



SEMANTIC

end-to-end Slicing and data-drivEn autoMAtion of Next generation cellular neTworks with moblle edge Clouds

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WP5 – Training

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Executive summary

This report summarizes the training activities, including feedback from early stage researchers (ESRs) and involved experts from the third year of activities. It reports on the School 5 and 6.

Table of Contents

Executive summary	3
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1	Introduction.....	5
2	School 5 and 6.....	5
2.1	Agenda School 5.....	6
2.2	Agenda School 6.....	8
2.3	Survey results.....	11
3	Conclusions.....	11
4	References.....	11

List of Tables and Figures

Table 1, page 5: Planned training activities within SEMANTIC.

Figure 1, page 12: Overview of the feedback on School 5.

Figure 2, page 12: Overview of the feedback on School 6.

1 Introduction

Work package 5 (WP5) in SEMANTIC is responsible for planning, organizing and executing the training events, schools and courses of the project. This report summarizes the training activities, including feedback from the early stage researchers (ESRs) and involved experts from the third year of activities.

The planned training activities within SEMANTIC are as in Table 1.

Table 1. Planned training activities within SEMANTIC.

	Main Training Events & Conferences	ECTS	Lead Partner	Month
1	School 1: 5G architectures, enabling technologies, vertical industries and KPIs	no	NOKIA (ind)	M12→M14
2	School 2: E2e validation of 5G networks: key analytical, prediction, simulation, experimental tools	no	EUR (ac)	M12→M14
3	First SEMANTIC Industrial Dissemination Day	no	TLN (ind)	M13→ M32
4	Course 1: Intellectual skills, scientific writing and research integrity	no	UOA (ac)	M14→ M18
5	Course 2: Team skills, leadership, multi-cultural awareness and gender issues	no	PDT (ac)	M14→M18
6	First Workshop	no	CLM (ac)	M20→M21
7	School 3: PHY layer techniques and design principles in 5G New Radio	no	CLM (ac)	M20→M25
8	School 4: MEC-empowered service provisioning and integration in 5G networks	no	FOG (ind)	M20→M25
9	School 5: Emerging models and trends for dynamic network slicing and resource virtualization	no	CTTC (ac)	M24→M29
10	School 6: Leveraging data analysis and machine learning for network management and automation	no	TLN (ind)	M24→M29
11	Course 3: Influence, outreach and communication skills	no	IQU (ind)	M28→M41
12	Course 4: IRP management and standardization	no	NOKIA (ind)	M28→M41
13	Second SEMANTIC Industrial Dissemination Day	no	NI (ind)	M32→M42
14	Second Workshop	no	EUR (ac)	M34
15	Course 5: Fundraising, Strategic Management and Entrepreneurship	no	TLN (ind)	M38
16	Final Conference	no	CTTC (ac)	M42→M48
17	Plenary Meetings	no	CTTC (ac)	3 per year

In Chapter 2 we report on the third and fourth schools, School 5 “Emerging models and trends for dynamic network slicing and resource virtualization” and School 6 “Leveraging data analysis and machine learning for network management and automation”.

All activities were held online, due to remaining pandemic restrictions, and the content of SEMANTIC Schools and Courses (slides, presentations, photos, etc.) are available to the ESRs in the SEMANTIC cloud.

2 School 5 and 6

School 5 “Emerging models and trends for dynamic network slicing and resource virtualization” and School 6 “Leveraging data analysis and machine learning for network management and

automation” were composed of 18 speeches by 13 different speakers over 2+2 days during the period June 15–16 and June 20–21, 2022 for School 6 and School 5, respectively.

