SEMANTIC

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

Marie Skłodowska-Curie Actions (MSCA)
Innovative Training Networks (ITN)
H2020-MSCA-ITN-2019
861165 - SEMANTIC

WP7 – Dissemination, communication and standardization

D7.5: Dissemination, standardization, communication and public engagement plan

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Executive Summary

The SEMANTIC project has strong commitment to ensure that all activities and research findings are disseminated, communicated, transferred into other research settings and to the society at large, in order to promote understanding of science by non-specialists. This mission will be accomplished through three main activities: dissemination of research results, their exploitation and public engagement.

This deliverable provides an update of the dissemination, communication, and standardisation plan. The first objective is to disseminate research achievements in order to foster adequate visibility in standardisation bodies, to promote results visibility in specialised and non-specialised communities. The dissemination of research results comprises the set-up of a public web site, conference and journal publications, open access engagement, 5GPPP initiative, standardisation, workshops and conference organisation, industrial dissemination days and participation in technical committees and special interest groups.

The second objective is to exploit the results and IPR created in SEMANTIC. SEMANTIC has the potential for introducing radical scientific and industrial innovations. All partners have well-defined exploitation plans which are described in this deliverable: Academics in terms of journal publications, conference attendance, international visibility, and the provision for adding new modules in their postgraduate programs, industrials in terms of products development and submission of patents to secure new technological know-how.

This deliverable is the fourth report on dissemination, communication and standardisation of SEMANTIC. It is a living document which will evolve over time, summing up all dissemination, communication and standardization activities undertaken by the partners during the project's lifetime.

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1. Introduction

The dissemination, communication, and standardisation plan to be followed within SEMANTIC will be developed along a line of well-defined actions and activities. They will cover all relevant aspects for all partners regardless of their type. A first structure to support and monitor all relevant activities is given below.

SEMANTIC has a strong commitment to ensure that all activities and research findings are disseminated, communicated, transferred into other research settings and to the society at large, in order to promote understanding of science by non-specialists. This mission will be accomplished through three main activities:

1. Dissemination of research results
2. Their exploitation
3. Public engagement.

2. General structure

SEMANTIC is introducing a general structure to manage and monitor all related dissemination and exploitation activities. In the course of the project, the topics will be "translated" into real actions. The following draft provides the overall structure with first tangible adaptations. Further details will be provided later on.

A. Dissemination of research results

- A.1 Conference/journal publications

  Scientific publications journals and conferences will be one of the main dissemination mechanisms. It is expected that, on average, each ESR will publish two conference papers and one journal paper a year.

- A.2 Open access engagement

  Open access will be provided for all scholarly results, by traditional (e.g., IEEE) or open access publishers, who publish only open access journals (gold open access). The practice of depositing articles in institutional repositories or a subject repository (e.g., arXiv) will be also adopted (green open access). All publications will be available in www.openaire.eu, the Open Access Infrastructure for Research in EU. To follow the H2020 open data strategy, a local open data repository will be available, conforming to potential ethical issues.

- A.3 5GPPP Initiative

The most innovative and industrial-oriented results will be presented at the 5GPPP (http://5g-ppp.eu/). SEMANTIC will exploit the presence of almost all the beneficiaries in 5GPPP projects. The results of recruited ESR in the project will be presented through multiple channels (e.g., white papers or presentations), consolidating the SEMANTIC viewpoint in different Work Groups (WG): Spectrum WG, 5G Architecture, Software Networks and Network Management and QoS.

- A.4 Standardization

  The industrial partners will contribute to ongoing standardisation activities by presenting achieved results to the relevant bodies. Since standardisation is a long lasting process, such activities may continue even after the end of the project.

- A.5 Industrial Dissemination Days

  Two IDDs will be organized, enabling ESRs to present results to industrial experts, potentially exploiting co-location of flagship events organized by the partners (e.g. NI Week conference, NOKIA Hackathon) to provide valuable networking and feedback to the ESRs, while maximizing the project visibility.

- A.6 Workshop/Conference Organization

  In close collaboration with the consortium, two workshops and one conference will be organized, which will be open to academic and industrial communities, in order to disseminate a unified view of all project achievements. Specific details on the organisation will be determined later on.

- A.7 Participation in IEEE Technical Committees (TC)

  SEMANTIC will be present at IEEE TCs, e.g., by creating special interest groups, exploiting the active participation of the consortium in IEEE TCs. ESRs will become members of relevant TCs and attend meetings co-located with IEEE flagship conferences (e.g., ICC, GLOBECOM). The TCs organize different forms (e.g., standardization activities, workshops) of information exchange in the multi-disciplinary fields.

B. Exploitation of results and intellectual property

- B.1 Mainly for academic partners

  Academic partners will publish results in journals, they will make presentations in conferences, increasing their international visibility, and they will add new modules in their postgraduate programs.

- B.2 Mainly for industrial partners

Improve their products and solutions, enhance their services, train current and future teams to use the newest research knowledge into industrial efforts, and expand business opportunities.

SEMANTIC is expected to generate a significant amount of intellectual assets, which will include specific methods (protocols, algorithms, policies, etc.), network data statistics and analytics, and network architectural models. Whenever possible, an open access strategy will be adopted (see the policies for disseminating results above), so as to motivate further innovation by academia and industry.

C. Communication and public engagement

- C.1 Communication strategy

  SEMANTIC will use different communication channels to promote the project widely to different target groups and to contribute to an EU "Innovation Union", such as:

  i) brochures and leaflets describing the potential applications and services of the Project;

  ii) social network accounts (Twitter, LinkedIn, etc.);

  iii) multimedia content to target public. SEMANTIC will use a YouTube channel for the project showing trailers on the plans, activities and achievements of the project;

  iv) e-newsletters with the project achievements and distributed to different mailing lists;

  v) online/printed press releases and attempt to reach a general audience by approaching TV and radio networks to provide interviews;

  vi) present results and deploy stands and demos showing the project results in industrial exhibitions;

  vii) white papers to identify project contributions and open issues, targeting to influence policy-makers, regulators and experts.

- C.2 Public engagement strategy

  The aim is to interact with the general public and a wide range of public engagement activities will be organized:

i) “Doors Open Days” events will be organized in collaboration with existing events;

ii) social media, use of several online social media sites;

iii) SEMANTIC hackathons;

iv) café science. Four cafe science events will be scheduled along with some training activities (e.g., workshops, plenary meetings) in informal setting at public areas (e.g., cafe, pubs, etc.) where the ESRs will make a short presentation about their work;

v) each ESR will give 3 public talks at different local associations, universities, science festivals, high-schools, etc. ESR will explain open issues in a didactic manner to promote the research carried out in the EU and generate interest for science and technology.

3. Supporting Activities

3.1 Website

The project website has been created by CTTC and is available at: https://semantic2020.eu/. The website presents the project concept and objectives, as well as information on the consortium, workpackages, the SEMANTIC Fellows, and training activities. The website also includes public documents (e.g., deliverables) and communication material (e.g., newsletters) that is publicly available on the website. Further, it includes links to communication media (e.g., Twitter and Linkedin). The website significantly contributes to disseminating the vision and the results of SEMANTIC to the community of interested parties. To this end, the website comprises a section were all publications and communication material is uploaded.

Finally, all the learning contents (i.e., school/courses videos, slides, agendas, etc.) are available in the “Seminars and Schools” folder in a private nextcloud cloud storage accessible from all ESRs.

Figure *1* reports a screenshot of the Home section of the website.

