
**PhD in Information Technology and Electrical Engineering**

**Università degli Studi di Napoli Federico II**

# PhD Student: Flavio Cirillo

**XXXIII Cycle**

## Training and Research Activities Report – Second Year

**Tutor: Prof. Simon Pietro Romano**

# 1. Information

**Title:** Flavio Cirillo, Master Degree in Computer Engineering, from University of Naples "Federico II" in 2014
**Cycle:** Ph.D. student of the XXXIII Cycle of the ITEE Course, at the University of Naples "Federico II"
**Fellowship:** No Fellowship
**Tutor:** Prof. Simon Pietro Romano

# 2. Study and Training Activities

## Seminars

| Seminar | Lecturer | Date | Place | H | CFU |
|---|---|---|---|---|---|
| Automated Machine Learning via Hierarchical Planning | Dr. Felix Mohr, Paderborn University | 2019/01/11 | NEC Laboratories Europe, Heidelberg, Germany | 1 | 0.2 |
| Long-Term Protection of Integrity and Confidentiality: Security Foundations and New Constructions | Dr. Matthias Geihs, TU Darmstadt, Germany | 2019/03/07 | NEC Laboratories Europe, Heidelberg, Germany | 1 | 0.2 |
| Combining text and external knowledge for question answering | Todor Mihaylov, Heidelberg University | 2019/03/13 | NEC Laboratories Europe, Heidelberg, Germany | 1.5 | 0.3 |
| Designing thinking bootcamp. | Prof Dr. Falk Uebernickel, University St. Gallen, and Jennifer Hehn, IT Management Partner St. Gallen | 2019/03/14-2019/03/15 | NEC Laboratories Europe, Heidelberg, Germany | 8 | 1.6 |
| Convolutional Neural Networks for Protein Folding Prediction | Scott Burkholz, Flow Pharma, USA | 2019/03/21 | NEC Laboratories Europe, Heidelberg, Germany | 1.5 | 0.3 |
| Ad hoc, sensor, IoT, fog... - past, current and future research challenges of networking without (heavy) infrastructure | Prof. Damla Turgut, University of Central Florida | 2019/03/22 | NEC Laboratories Europe, Heidelberg, Germany | 1 | 0.2 |
| Apply AI in your field of choice for fun and profit | Prof. Lotzi Boloni, University of Central Florida | 2019/03/22 | NEC Laboratories Europe, Heidelberg, | 1 | 0.2 |

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| | | | Germany | | |
| Tutorial: Quantum Annealing & D-wave | Akira Kon, Dr. Ryoji Miyazaki, Dr. Yuki Susa. NEC Central Research Laboratories, Tokyo, Japan | 2019/03/29 | NEC Laboratories Europe, Heidelberg, Germany | 2 | 0.4 |
| 1st Design Thinking Practice | Tobias Jöst, SAP, Germany; Detlef Straeten, NEC Laboratories Europe, Heidelberg, Germany. | 2019/05/09 | NEC Laboratories Europe, Heidelberg, Germany | 2.5 | 0.5 |
| OPIEC: The Open Information Extraction Corpus | Kiril Gashteovski, Uni Mannheim, Germany | 2019/06/05 | NEC Laboratories Europe, Heidelberg, Germany | 1 | 0.2 |
| 2nd Design Thinking Practice | Dr. Niels Feldmann, Karlsruhe Institut for Technologies, Germany; Detlef Straeten, NEC Laboratories Europe, Heidelberg, Germany. | 2019/07/05 | NEC Laboratories Europe, Heidelberg, Germany | 2.5 | 0.5 |
| Exploring and Exploiting Quantum Computing for Optimization and Machine Learning | Dr. Abishek Awasthi, University of Applied Sciences Zittau/Görlitz | 2019/07/17 | NEC Laboratories Europe, Heidelberg, Germany | 1 | 0.2 |
| A city-scale sensing infrastructure using the roaming edge | Prof. Suman Banerjee, University of Wisconsin-Madison, USA. | 2019/08/21 | NEC Laboratories Europe, Heidelberg, Germany | 1 | 0.2 |
| 4th Design Thinking Practice | Jörg Holzschuh, 'IBM Garage'; Detlef Straeten, NEC Laboratories Europe, Heidelberg, Germany | 2019/09/26 | NEC Laboratories Europe, Heidelberg, Germany | 2.5 | 0.5 |
| Autonomous systems | Prof. Joseph Sifakis, Verimag, | 2019/09/27 | NEC Laboratories Europe, | 1 | 0.2 |