2.1 Agenda School 5



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School 5: “Emerging models and trends for dynamic network slicing and resource virtualization”

From the 20th to the 21th of June 2022*

1st Day – 20th June 2022

Time	Speaker	Title	Syllabus
09:15-10:30	Engin Zeydan and Josep Mangués (CTTC)	Recent Advances in Data Engineering for Networking (Part I)	<ul style="list-style-type: none"> Motivation and scope. Data engineering and network automation relation. Overview of the data engineering ecosystem (Data connection, Data ingestion, analysis and processing frameworks, monitoring and visualization). Data orchestration and management
10:30-11:00	Coffee Break		
11:00-12:30	Engin Zeydan and Josep Mangués (CTTC)	Recent Advances in Data Engineering for Networking (Part II)	<ul style="list-style-type: none"> Recent Developments in Network Management and Orchestration (Virtualization, 5G, SDN/NFV and IoT) and their relationship with data engineering. Two Example Demonstrations: <ol style="list-style-type: none"> Log Management in NFV Service Orchestration AI/ML-driven scaling of Digital Twin Service in 5G Growth Research Challenges and Future Aspects for data engineering for networking
12:30-13:30	Lunch Break		
13:30-15:00	Anestis Dalgkitis (Iquadrat)	Automation of 5G and beyond network orchestration with machine learning	<ul style="list-style-type: none"> Motivation. The need for orchestration & management automation. Intelligent SDN-NFV orchestration in recent literature. SCHEMA: Service CHain Elastic MAnagement with DRL Demonstration Challenges & future work
15:00-15:30	Coffee Break		
15:30-17:00	Luis A. Garrido (Iquadrat)	Automation of 5G and beyond network orchestration with machine learning (Part II)	<ul style="list-style-type: none"> Network Orchestration and Machine Learning: State-of-the-art Forecasting as means for orchestration in 5G and Beyond-5G networks. Leveraging Data Analytics and Machine Learning for Zero-Touch Management Current Challenges of Machine Learning and Future Problems

* All times are in CEST



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2nd Day – 21th June 2022

Time	Speaker	Tentative Title	Syllabus
09:15-10:30	Hossein Fotouhi (Mälardalens University, Sweden)	Mobility Management Solutions: from 5G to IoT networks	<ul style="list-style-type: none"> Mobility management is the process of handling mobile devices while providing quality of service requirements. This process is one of the most challenging issues in mobile networks. It has been conventionally proposed for Cellular networks, and then expanded to other wireless networks, such as Internet of Things networks with low-power radios. In this talk, we will address solutions from the past to the future, when applying different wireless networks.
	Moris Behnam (Mälardalens University, Sweden)	Virtualization Techniques for industrial systems	<ul style="list-style-type: none"> Resource virtualization is an essential technology of cloud computing and IoT. In this talk we will cover the virtualization in OS and communication levels in connection with industrial systems requirements. In addition we will show how virtualization is used in different technologies including 5G.
10:30-11:00	Coffee Break		
11:00-12:30	Moris Behnam (Mälardalens University, Sweden)	Virtualization Techniques for industrial systems	<ul style="list-style-type: none"> CONT. Resource virtualization is an essential technology of cloud computing and IoT.
	Tiberiu Seceleanu (Mälardalens University, Sweden)	Dynamic and Robust Distributed (Control) Systems – A Research Approach	<ul style="list-style-type: none"> The presentation describes an approach to build and maintain distributed systems – with a focus on control systems. It employs both machine learning and formal verification techniques, targeting the creation of a scalable and resilient infrastructure, setting also solid grounds for autonomous operations. The main focus of the approach is the optimality of the resulting system implementation and the correctness of the operations with respect to overall system requirements and constraints. The approach successfully “marries” service-based, model-based, self-healing and network-centric concepts towards improving design time and ease of deployment, providing dynamicity during operations.
12:30-13:30	Lunch Break		
13:30-15:00	Adlen Ksentini (EURECOM)	Zero-touch network management in B5G	<ul style="list-style-type: none"> 6G network architecture and vision Emerging challenges to achieve zero-touch management and orchestration. Review AI/ML solutions applied to orchestration and management issues considering different technological domains.
15:00-15:30	Coffee Break		
15:30-17:00	Andrés García Saavedra (NEC)	O-RAN and RAN virtualization	<ul style="list-style-type: none"> Summary of O-RAN Nuberu: a reliable O-DU design suitable for virtualization platforms EdgeBol: O-RAN RIC Bayesian learning algorithms to increase energy efficiency.