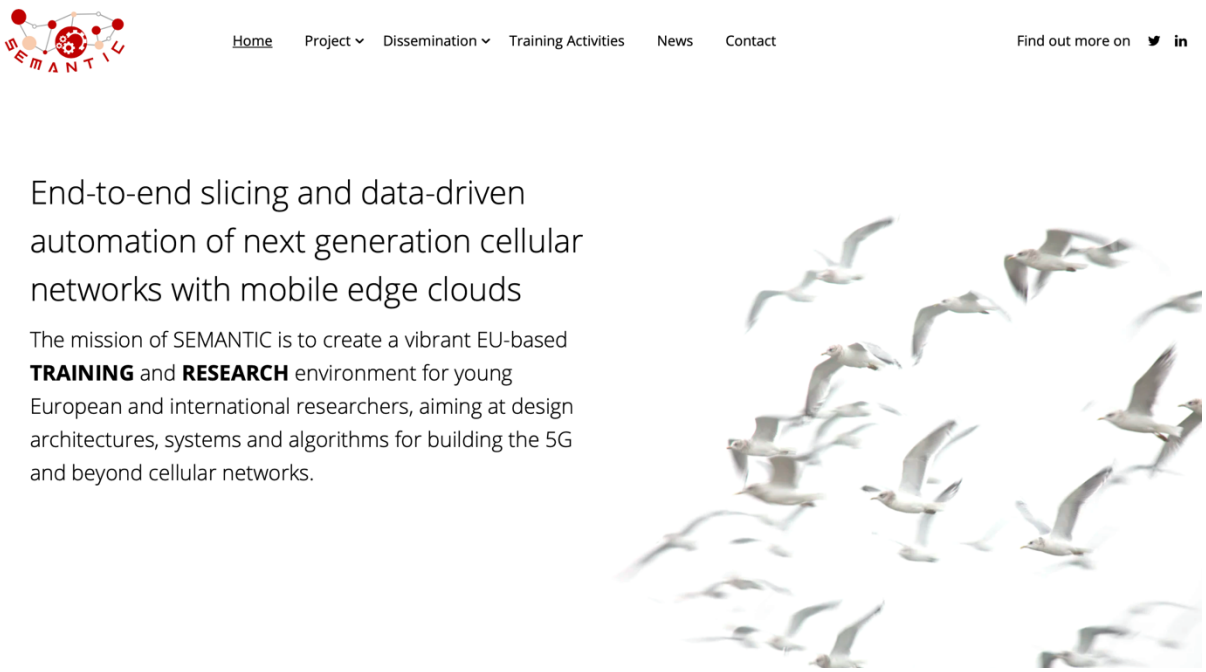


Figure 1: SEMANTIC web page (Home section)

3.2 Online application system

An online application system has been setup to receive all applications centralized, all candidates are submitting their applications through the online system and this way it is easier to control all the applications received and to preserve the security and privacy of applicants. CTTC has setup this online system and controls and distributes all the applications received to the rest of the partners.

The link to the online system is https://jobapp.semantic2020.eu/. A snapshot of the website is shown below:

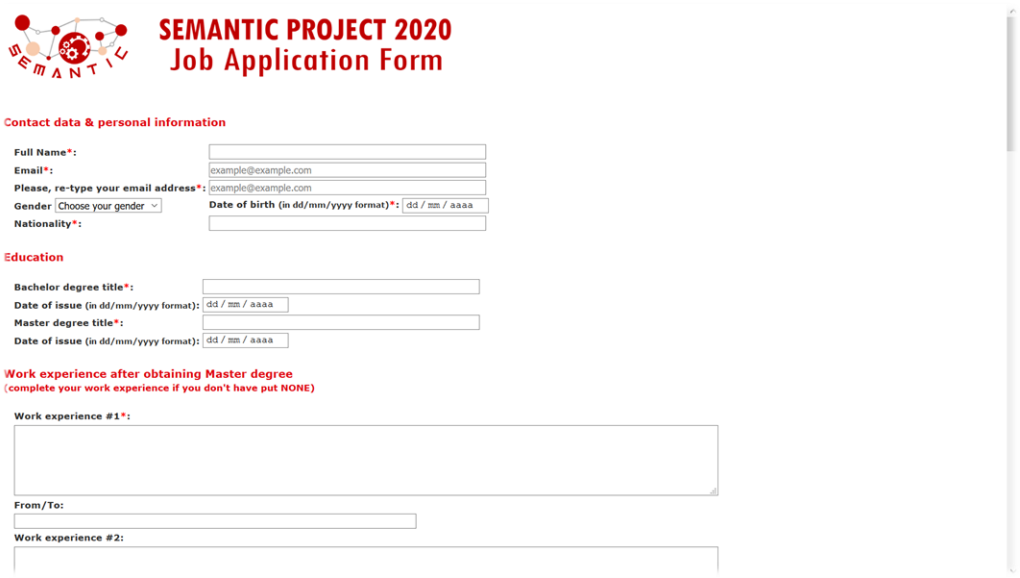


Figure 2: Online application system

3.3 Twitter social network

The information on the Twitter (@semantic_itn) account created for the project are kept up-to-date on a regular basis, thanks to the work coordinated by CTTC.

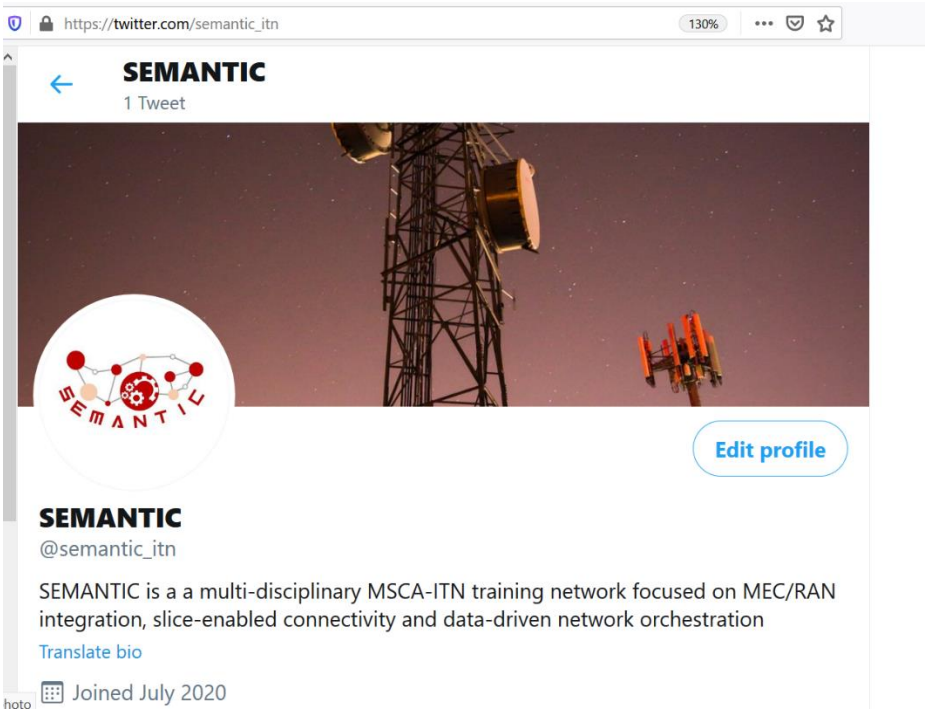


Figure 3: Twitter account (snapshot)

3.3 LinkedIn

The information on the LinkedIn (linkedin.com/in/semantic-msca-itn-9349851b2) account created for the project are kept up-to-date in a regular basis, thanks to the work coordinated by CTTC.