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| | France | | Heidelberg, Germany | | |
| Theoretical and Practical Guide to Proposal Writing of H2020 R&I Projects | Dr. Robert Carroll, European Fund Management Consulting – EFMC | 2019/11/052019/11/06 | NEC Laboratories Europe, Heidelberg, Germany | 6 | 1.2 |
| Get to the Point! (Speaking, writing and presenting concisely and clearly) | Dr. Jillian Anderton, Haufe Akademie | 2019/11/072019/11/08 | NEC Laboratories Europe, Heidelberg, Germany | 8 | 1.6 |
| 6st Design Thinking Practice | Felix Kirschstein, SRH Gründer-Institut | 2019/11/22 | NEC Laboratories Europe, Heidelberg, Germany | 2 | 0.4 |
| NEC SX-Aurora Seminar | Nicolas Weber, NEC Laboratories Europe | 2019/12/11 | NEC Laboratories Europe, Heidelberg, Germany | 2 | 0.4 |
| Efficient 2-Party Protocols for Tree Classifiers | Dr. Anselme Tueno, SAP Security Research in Karlsruhe, Germany | 2019/12/12 | NEC Laboratories Europe, Heidelberg, Germany | 1 | 0.2 |

| | Credits year 1 | | | | | | | | Credits year 2 | | | | | | | | Credits year 3 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | | | 1 | 2 | 3 | 4 | 5 | 6 | | | 1 | 2 | 3 | 4 | 5 | 6 | | | |
| | Estimated | bimonth | bimonth | bimonth | bimonth | bimonth | bimonth | Summary | Estimated | bimonth | bimonth | bimonth | bimonth | bimonth | bimonth | Summary | Estimated | bimonth | bimonth | bimonth | bimonth | bimonth | bimonth | Summary | Total | Check |
| Modules | 15 | | | | | 6 | 6 | 12 | 15 | | | | | | | 0 | 14 | | | | | | | 0 | 12 | 30-70 |
| Seminars | 3 | 0,6 | 0,3 | 0,2 | 1,6 | | | 2,7 | 5 | 0,2 | 3,2 | 0,7 | 0,9 | 0,7 | 3,8 | 9,5 | 5 | | | | | | | 0 | 12,2 | 10-30 |
| Research | 42 | 4 | 4 | 10 | 7 | 13 | 8 | 46 | 40 | 10,5 | 6 | 9 | 6,5 | 11,5 | 6,5 | 50 | 41 | | | | | | | 0 | 96 | 80-140 |
| | 60 | 4,6 | 4,3 | 10,2 | 8,6 | 19 | 14 | 60,7 | 60 | 10,7 | 9,2 | 9,7 | 7,4 | 12,2 | 10,3 | 59,5 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 120 | 180 |

During the second year of PhD I planned to participate to at least two summer schools in order to catch up with the missing courses credits. This was not possible due to work duties I work full-time at NEC Laboratories Europe, Germany). I plan to cover the missing credits during the 3rd year.