2.2 Agenda School 6



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School 6: “Leveraging data analysis and machine learning for network management and automation”

From the 15th to the 16th of June 2022*

1st Day – 15th June 2022

Time	Speaker	Tentative Title	Syllabus
09:00-10:30	Pavlos Sermpezis	Data science for network monitoring: challenges, practical problems, and potential solutions	Data science and ML/AI have been a success story in many domains. However, in practical operations in communication networks, applying off-the-shelf methods and algorithms may have several challenges. This talk will provide an overview of challenges in applying data science and ML/AI methods for networking, in general, and further focus on network monitoring/measurements use cases. From practical challenges in the collection, cleaning, and aggregation of data from multiple and heterogeneous sources, to challenges in the applicability of ML/AI algorithms (such as Graph ML methods) or their explainability.
10:30-11:00	Coffee Break		
11.00-12.30	Pavlos Sermpezis	Data science for network monitoring: challenges, practical problems, and potential solutions	The aspect of bias in network measurement data and its impact will be analyzed, and the use case of AI4NetMon project will be presented.
12.30-13:30	Lunch Break		
13.30-15.00	Kostas Tsagkaris & Aristotelis Margaris	<p>Part I: Big Data and Machine Learning for Optimizing Telecom (Network) Operations</p> <p>Part II: Localization</p>	<p>Big Data and Machine Learning for Optimizing Telecom (Network) Operations</p> <ul style="list-style-type: none"> • Overview of the Big Data & AI/Machine Learning landscape in Telecom Operators (from the perspective of a Telecom Data Analytics SME) • Use cases/Examples of big-data driven Network- and Customer- related applications & Lessons learnt <p>Localization Analytics as a Service</p> <ul style="list-style-type: none"> • Localization Data Analytics Platform/Design principles & Architectural aspects

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15.00-15:30		Analytics as a service	<ul style="list-style-type: none"> • Use cases: Network Management and optimization / Vertical businesses • Deployment scenarios and business exploitation • Demonstration of platform and solution components
	Coffee Break		
15.30-17.00	Lorenzo Maggi	An engineer's guide to ML algorithm selection for Radio Resource Management	<ul style="list-style-type: none"> • Bayesian optimization, Reinforcement learning, Beamforming, Energy Savings, power control

2nd Day – 16th June 2022

Time	Speaker	Tentative Title	Syllabus
09:00-10:30	Nokia (Peter Szilagy)	Anomaly Detection applied to 5G (and beyond) networks	Anomaly detection refers to a collection of methods that aim to find unusual but relevant patterns in a diverse set of data without human supervision. When applied to network measurements, it can detect symptoms of various problems or suboptimal configurations related to the network domain represented by the input data. However, anomaly detection is not only a machine learning use case: it is a fundamental asset to enable data driven network automation by creating situational awareness leveraged by the autonomous network to make decisions and to perform actions.
10:30-11:00	Coffee Break		
11:00-12:30	Nokia (Peter Szilagy)	Anomaly Detection applied to 5G (and beyond) networks	Anomaly detection refers to a collection of methods that aim to find unusual but relevant patterns in a diverse set of data without human supervision. When applied to network measurements, it can detect symptoms of various problems or suboptimal configurations related to the network domain represented by the input data. However, anomaly detection is not only a machine learning use case: it is a fundamental asset to enable data driven network automation by creating situational awareness leveraged by the autonomous network to make decisions and to perform actions.
12.30-13:30	Lunch Break		
13.30-15.00	Ericsson (Gemma Vall-Ilosera)	Overview on privacy preserving	<ul style="list-style-type: none"> • Recent advances, and open challenges in big data analytics for mobile network automation.