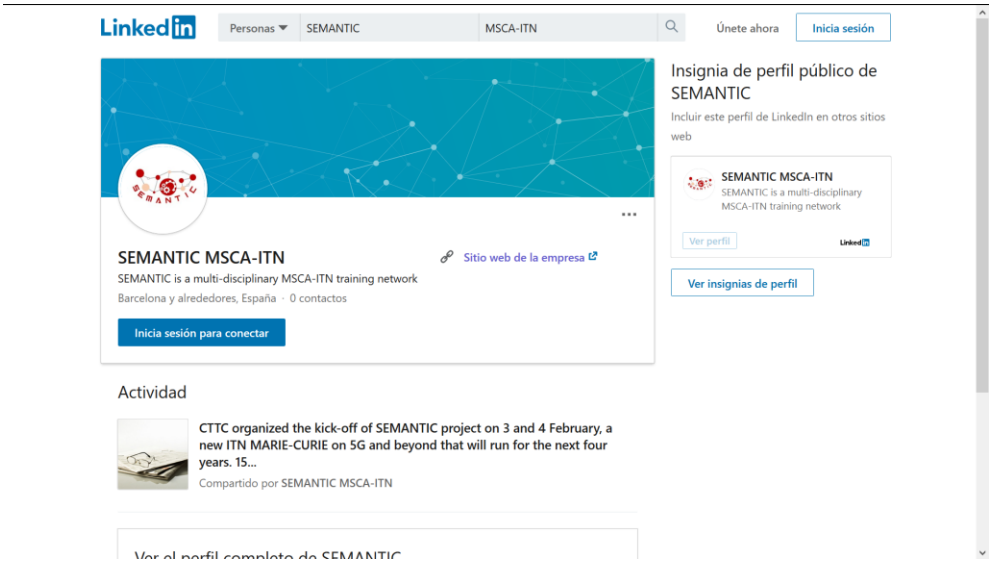


Figure 4: LinkedIn account (snapshot)

3.4 YouTube

A YouTube channel has been setup to host videos related to the SEMANTIC project. The link to the channel is https://www.youtube.com/channel/UCelgjbh_hpsFNy645CMMknQ. The channel currently hosts two videos of the SEMANTIC School 2: “OpenAirInterface for 5G cloud native and open RAN deployments” by Dr. Florian Kaltenberger and R. Schmidt, and "OpenAirInterface and Mosaic 5G, ecosystem, Kube5G and FlexRAN" by Prof. Nikaein and Osama Arouk. A screenshot of the SEMANTIC YouTube channel is reported in Figure 5.

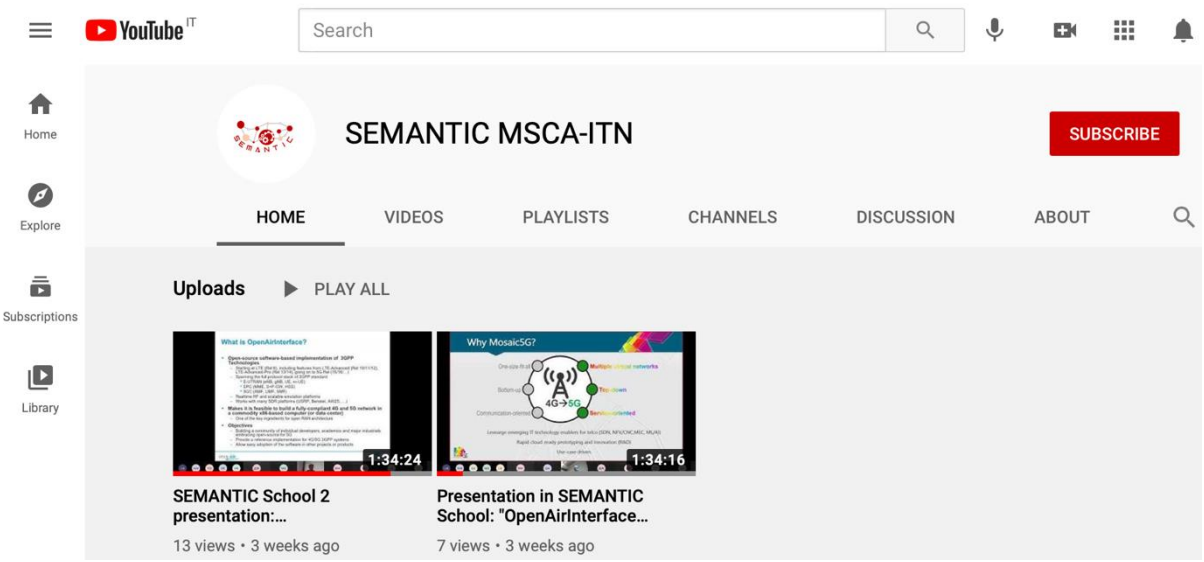


Figure 5: YouTube page

3.5 Logo

In order to increase visibility and to create a recognition feature, the SEMANTIC logo was designed. It will be largely used in every possible context related to the project.

Figure 6: Project logo

4. Dissemination of research results

4.1 Conference/journal publications

The ESRs from academic and industrial partners are expected to participate to one international conference (e.g., IEEE ICC, IEEE GLOBECOM, EUCAP, IEEE VTC, IEEE PIMRC) per year of their recruitments, they will be encouraged to contribute to EU

conferences (e.g., EUCNC) and to publish their work to 2–3 high impact journals. These include:

- IEEE Transactions on Mobile Computing (www.computer.org/portal/web/tmc/home)
- Computer Networks Journal, Elsevier (www.journals.elsevier.com/computernetworks)
- The Journal of Mobile Communication, Computation and Information (Wireless Networks), Springer (http://www.springer.com/engineering/signals/journal/11276)
- ACM Springer Mobile Networks and Applications (MONET) Journal (http://link.springer.com/journal/11036)
- EURASIP Journal on Wireless Communications and Networking (www.jwcn.eurasipjournals.com)
- IEEE Transactions on Vehicular Technology (www.vtsociety.org)
- IEEE Network (www.comsoc.org/netmag)
- IEEE Transactions on Communications (www.comsoc.org/tc)
- IEEE Transactions on Wireless Communications (www.comsoc.org/twc)
- IEEE Communications Magazine (www.comsoc.org/commag)
- IEEE Vehicular Communications Magazine (http://ieeexplore.ieee.org)

Conference Publications

Following is the list of papers by ESRs that are accepted/published in various conferences.

1. **S. Roy**, H. Chergui, L. Sanabria-Russo and C. Verikoukis, "A Cloud Native SLA-Driven Stochastic Federated Learning Policy for 6G Zero-Touch Network Slicing," *ICC 2022 - IEEE International Conference on Communications*, 2022, pp. 4269-4274, doi: 10.1109/ICC45855.2022.9838376.

2. **M. Adeppady**, C. F. Chiasserini, H. Karl and P. Giaccone, "iPlace: An Interference-aware Clustering Algorithm for Microservice Placement," *ICC 2022 - IEEE International Conference on Communications*, 2022, pp. 5457-5462, doi: 10.1109/ICC45855.2022.9839222.

3. **P. Doanis**, T. Giannakas and T. Spyropoulos, “Scalable end-to-end slice embedding and reconfiguration based on independent DQN agents,” *GLOBECOM 2022 - IEEE Global Communications Conference*, 2022, pp. 3429-3434, doi: 10.1109/GLOBECOM48099.2022.10001068.

4. **S. Roy**, F. Rezazadeh, H. Chergui, L. Sanabria-Russo and C. Verikoukis, "Joint Explainability and Sensitivity-Aware Federated Deep Learning for Transparent 6G RAN Slicing," *ICC 2023 - IEEE International Conference on Communications*, 2022, pp. 4269-4274, doi: 10.1109/ICC45041.2023.10279790.