## 3. Research Activities

### De-centralization of IoT Platforms: Federation, Interoperability, Scalability, Security, Privacy

Internet-of-Things (IoT) has entered all the fields where data are produced and processed. IoT benefits has been extensively acknowledged by the many real application deployments, e.g. in smart cities. The developments of those applications usually happen as standalone activities resulting in IoT segments fragmentation. Allowing coordination and cooperation among IoT systems is fundamental to build “smarter” IoT services toward a hyper-connected IoT. Significant efforts have been devoted to IoT system integration, recurrently resulting into big centralized infrastructures. Such an approach often stumbles upon the reluctance of IoT system owners to lose the dominion over data. During this second year research, I targeted multiple aspects in order to enable the IoT data sharing using a de-centralized approach: 1) privacy-preserving discoverability, 2) data usage control and secondary usage control, 3) data analytics cloud-to-cloud and clout-to-edge orchestration, 4) standards and semantics,

## Privacy-preserving discoverability

To enable the mutual discoverability of data among independent IoT platforms it is necessary that a knowledge graph is shared among parties. This graph contains the description of the data together with the pointer to the providing party. This graph is maintained by the administrators of each IoT system by the means of registration of data availability. On the one hand, keeping registrations that are too much generic (for example only the list of reference providers) into the registry would produce unnecessary requests to providers since they will be always contacted mostly for data not available on their side. On the other hand, having a too detailed description of the data (e.g. sensorId, exact sensor location, name of sensor’s maintainer) would disclose information which is sensitive as much as actual data.

If such registrations are made by human administrators, making detailed but privacy-preserving registration might require a lot of expertise for each deployment amend but also would induce latency on an effective usage of the sources.

In addition, the IoT providers need to specify the access policies which are used by the Policy Decision Point for taking decisions that are applied by the Policy Enforcement Points. Without these policies the default policy is applied that usually is very conservative (in order to avoid unsecured protection), which means that without a specific policy the access to data is not allowed, thus impeding the IoT systems federation. Also the declaration of these policies is under responsibilities of the administrators.

As a sort of glue between the IoT systems I have designed the IoT Registrar. It makes availability registration to discovery components and access policies update to security components on behalf of human administrators. As discussed before, a registration to the discovery is required in order to allow automatic brokering of messages. The IoT registrar, which subscribes for information, and automatically synthesizes registration (or updates old ones) when necessary, solve this problem. In addition the IoT registrar might allow the specification of directives for correctly aggregating information, thus preserving privacy. For example, it could be instructed to registers sensors only by type (hence if a second sensors for the same type appears, no changes are made to the registrations set) and by loose geographical area (for example, to register the location is used not the (lat;long) pair but rather the nearest municipality name). In addition the registrar is also dynamically populating the Policy Decision Point with policies which otherwise would never allow the new data available to be accessed.

As solution for distributing the knowledge graph among parties, it was used blockchain technology (based on Hyperledger Fabric) to implement a secure, trusted and immutable communication channel for federation access control rules propagation and data announcement.

**Collaborations:**

- Prof. Simon Pietro Romano, University of Naples “Federico II”

- Nicola Capuano, , University of Naples “Federico II”
- Dr. Ernoe Kovacs, NEC Laboratories Europe, Germany

### Data usage control and secondary usage control

A step forward to the data access control is the data usage control that regulates how the data can be used after they have been released. I worked on a design of a data usage control system. The approach adopted started from the definition of a use case on the topic of Smart City and IoT. In particular it was identified a multi-stakeholders and multi-domains use case. The scenario is a smart city where independent organizations own their data and IoT systems, such as homeland security with surveillance cameras, public transportation company with in-vehicle sensors, and tourist operators with app installed on mobile phones. From such use case a set of data usage policy examples are defined: e.g., secrecy (e.g., data can be used only as input to data analytics), data anonymization, and fenced data that requires data not to leave a computer network fence. A system is designed to enforce each of the example policies. As complementary to the control on the usage of the data, it is necessary for the original data owner to control the distribution and usage of the processed data: secondary usage control.

I have designed a system using the NEC FogFlow framework to orchestrate the runtime execution environment, and to manage the secured data flow.