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15.00- 15:30 15.30- 17.00		<p>technologies for network automation: homomorphic encryption, secure multi party computation - Melanie Andersson, 60 min</p> <p>Differential privacy- Tigge Nilsson, 30 min</p>	<ul style="list-style-type: none"> • Specific case studies and enablers for data-driven automation in vertical markets.
	Coffee Break		
	<p>Ericsson (Gemma Vall-Iloera)</p>	<p>NPP -Tomas Keller, 30 min incl questions</p> <p>A&AI 5G rollout dashboards - Erika Lyxell, 30 min incl questions</p> <p>Overview of quantum technologies for telecom - Gemma Vall Lloera, 30 min incl questions.</p>	<ul style="list-style-type: none"> • Recent advances, and open challenges in big data analytics for mobile network automation. • Specific case studies and enablers for data-driven automation in vertical markets.

2.3 Survey results

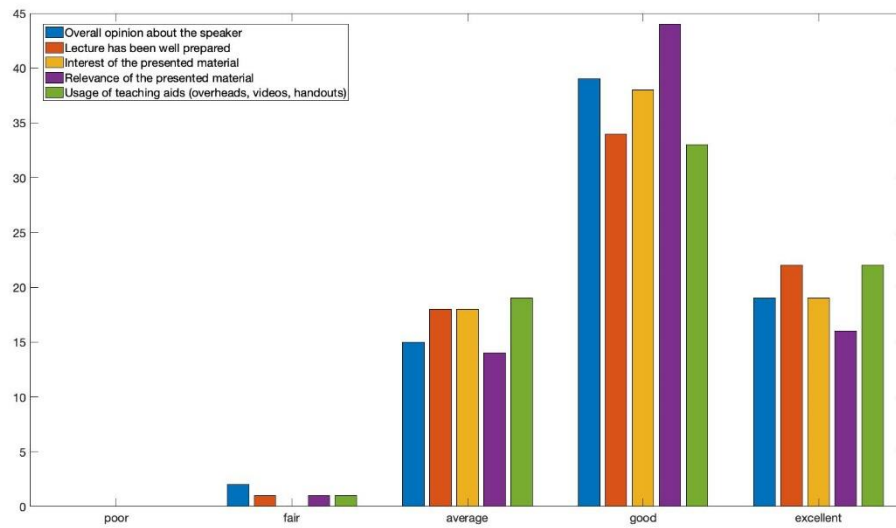


Fig. 1. Overview of the feedback on School 5.

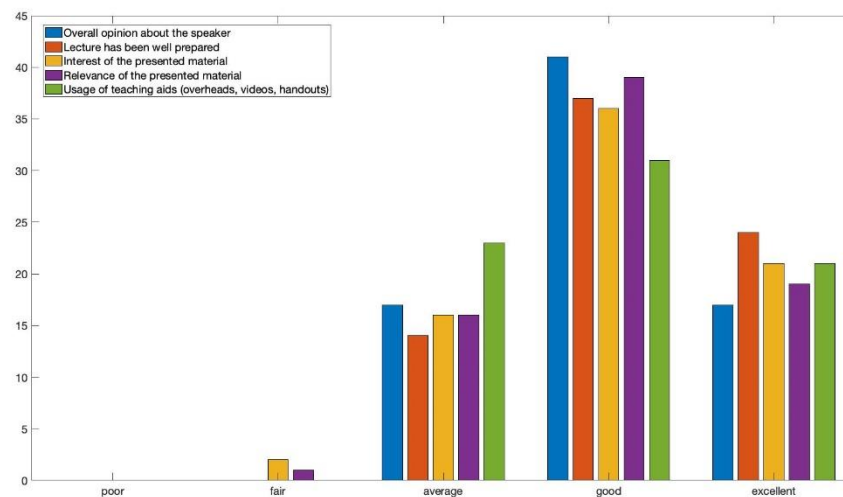


Fig. 2. Overview of the feedback on School 6.

In Fig. 1 and Fig. 2, we summarize the survey results for School 5 and 6. As can be seen, the seminars were almost all well received. In total 15 out of 15 ESRs responded. In the surveys there were also the opportunity to provide additional comments, but no comments were received.

3 Conclusions

The third year of the SEMANTIC Training activities have been implemented with the scope as planned in the DoA. School 5 & 6 were well received by the ESRs. This is especially encouraging, given that all activities were held online due to remaining pandemic restrictions.

4 References

None.