5. **M. Adeppady**, A. Conte, H. Karl, P. Giaccone and C. F. Chiasserini, "Energy-aware Provisioning of Microservices for Serverless Edge Computing," *GLOBECOM 2023 - IEEE Global Communications Conference*, 2023, pp. 3070-3075, doi: 10.1109/GLOBECOM54140.2023.10437798.

6. **V. Kasuluru**, L. Blanco and E. Zeydan, "On the use of Probabilistic Forecasting for Network Analysis in Open RAN," *MeditCom 2023 - IEEE International Mediterranean Conference on Communications and Networking,* pp. 258-263, doi: 10.1109/MeditCom58224.2023.10266607.

7. **V. Kasuluru**, L. Blanco, E. Zeydan, Albert Bel, Angelos Antonopoulos, "Enhancing Cloud-Native Resource Allocation with Probabilistic Forecasting Techniques in O-RAN," accepted for publication at *EuCNC 2024 - European Conference on Networks and Communications.*

8. **M. Q. Khan**, A. Gaber, M. Parvini P. Schulz and G. Fettweis, *"*On the Generalization of Machine Learning for mmWave Beam Prediction,*"* accepted for publication at *ICWCS 2024 - International Symposium on Wireless Communication Systems.*

9. **P. Doanis** and T. Spyropoulos, "Multi-agent DQN with sample-efficient updates for large inter-slice orchestration problems," accepted for publication at *ICNC 2024 - IEEE International Conference on Computing, Networking and Communications.*

10. **P. Doanis** and T. Spyropoulos, "The Curse of (Too Much) Choice: Handling combinatorial action spaces in slice orchestration problems using DQN with coordinated branches," accepted for publication at *INFOCOM Workshops 2024 -IEEE International Conference on Computer Communications.*

11. **A. Ehsanian** and T. Spyropoulos, "Distributed LSTM-based Slide Resource Allocation for Beyond 5G Networks," accepted for publication at *ICNC 2024 - IEEE International Conference on Computing, Networking and Communications.*

12. **A. Ehsanian** and T. Spyropoulos, " Edge/Cloud Slice Resource Allocation for Beyond 5G Networks with Distributed LSTM," accepted for publication at PIMRC *2024 - IEEE* International Symposium on Personal, Indoor and Mobile Radio Communications.

Journal Publications:

Following is the list of articles submitted/published by ESRs at various journals.

1. **M. Adeppady**, P. Giaccone, H. Karl and C. F. Chiasserini, "Reducing Microservices Interference and Deployment Time in Resource-Constrained Cloud Systems," in *IEEE Transactions on Network and Service Management*, vol. 20, no. 3, pp. 3135-3147, Sept. 2023, doi: 10.1109/TNSM.2023.3235710.

2. **M. Q. Khan**, A. Gaber, P. Schulz and G. Fettweis, "Machine Learning for Millimeter Wave and Terahertz Beam Management: A Survey and Open Challenges," in *IEEE Access*, vol. 11, pp. 11880-11902, 2023, doi: 10.1109/ACCESS.2023.3242582.

3. **M. Q. Khan**, A. Gaber, M. Parvini, P. Schulz and G. Fettweis, "A Low-Complexity Machine Learning Design for mmWave Beam Prediction," in *IEEE Wireless Communications Letters*, vol. 13, no. 6, pp. 1551-1555, June 2024, doi: 10.1109/LWC.2024.3381447.

4. **M. Bandali**'s journal paper "ML-based Fault Management Automation in Large-scale Fixed and Mobile Telecommunication Networks" was submitted to *IEEE Transactions on Network and Service Management (January 2024).*

5. **M. Sattari**'s journal paper "Full-Duplex Millimeter Wave MIMO Channel Estimation: A Neural Network Approach" was submitted to IEEE Transactions on Machine Learning in Communications and Networking (Feburary 2024).

6. **M. Adeppady**'s journal paper "Dynamic Management of Edge Computing Resources for Serverless Services" was submitted to *IEEE Transactions on Network and Service Management (March 2024).*

Special sessions

MeditCom 2021

Friday, September 10

Friday, September 10 9:00 – 16:00

SS5: End-to-end slicing and data-driven automation of next generation cellular networks with mobile edge clouds (SEMANTIC)

Room: Virtual 1

Chairs: Abdo Gaber (Physical Layer and System Design, Germany), Walter Nitzold (National Instruments, Germany), Tommy Svensson (Chalmers University of Technology, Sweden), Anna Tzanakaki (National and Kapodistrian University of Athens, Greece), Dionysis Xenakis (National and Kapodistrian University of Athens, Greece)

Building Datasets for Predicting VNF Interference
Madhura Adeppady, Carla Fabiana Chiasserini and Paolo Giaccone (Politecnico di Torino, Italy)

Zero Touch Enabled Management and Orchestration of The Next Generation E2E Networks & Services
S. Roy (Universitat Politècnica de Catalunya & Centre Tecnològic Telecomunicacions Catalunya, Spain)

MEC Service Integration in Open RAN Based on AI/ML
Vaishnavi Kasuluru (Universitat Politècnica de Catalunya & Centre Tecnològic Telecomunicacions Catalunya, Spain)

AI-enabled techniques for enhanced video service provisioning in mobile data networks
Yevhenii Osadchuk (National and Kapodistrian University of Athens, Greece); Dionysios Xenakis (National And Kapodistrian University of Athens, Greece)

End-to-end network slicing and orchestration
Suvidha Sudhakar Mhatre (Iquadrat Informatica, Spain)

A reinforcement learning approach for end-to-end slicing in beyond 5G networks
Pavlos Doanis, Theodoros Giannakas and Thrasyvoulos Spyropoulos (EURECOM, France)

Identification of Network KPIs to Improve Network performance using Machine Learning Techniques
Qurat Ulain, Vestergaard Christian, Arne Morten Kastel, Enver Asad and Bjorling Axel (Telenor, Sweden); Colella Riccardo (Telenor, Sweden & Politecnico di Milano, Italy); Rius I Riu Jaume (Telenor & Lund Technical University, Sweden)

Deep Learning-based Channel Estimation for Intelligent Reflecting Surfaces aided MIMO Systems
Mehdi Sattari and Tommy Svensson (Chalmers University of Technology, Sweden)

Towards Application-aware Efficient and Agile Non-orthogonal Multiple Access Techniques
Azadeh Tabeshnezhad and Tommy Svensson (Chalmers University of Technology, Sweden)

O-RAN meets AI
Sudharshan Paindi Jayakumar (Nokia Bell Labs, France)

Towards SEMANTIC massive connectivity in 5G networks using MEC and blockchain technologies
Diana Zhussip (Fogus Innovations and Services P. C., Greece); Dionysis Xenakis (National and Kapodistrian University of Athens, Greece)

Resource allocation in beyond 5G Virtualized Networks with Distributed Deep Neural Networks
Ali Ehsanian, Thrasyvoulos Spyropoulos and Theodoros Giannakas (EURECOM, France)