**Collaborations:**

- Prof. Simon Pietro Romano, University of Naples “Federico II”
- Dr. Bin Cheng, NEC Laboratories Europe, Germany,

### Standards and semantics

Many general and specific-purpose IoT platforms are already available. One of the most prominent open source frameworks for building IoT platforms in the European scenario is FIWARE, which is transitioning from a research to a commercial level. One of the strength points of FIWARE is that is continually evolving keeping pace of new technologies, thanks to the contribution given by a wide community of researchers and industries. FIWARE adopt the open standard OMA NGSI that is lately moving towards handling linked graph of things. ETSI NGSI-LD is the new version of the standard and implementations of it are already available, such as Scorpio Broker. I have integrated data from six cities in Europe within one instance of the Scorpio Broker. More than 90000 entities from Milan, Helsinki, Carouge, Murcia, Porto, and Santander are made available through the new API specified by ETSI CIM.

On top of this, I have also developed a first application based on NGSI-LD. This application is a graphical interface to visualize data from different smart cities in Europe. The data is federated in multiple NGSI-LD Scorpio brokers, each handling data from different deployments. The cities involved are all the six cities plus to data coming from autonomous driving testbeds. The graphical interface has been demonstrated to the European Commission within the AutoPilot EU project review.

As further activities, I had the opportunity to directly collaborate with the above mentioned cities together with other cities (Antwerp, Manchester, Eindhoven) within the scope of the EU project SynchroniCity. I have mainly led the task for developing city services based on IoT. Given the data integrated with the FIWARE standards and API. The target is to adopt a collaborative methodology to share efforts towards the creation of a common ecosystem for the development of smart city services. The design evolves around the concept of "atomic services" that implements a single functional block to be composed for full-fledged smart city services. In this manner, expertise and know-how can be re-used and the effort shared. The final results of this activity extended further covering 35 city services in 27 cities between Europe and South Korea. We

have identified 15 atomic services addressing smart city challenges in data analytics, data evaluation, data integration, data validation, and visualization. 38 instances of the atomic services are already operational in several smart city services.

**Collaborations:**

- Dr. David Gomez Fernandez, ATOS, Spain
- Jose Gato, ATOS, Spain
- Dr. Luis Diez, University of Cantabria, Spain
- Dr. Ignacio Elicegui Maestro, University of Cantabria, Spain

### Contribution to the research community

- Serve as TPC member for IEEE Sensors Conference
- Serve as reviewer for IEEE WF-IoT Conference
- Serve as reviewer for IEEE Access journal
- Serve as reviewer for MDPI Smart Cities Journal
- Serve as reviewer for IEEE IoT Journal
- Serve as reviewer for MDPI Sensors Journal
- Serve as reviewer for Elsevier Evise Computer Networks Journal
- Serve as reviewer for IEEE IoT Magazine
- Serve as reviewer for IEEE Transactions on Industrial Informatics

## 4. Products

### Publications

#### Published

- [Journal] G. Solmaz, F-J. Wu, **F. Cirillo**, E. Kovacs, J.R. Santana, L. Sánchez, P. Sotres and L. Munoz. "*Towards Understanding Crowd Mobility in Smart Cities through Internet of Things*". IEEE Communications Magazine.
- [Journal] **F. Cirillo**, F-J. Wu, G. Solmaz and E. Kovacs, *"Embracing the Future Internet of Things*", MDPI Sensors Journal
- [Conference] **F. Cirillo**, D. Straeten, D. Gomez, J. Gato, L. Diez, I. Elicegui Maestro, R. Akhavan, "*Atomic Services: sustainable ecosystem of smart city services through pan-European collaboration*", IEEE Global IoT Summit 2019. Aarhus, Denmark.
- [Journal] L. Zanzi, **F. Cirillo**, S. Mangiante, V. Sciancalepore, F. Giust, X Costa-Perez and G. Klas, "*Evolving Multi-Access Edge Computing to support enhanced IoT deployments*", IEEE Communications Standards Magazine
- [Journal] **F. Cirillo**, E. L. Berz, G. Solmaz, M. Bauer and E. Kovacs. "*A Standard-based Open Source IoT Platform: FIWARE*", IEEE Internet of Things Magazine (IoTM)
- [Conference] **F. Cirillo**, Nicola Capuano, Ernoe Kovacs, Simon Pietro Romano. *LIoTS: League of IoT Sovereignties. A Scalable-approach for a Transparent Privacy-safe Federation of Secured IoT Platforms*, IEEE LCN 2019, Osnabrück, Germany

