduler, interrupt management; but also hardware, MMU utilization, cache memory, and so on). For this reason, I set out to devise a methodology for the temporal characterization of these kinds of systems and to develop an analytical model for describing measurements of interrupts latency.

#### Threat Intelligence

Threat Intelligence in the last decade has attracted considerable interest in both industry and the research world. Formally speaking, there is no unambiguous definition of what Threat Intelligence actually is. It can be defined as that set of threat information that has been aggregated, transformed, analyzed, interpreted, or enriched to provide the necessary context for decision-making processes. In this area of research, I was responsible for first gathering a state of the art on the topic, then analyzing the main

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technological solutions that support threat intelligence; finally, thanks to one of them, I developed a threat intelligence service for a railway-infrastructure monitoring-system.

## 4. Research products:

### The railway domain

Title: “Online Execution-Trace Analysis in Real-Time Systems to Detect Timing Bugs”

Type: Master Thesis (as Co-rapporteur)

Status: Released

Title: SCSC - Sistema Controllo e Smistamento delle Comunicazioni

Type: Software library

Status: Released

Description: This work is part of a joint project between the Dipartimento di Ingegneria Elettrica e delle Tecnologie dell’Informazione (DIETI) and the Rete Ferroviaria Italiana - Gruppo delle Ferrovie dello Stato S.p.a (RFI) which aims to design and build a prototype for a Unmanned Railway Vehicle (URV) for the monitoring and maintenance of the high-speed railway line. In particular, the research activity refers to the design and development of a prototype for a software library that abstracts all the communication mechanisms that the railway logic can use.

Title: Manuale d’uso e installazione della libreria SCSC

Type: User Manual

Status: Released

Description: This work is part of a joint project between the Dipartimento di Ingegneria Elettrica e delle Tecnologie dell’Informazione (DIETI) and the Rete Ferroviaria Italiana - Gruppo delle Ferrovie dello Stato S.p.a (RFI) which aims to design and build a prototype for a Unmanned Railway Vehicle (URV) for the monitoring and maintenance of the high-speed railway line. In particular, the research activity refers to the design and development of a prototype for a software library that abstracts all the communication mechanisms that the railway logic can use.

Title: Testing di MASK - Middleware tra Applicativi Software e Kernel

Type: Software tests

Status: Released

Description: This work is part of a joint project between the Dipartimento di Ingegneria Elettrica e delle Tecnologie dell’Informazione (DIETI), the Consorzio Interuniversitario Nazionale per l’Informatica (CINI) and the Rete Ferroviaria Italiana - Gruppo delle Ferrovie dello Stato S.p.a (RFI). which aims to test an ERTMS/ETCS prototype system on hybrid ARM/FPGA technology. The object in question is a software layer used in the context of railway control and signalling systems. Its purpose is to allow a set of railway application logic to carry out their tasks without having direct dependencies on the operating system and hardware on their processing node. The software has been designed to be distributed on the various and different systems in the railway context.

Title: Testing dei modelli dei Controllori d’ente

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Type: Models tests

Status: Released

Description: This work is part of a joint project between the Dipartimento di Ingegneria Elettrica e delle Tecnologie dell'Informazione (DIETI), the Consorzio Interuniversitario Nazionale per l'Informatica (CINI) and the Rete Ferroviaria Italiana - Gruppo delle Ferrovie dello Stato S.p.a (RFI). which aims to test an ERTMS/ETCS prototype system on ARM technology. The objects in question are software model, developed in MATLAB/Simulink environment, used in the context of railway control and signalling systems. Their purpose is to allow their purpose is to enable the control and monitoring functionality of the various entity controllers belonging to the railway signaling system.

Title: Testing di RFIOS

Type: Software tests

Status: Under development

Description: This work is part of a joint project between the Dipartimento di Ingegneria Elettrica e delle Tecnologie dell'Informazione (DIETI) and the Rete Ferroviaria Italiana - Gruppo delle Ferrovie dello Stato S.p.a (RFI). which aims to test an ERTMS/ETCS prototype system on hybrid ARM/FPGA technology. The object in question is a hard-real time operating system used in the context of railway control and signalling systems. Its purpose is to provide a set of real-time functionalities to railway logic applications. The software has been designed to be distributed on the various and different systems in the railway context.

## **Predictability of real-time systems**

Title: Behavioral characterization of real-time systems owing hybrid timing analysis

Type: Workshop article

Authors: S. Barone, V. Casola, S. Della Torca, D. Lombardi

Status: Under review

Abstract: The spread of computing-systems, especially the real-time embedded ones, is rapidly growing in the last years, since they find usage in numerous fields of application, including, but not limited to, industry process, transportation systems, as so forth. Indeed, in this kind of systems, precise time-constraints hold, and, thus, the tasks they perform do not only need to be correct from the functional perspective, but also they have to be accomplished before a deadline. From the latter perspective, it is relevant to characterize their timing behavior. This is usually done by exploiting either static or dynamic analysis techniques, which, respectively, leverage estimations based on either models of hardware and software, or on the execution of the actual system. On the other hand, hybrid approaches allow characterizing the timing behavior of a system by exploiting advantages of both previous methods and, simultaneously, avoiding their disadvantages. In this paper, we propose an automated hybrid approach that allows characterizing systems, without counterfeiting their temporal behavior, by resorting to instruction-level tracing. Also, such approach is context-sensitive and allows re-using some results obtained during the development of the system. We evaluate our approach while resorting to a real-time system as a case study, empirically proving that it allows for a faithful characterization of systems, in terms of worst-case execution time of their tasks.

Conference: Workshop on Next Generation Real-Time Embedded Systems @ HiPEAC Conference

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Title: Interrupts-latency measurement: an evaluation mode

Type: Journal article

Type: M. Barbareschi, S. Barone, V. Casola, D. Lombardi

Status: Still writing

Abstract: In the last few decades, the increasing adoption of computer systems for monitoring and control applications has fostered growing attention to real-time behavior, i.e. the property that ensures predictable reaction times to react on external events. In this perspective, performance of the interrupt management mechanisms are among the most relevant aspects to be considered. Therefore, the service-latency of interrupts is one of the metrics considered while assessing the predictability of such systems. To this purpose, there are different techniques to estimate it, including the use of on-board timers, oscilloscopes and logic analyzers, or even real-time tracers. Each of these techniques, however, is affected by some degrees of inaccuracy, and choosing one over the other have pros and cons. In this paper, we review methodologies for measuring interrupt-latency from the scientific literature and, for the first time, we define an analytical model that we exploit to figure out measurement errors committed. Finally, we present a case study whose purpose is to validate the proposed model.

Journal: Transactions on Embedded Computing Systems

Publisher: ACM

## Threat Intelligence

Title: MAIA – Threat Intelligence service

Type: Software platform

Status: Released

Description: This work is part of a joint project between several academic and industrial partners. Its purpose is the development and design of a platform for monitoring rail infrastructure, relying on a modular and scalable architecture. Specifically, within this project, my goal was to develop a cyber and physical threat intelligence service integrated within the entire architectural platform.

Title: “Cyber physical threat intelligence in critical domains”

Type: Thesis (as Co-rapporteur)

Status: Still writing

## 5. Conferences and seminars attended

*RFI – Industrial Workshop on “Piattaforme innovative SIL4 per ACC”, 17.03.2022 Afragola (NA)*

## 6. Activity abroad:

*Not yet.*

## 7. Tutorship

*Not yet.*