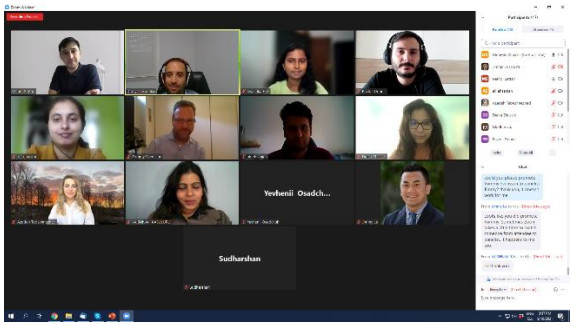


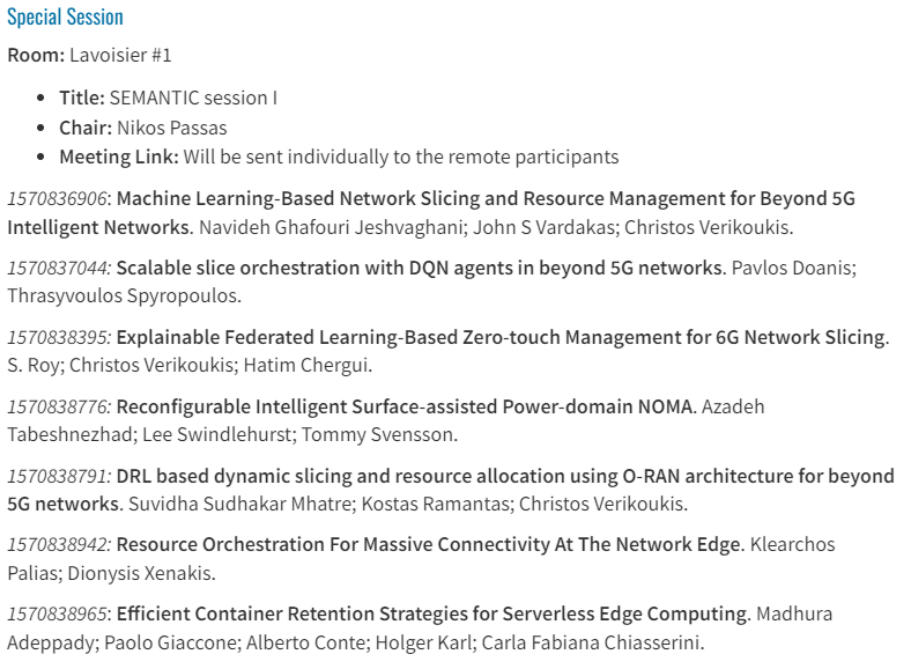
Figure 7: SEMANTIC Special Session at Meditcom 2021

On Friday 10 September 2021 took place the SEMANTIC Special Session at IEEE International Mediterranean Conference on Communications and Networking (IEEE MeditCom 2021). Our ESRs presented their research topics and had the opportunity to discuss current opportunities and challenges in the design of beyond 5G NR techniques, MEC/RAN integration, network slicing in joint MEC/RAN infrastructures and data–driven network automation.

More info available at (Special Session 5 – Virtual): https://meditcom2021.ieee-meditcom.org/program/special-sessions/. All the recruited fellows in Sept 2021 (12 ESRs) have presented their research topics.

Special Session call for papers available at: https://meditcom2021.ieee-meditcom.org/wp-content/uploads/sites/159/2021/03/SS5_SEMANTIC_Meditcom_2021_Special_Session.pdf

CAMAD 2022



Special Session

Room: Lavoisier #1

- **Title:** SEMANTIC session I
- **Chair:** Nikos Passas
- **Meeting Link:** Will be sent individually to the remote participants

1570836906: **Machine Learning-Based Network Slicing and Resource Management for Beyond 5G Intelligent Networks.** Navideh Ghafouri Jeshvaghani; John S Vardakas; Christos Verikoukis.

1570837044: **Scalable slice orchestration with DQN agents in beyond 5G networks.** Pavlos Doanis; Thrasyvoulos Spyropoulos.

1570838395: **Explainable Federated Learning-Based Zero-touch Management for 6G Network Slicing.** S. Roy; Christos Verikoukis; Hatim Chergui.

1570838776: **Reconfigurable Intelligent Surface-assisted Power-domain NOMA.** Azadeh Tabeshnezhad; Lee Swindlehurst; Tommy Svensson.

1570838791: **DRL based dynamic slicing and resource allocation using O-RAN architecture for beyond 5G networks.** Suvidha Sudhakar Mhatre; Kostas Ramantas; Christos Verikoukis.

1570838942: **Resource Orchestration For Massive Connectivity At The Network Edge.** Klearchos Palias; Dionysis Xenakis.

1570838965: **Efficient Container Retention Strategies for Serverless Edge Computing.** Madhura Adeppady; Paolo Giaccone; Alberto Conte; Holger Karl; Carla Fabiana Chiasserini.

Figure 8: Program List of SEMANTIC Session at CAMAD 2022 (Part-1)

On Thursday, 3 November 2022, the SEMANTIC Special Session was held at IEEE International Workshop on Computer Aided Modeling and Design of Communication Links and Networks (IEEE CAMAD). All the recruited ESRs attended the workshop in person and presented their research on various topics, including network slicing in joint MEC/RAN infrastructures, resource allocation and orchestration, 5G NR techniques, and data-driven network automation.

Thursday Afternoon Sessions

Room: Amphithéâtre Lavoisier

- **Title:** SEMANTIC session II
- **Chair:** Nikos Passas
- **Meeting Link:** Will be sent individually to the remote participants

1570839062: **Full-Duplex mmWave Massive MIMO Channel Estimation**. Mehdi Sattari; Tommy Svensson.

1570839099: **ML-based Resolution Time Prediction of Trouble Ticket for Operational Telecommunication Networks**. Maryam Bandali, Rius I Riu Jaume, James Gross, Andreas Lewitzki.

1570839159: **Joint Beamforming Design and APs Selection in Cell-free mMIMO O-RAN system**. Vaishnavi Kasuluru.

1570839215: **A Bitrate Adaptation Scheme for Streaming Media Over HTTP in MEC-empowered Slice-Enabled Networks**. Vasilis Gretsistas; Dionysis Xenakis; Nikos Passas.

1570839276: **Performance Analysis and Optimization of Integrated Access and Backhaul at mmWaves**. Ayham Alyosef; Nikos Passas; Dionysis Xenakis.

1570839280: **Machine Learning-based Beam Management for mmWave Bands: A Short Review**. Muhammad Qurratulain Khan; Abdo Gaber.

1570842814: **AI-driven Base Station Clustering for Parameter Optimization and RAN Automation**. Sudharshan Paindi Jayakumar; Alberto Conte.

1570863019: **Edge/Cloud Traffic Prediction in 5G/6G Networks with Distributed Deep Neural Networks**; Ali Ehsanian; Thrasyvoulos Spyropoulos.

Figure 9: Program List of SEMANTIC Special Session at CAMAD 2022 (Part 2)

Figure 10: Group Photo of SEMANTIC special session at CAMAD 2022

Final Conference 2023

On Wednesday, 27th September 2023, the SEMANTIC final conference was held at Department of Informatics & Telecommunications, University of Athens. All the ESRs attended the final conference in person and presented their research progress on various topics. The session 1 and session 2 program list is shown in Fig. 11 and Fig, 12, respectively.