#### Submitted (under review)

- [Journal] **F. Cirillo**, David Gomez, Luis Diez, Ignacio Elicegui Maestro, Thomas Barrie Juel Gilbert, Reza Akhavan, *Smart City IoT Services Creation through Large Scale Collaboration*, IEEE IoT Journal.

### Demonstrations

- [Booth Demo at Conference] **F. Cirillo,** M. Fadel-Agerich. Smart City Magnifier: Smart City Solutions on FIWARE-based IoT Platform, At 5th IEEE World Forum on Internet of Things (WF-IoT) Conference, Limerick, Ireland
- [Conference Demo] Bin Cheng, Gürkan Solmaz and **F. Cirillo**. Intent-based Fog Computing with FogFlow. At at 44th IEEE Conference on Local Computer Network (LCN), Osnabrück, Germany
- [Booth Demo at Conference] **F. Cirillo,** B. Hebgen, and M. Bauer. Federating European Large Scale Pilots, At 5th EU Project Autopilot review, Bruxelles, Belgium

## Patents

### Filed

- US 16/384,989, **F. Cirillo**, Method and System for an Internet of Things Platform. Privacy-preserving IoT data availability announcement and regulating method for federating IoT platforms.
- US 16/699,161, J. Fuerst, **F. Cirillo**, M. Fadel Argerich, Automated Control Through a Traffic Model. Method and System for a City Mobility Benchmark Model

# 5. Conferences and Seminars

### Attended Conferences, Seminars and Events

| Event | Date | Place |
|---|---|---|
| SynchroniCity Bootcamp for smart cities pilots | 2019/02/06-07 | London, UK |
| Workshop oneM2M and Industrie 4.0 | 2019/02/12 | Frankfurt, Germany |
| **3rd IEEE Global IoT Summit (GIoTS)** | 2019/06/17-21 | Aarhus, Denmark |
| IoT Week 2019 | 2019/06/18-19 | Aarhus, Denmark |
| International Data Space summit 2019 | 2019/06/25-26 | Bonn, Germany |
| 44th IEEE Conference on Local Computer Network (LCN) | 2019/10/13-17 | Osnabrück, Germany |
| SynchroniCity Scaling Up | 2019/10/02-03 | Milan, Italy |

### Presentations

| Presentation | Event | Date | Place |
|---|---|---|---|

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|---|---|---|---|
| F. Cirillo, D. Straeten, D. Gomez, J. Gato, L. Diez, I. Elicegui Maestro, R. Akhavan, "Atomic Services: sustainable ecosystem of smart city services through pan-European collaboration" | IEEE Global IoT Summit 2019 | 2019/06/19 | Aarhus, Denmark |
| F. Cirillo, Nicola Capuano, Ernoe Kovacs, Simon Pietro Romano. LIoTS: League of IoT Sovereignties. "A Scalable-approach for a Transparent Privacy-safe Federation of Secured IoT Platforms." [Poster] | IEEE LCN 2019 | 2019/10/16 | Osnabrück, Germany |
| Bin Cheng, Gürkan Solmaz and F. Cirillo. "Intent-based Fog Computing with FogFlow." [Demo] | IEEE LCN 2019 | 2019/10/15 | Osnabrück, Germany |

## 6. Activities abroad

I have spent the whole 2019, corresponding to my second year of PhD, at the NEC Laboratories Europe, Heidelberg Germany.

## 7. Tutorship

I have tutored a Master degree student to develop the project for his Master thesis.