Time	Title	Presentations
09:00-11:00	**Conference Session 1**	• Nikos Passas - Welcome, intro to the project • Suvidha Mhatre - Intelligent QoS aware slice resource allocation and management for ORAN based architecture using DRL • Swastika Roy - Transparent Federated Learning for Trustworthy 6G Zero-Touch Slicing • Madhura Adeppady - Energy-aware Provisioning of Microservices for Serverless Edge Computing • Pavlos Doanis - Decomposing the action space of DQN for scalable inter-slice orchestration • Vaishnavi Kasuluru - On the use of probabilistic forecasting for Open-RAN analytics and resource provisioning • Azadeh Tabeshnezhad - RIS-Assisted Interference Mitigation for Uplink NOMA • Mehdi Sattari - Neural Network-Based Full-Duplex Millimeter Wave Massive MIMO Channel Estimation

Figure 11: Session 1 of SEMANTIC Final Conference 2023

11.30-13.30	**Conference Session 2**	• Sudharshan Paindi Jayakumar - Clustering-Driven Approach for Base Station Parameter Optimization and Automation (CeDA-BatOp) • Ali Ehsanian - Slice Resource Allocation with distributed Deep Neural Networks for 5G+ Networks • Maryam Bandali - Data-driven Analysis and Automation for Telecommunication Network Operation • Klearchos Palias - AR-Assisted GPS-Free Indoor Positioning • Navideh Ghafouri - Machine Learning-Based Network Slicing and Resource Management for Beyond 5G Intelligent Networks • Muhammad Qurratulain Khan - Machine Learning based mmWave Beam Management • Vasilis Gretsistas - A Video bitrate adaptation scheme in MEC-empowered Cellular Networks • Ayham Alyosef - Resource allocation in high-dense IAB networks for future 5G Mobile Communications

Figure 12: Session 2 of SEMANTIC Final Conference 2023

Figure 13: Group Photo of SEMANTIC Final Conference at Athens 2023

4.2 Open access engagement

Open access will be provided for all scholarly results, by traditional (e.g., IEEE) or open access publishers, who publish only open access journals (gold open access). The practice of depositing articles in institutional repositories or a subject repository (e.g. arXiv) will be also adopted (green open access). All publications will be available in www.openaire.eu, the Open Access Infrastructure for Research in EU. To follow the H2020 open data strategy, a local open data repository will be available, conforming to potential ethical issues.

4.3 5GPPP initiative

The most innovative and industrial-oriented results will be presented at the 5GPPP initiative (http://5g-ppp.eu/). SEMANTIC will exploit the presence of almost all beneficiaries in 5GPPP projects (e.g. FOG, EUR, NOKIA and TLN participate in three out of three 5GPPP- Phase 3 infrastructure projects, to articulate the results of recruited ESRs through multiple channels (white papers, presentations, etc.), consolidating the SEMANTIC viewpoint in WGs: i) the spectrum WG (NI is member), ii) 5G Architecture (IQU is member), Software Networks (Nokia is leader) and Network Management & QoS (FOG is member).

SEMANTIC will publish a white paper, led by NOKIA, to identify the project contribution and state open issues, targeting to influence policy-makers, regulators and experts. This white paper will be also articulated in the 5GPPP and IEEE Future Networks Initiatives.

4.4 Standardization

SEMANTIC targets at a significant impact on 5G standardization, fully leveraging the leading role of SEMANTIC partners in relevant standardization bodies (e.g. TLN in IETF/IRTF, NI and NOKIA in 3GPP, POLITO and CTTC in ETSI, NOKIA and EUR in NGMN), setting the ambitious aim to achieve at least 6 impactful contributions in relevant standards and 6 presentations/posters in workshops/meetings organized by these bodies. **1) IETF** (Internet Engineering Task Force): TLN (IETF group member) is committed to contribute in the traffic engineering and signaling (TEAS) working group (WG) with research outcomes on inter-slice control, **2) 3GPP**: NI will process the results on MIMO/beam management to contribute in 3GPP RAN WG1 (NI is group member with focus on MIMO) and 3GPP RAN WG2 (NI is group member with focus on beam management). Also, NOKIA will further contribute to SA5 on management operations for network virtualization and SFC. **3) ETSI** (European Telecommunications Standards Institute): NI will contribute to the ETSI mmWave Transmission (mWT) group with results of his/her study for high band utilization/interference modelling (Table 3.1.d). POLITO and CTTC (active ETSI members) are also committed to promote POLITO-1 and CTTC-1 contributions in ETSI MEC on MEC/RAN integration and location-based service continuity. **4) IRTF** (Internet Research Task Force): TLN will integrate outcome of his/her work on the joint orchestration of MEC/RAN resources to the IRTF Network Management (TLN is group member), **5) ITU:** NOKIA will contribute to the new ITU-T focus group on “ML for Future Networks including 5G” (FG-ML5G) with his/her outcome on data-driven prediction for SFC in MEC/RAN, **6) NGMN** (Next Generation Mobile Networks): NOKIA (NGMN contributor) and EUR (NGMN advisor) will analyze the results on e2e integration (WP4), to contribute (e.g. white papers) in the Network Management & Orchestration and the 5G Trial & Testing Initiatives.

4.5 Industrial Dissemination Days (IDDs)

Two IDDs will be organized, enabling ESRs to present results to industrial experts, potentially exploiting co-location of flagship events organized by the SEMANTIC partners (e.g. NI Week conference, NOKIA Hackathon) to provide valuable networking and feedback to the ESRs while maximizing the project visibility. During the IDDs, industry-focused keynotes will be presented, while sessions for oral, poster and demo presentation will be organized. Through IDDs, all ESRs will be given the opportunity to apply theoretical knowledge and skills to

significant practical problems, further to establishing links with other industry and academic partners (e.g. for fostering new career opportunities and future collaborations).

SEMANTIC IDD 2023

On September 27th 2023, SEMANTIC IDD was held at Department of Informatics & Telecommunications, University of Athens. As part of the IDD, ESRs presented and discussed their posters with other ESRs, academic and industry partners. The titles of the posters presented by the ESRs is described in Fig. 14.

15.00-17.00	**Industrial Dissemination Session** **(Poster session)**	• Suvidha Mhatre - Intelligent QoS based multi time scale resource handling for 6G networks • Swastika Roy - Trustworthy 6G Zero-Touch Networks: Future Perspectives • Madhura Adeppady - Microservice Deployment and Management at the Edge • Pavlos Doanis - Data-driven end-to-end slicing in beyond 5G networks using deep RL • Vaishnavi Kasuluru - Integration of AI/ML based services in Cell-Free mMIMO Open-RAN systems • Azadeh Tabeshnezhad - Optimizing Energy Efficiency of RIS-assisted NOMA Systems • Mehdi Sattari - Low-Complexity Channel Estimation Methods for mmWave Full-duplex Massive MIMO Systems • Sudharshan Paindi Jayakumar - Clustering-Driven Approach for Base Station Parameter Optimization and Automation (CeDA-BatOp) • Ali Ehsanian - Slice Resource Allocation with distributed Deep Neural Networks for 5G+ Networks • Maryam Bandali - Data-driven Analysis and Automation for Telecommunication Network Operation • Klearchos Palias - AR-Assisted GPS-Free Indoor Positioning • Navideh Ghafouri - Machine Learning-Based Network Slicing and Resource Management for Beyond 5G Intelligent Networks • Muhammad Qurratulain Khan - Machine Learning based mmWave Beam Management • Vasilis Gretsistas - Video bitrate adaptation in MEC-empowered Cellular Networks • Ayham Alyosef - Resource allocation in high-dense IAB networks for future 5G Mobile Communications

Figure 14: Poster Session at SEMANTIC IDD 2023


27 September 2023 15:09


Video Bitrate Adaptation in MEC-empowered Cellular Networks
27 September 2023 15:09

Figure 15: Some Photos of Poster Session at SEMANTIC IDD 2023

4.6 Organization of Workshops and Conferences

SEMANTIC will organize two workshops and one conference, which will be open to academic and industrial communities and co-located with important IEEE conferences (e.g., ICC, GLOBECOM, EuCNC, CAMAD, etc.), aiming to disseminate a unified view of all the project achievements. ESRs will present their results in the workshops, receiving valuable feedback for their research. All project achievements will be shown at the final conference. It is expected that around 100 people will attend each workshop while more than 300 people will attend the conference.

4.7 Participation in IEEE Technical Committees (TC)

TCs foster different forms of information exchange in multidisciplinary fields of wireless networking (e.g., standardization, workshops). SEMANTIC will be present at IEEE TCs, e.g. by creating special interest groups, exploiting the active participation of the consortium in IEEE TCs (e.g., CTTC is officer of the IEEE Communications Systems Integration and Modelling – CSIM TC). ESRs will become members of relevant TCs and attend meetings co-located with IEEE flagship conferences (e.g., ICC, GLOBECOM, etc.) to present and discuss steps toward standardization. It is expected that the ESRs will attend one meeting per year.

5. Communication and public engagement strategy

5.1 E-newsletters

E-newsletters with the project achievements (e.g., novel technologies), events organized (e.g., training schools, workshops) and the societal benefits of providing high speed communications, will be distributed to different mailing lists and made available via the project website. Short interviews with the ESRs will show the impact of the multidisciplinary Network in his/her career/excellence/life. A new issue will be released every three months starting from M10 and ESRs will be involved in the preparation of them.

5.2 Broadcast media

Three TV/radio interviews, and at least one visit of a recognized EU or local politician in the lab facilities of beneficiaries (followed by the press) will be targeted by SEMANTIC, aiming at maximum visibility of the project at the public at large, communicating the impact of EU-funded research and 5G and beyond networks to the life of EU citizens. The objective is to inform public audience about: i) benefits – scientific excellence, new products & services – for setting up a collaborative Network of young researchers hosted by 10 different institutions, and ii) how people's interaction with the Internet will change and will open up new kinds of intelligent analytics ready to be harnessed for tangible business and everyday life benefits.

5.3 Brochures and leaflets

In order to increase visibility, the first brochure has been created by POLITO, describing the project concept and vision, the goal of the workpackages, and the consortium, and introducing the ESR that have been hired. The brochures are reported in Figure 9 and 10.

Future brochures will be also translated in Spanish, Greek, French, German and Swedish, and will be disseminated to city councils, local universities, schools, recreational areas, etc.,

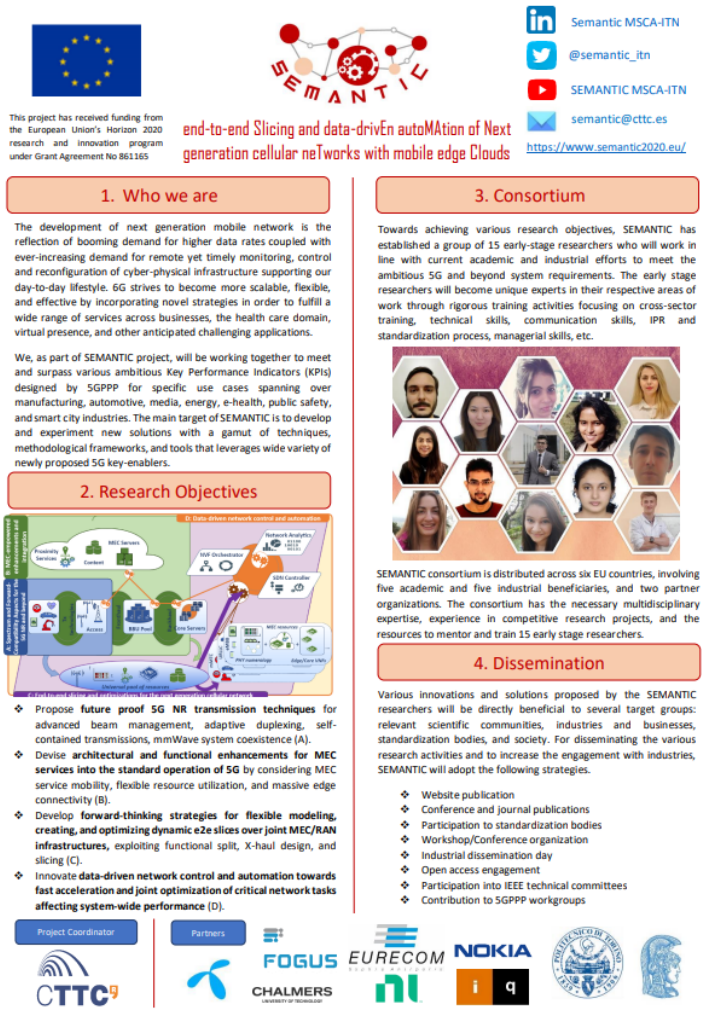


Figure 16: First SEMANTIC brochure

5.4 Online/printed Press

Four articles will be published in national/local (e)-newspapers to inform the general public (e.g., *El Pais* in Spain with 220k readers, *Protothema* in Greece with 7M visits per month), and university magazines (e.g., ≪το Καποδιστριακό≫ by UOA), on the societal benefits, scientific excellence, new products and services of the SEMANTIC consortium.

5.5 Industrial Exhibitions

The key ESR innovations will be presented through stands/demos of working testbeds in at least three industry-attended events (e.g., Mobile World Congress-110k visitors, 5G World-10k visitors), or events organized by the EC (e.g., 5G Summit, RAN World) and the project partners (e.g. NI Week conference). This activity will increase the awareness of the industrial stakeholders and operators on the SEMANTIC results. Next, we present the most relevant Industrial Exhibitions held so far.

Figure 17: Second SEMANTIC brochure

Mobile World Congress 2021

SEMANTIC participated in Mobile World Congress (MWC) 2021 where Suvidha Mhatre, one of the SEMANTIC fellows, presented 'beyond 5G end-to-end slicing and data-driven automation using mobile edge clouds'. The Mobile World Congress 2021 was held between

28 June and 1 July. It had more than 20,000 physical attendees and over 100,000 virtual visitors, according to the figures presented by the organizers, the GSMA.

More info available at: https://twitter.com/semantic_itn/status/1412810541253509126

Figure 18: ESR Presentation at Mobile World Congress (MWC) 2021

5.6 White paper

SEMANTIC will publish a white paper (M30), led by NOKIA, to identify the project contributions and state open issues, targeting to influence policy-makers, regulators and experts. The white paper will be also articulated in the 5GPPP and IEEE Future Networks Initiatives.

5.7 Open Days

SEMANTIC will organize 3 open days, collocated with existing events (e.g., Fete de la science in EUR, Science Week in CTTC, International Science Festival in Gothenburg, EU Researcher's Night), with a target 300-400 audience of students, engaging students in a research environment and to familiarize with EU-funded actions. Experimental demonstration, hands-on sessions an applied examples will be prepared by the ESRs. Locals and young students will be invited to familiarize themselves with the research activities performed by and provide valuable feedback to the ESRs through questioners. Next, we expose the most relevant Open Days activities held so far.

EU Researcher's night 2021

SEMANTIC was present at the European Researchers' Night to disseminate the general research objectives of the project and the planned targets. More info available at: https://lanitdelarecerca.cat/semantic/

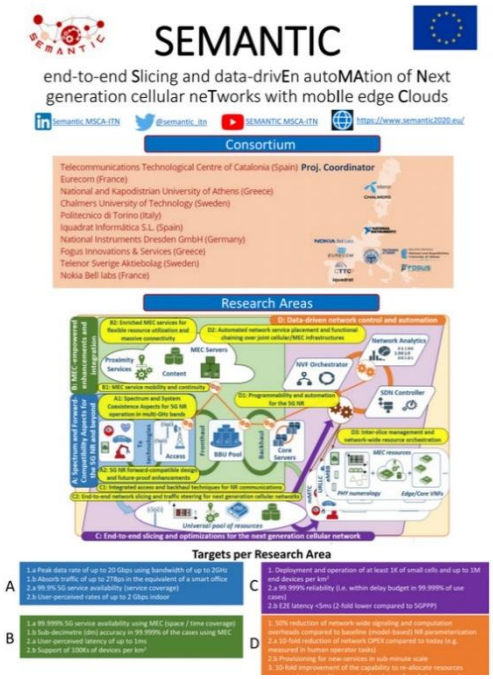


Figure 19: Poster used for the dissemination of the project in the European Researcher's Night.

5.8 Social media

The two-way access between the project partners and the public audience has been enabled via the use of several online social media sites (e.g., Twitter, Facebook, LinkedIn, YouTube). The ESRs regularly contribute to publish announcements and initiate discussions on topics of the project. The content will be updated in systematic regular basis (at least monthly updates) and the obtained feedback (comments, ideas, opinions, etc.) will heavily influence project's directions and decisions.

5.9 Multimedia content

SEMANTIC has set up a YouTube channel for the project, including i) four trailers on plans, activities, and achievements of the project, ii) at least one interview per ESR communicating his/her experience from the participation in MSCA actions, summarizing recent achievements, iii) at least one interview per beneficiary, highlighting how EU-funding and SEMANTIC promotes academic/ industrial innovation. The material will be also made available through the project website.

5.10 Public talks

Each ESR will give 3 public talks at different local associations, universities, science festivals, high-schools, etc. ESRs will explain open issues in a didactic manner (with examples and hands-on activities) to promote fruitful discussions to explain the research carried out in the project and generate interest for science and technology. The target audience is a

multidisciplinary public with interest in Science, Technology, Engineering and Math (e.g., STEM program in Greece). During the talks the ESRs will encourage the audience participations through interactive, multimedia presentations. The attendees will be asked to fill out questionnaires to get feedback about the content and its applicability in real life scenarios.

In the second semester of 2021, two Chalmers ERSs have presented their ongoing research work during the Communications Systems group seminar series at Chalmers University:

- ESR02 Mehdi Sattari, "**Channel Estimation and Passive Beamforming for IRS-assisted Systems**" (Oct 22, 2021). Abstract: The problems of channel estimation and passive beamforming are studied in intelligent reflecting surface (IRS)-assisted systems. To obtain channel estimates reflected by IRS and optimal phase configuration, we have utilized tools from deep neural networks and both TDD and FDD transmission are considered.
- ESR04 Azadeh Tabeshnejad, "**Using RIS for Agile Non-Orthogonal Multiple Access**" (Nov. 19, 2021). Abstract: Future mobile networks will need to be both highly efficient and agile to meet the envisioned requirements of diverse beyond-5G/6G services. Non-orthogonal multiple access (NOMA) allows flexible resource allocation via superposition of several signals in the same resource block. In this talk we give an introduction to our ongoing work on using reconfigurable intelligent surfaces (RIS) for agile non-orthogonal multiple access. In particular, we focus on the use of Simultaneous Transmission and Reflection (STAR)-based RIS as tools for achieving the channel gain differences necessary for NOMA to be effective.

In 2022, ESRs presented their ongoing research activities at various venues:

- Madhura Adeppady (ESR05) presented her work at the Italian Networking Workshop (INW) 2022, held at Courmayeur, Italy, on January 18. (https://inw2022.polito.it/).

  Abstract: Efficiently deploying microservices (MSs) is critical, especially in data centers at the edge of the network infrastructure where computing resources are precious. Unlike most of the existing approaches, we tackle this issue by accounting for the interference that arises when MSs compete for the same resources and degrades their performance. In particular, we first present some experiments highlighting the impact of interference on the throughput of co-located MSs. Then, we formulate an optimization problem that minimizes the number of used servers while meeting the MSs' performance requirements. In light of the

problem complexity, we design a low-complexity heuristic called iPlace, that clusters together MSs competing for resources as diverse as possible and, hence, interfering as little as possible. Importantly, the choice of clustering MSs allows us to exploit the benefit of parallel MSs deployment, which, as shown by experimental evidence, greatly reduces the deployment time as compared to the sequential approach applied in prior art.

- Maryam Bandali presented her work entitled "**ML-based Resolution Time Prediction of Trouble Ticket for Operational Telecommunication Networks**" at A5GARD (Achieving 5G service Assurance in the Residential Domain) project plenary session, Sweden, Stockholm 10-14 October 2022 and received feedback from partners.
- Klearchos Palias (ESR08), presented his work titled "**Massive Connectivity at the Network Edge**" at the Department of Digital Industry Technologies (University Of Athens) on 6 October 2022.

  Abstract: Due to the continuous growth of mobile video traffic, along with the demand for massive connectivity and fully personalised content consumption, new sets of standards for mobile data access have been set. Our proposed platform presents a blockchain based model, where 5G stakeholders can trade and share data in a fully decentralised and anonymous highly-robust fashion. Our proposed platform allows content streaming between peers, by utilising the openethereum blockchain consensus network. To this extent, different kinds of methods and functionalities can be executed and called through specific Smart Contract implementations and to finally allow users achieving secure communication and accurate content delivery, from one side to another (Client-PaymentRelay-ServiceProvider) through specific actions and procedures. Our proposed solution enables: high degree of decentralisation upon blockchain consensus, improved security mechanisms due to its blockchain distributed architecture, multi-million transactions/second, increased network's capacity throughput and finally anonymous instant off-chain payments, enabling fair-exchange of network and blockchain level resources.
- Swastika Roy (ESR09) is going to present her poster on "**Transparent 6G Network Slicing**" at the CTTC workshop, CTTC, Spain, 29 November 2022.

In 2023 and 2024, ESRs presented their ongoing research activities at various venues:

- Maryam Bandali collaborated with British Telecommunication (BT) company on providing the dataset of download throughput KPI time series with granularity of half an hour in Stockholm urban area during the period 2021-10-01 to 2021-10-05. The study was looking for the traffic profile to highlight its bursty nature in two timescales. 1. Busy Hour timescale (granularity: 1 second if possible) 2. Daily timescale (granularity: 30 minutes if possible).

- Maryam Bandali presented her work at yearly seminars of Information science and engineering (ISE) division of Electrical Engineering and computer science department of KTH royal institute of technology in April 13th, 2023 titled “Data driven analysis and automation for telecommunication network operation”.

  Abstract: his talk explores a data-driven algorithmic approach to help with fault automation and monitoring in the network operation domain. This research has been conducted using real Telenor Sweden telecommunication network data. Trouble Tickets (TTs) generated by network faults record the information about the problem and the actions taken throughout the troubleshooting. We study the evolution of TTs over time by investigating two use cases: 1. The prediction of the resolution time of the network faults and 2. the prediction of the need for technician dispatch. The objective is to assist the operators in scheduling their response effort, optimise resource usage, and provide the customers with reliable information. We implemented different machine learning models and studied their performances in our use cases to achieve the goal.

- Maryam Bandali presented her work at yearly seminars of ISE division of KTH royal institute of technology in May 2nd, 2024 titled “Churn Analysis of TV Customers in a Telecommunication Company Using Conventional and Causal Machine Learning Methods”.

  Abstract: Customer churn is defined as customers terminating their services with a company. Companies, specifically telecommunication operators (Telco), try to reduce the churn rate since it has been shown that attracting new customers could be up to six times more costly than retaining the existing ones . While extensive studies have been conducted around churn analysis and management using predictive and correlation based machine learning methods over the past two decades, a gap in the literature exists regarding causality analysis, particularly in the context of TV customer churn. In this seminar, we are going to discuss the

churn analysis of Telenor Sweden's TV customers. Our focus lies in the application of conventional and causal machine learning methods to analyse churn patterns and identify the primary factors affecting customers churning within this Telco operator.

- Maryam Bandali presented her research in Chalmers university titled “ML-based Fault Management Automation in Large-scale Fixed and Mobile Telecommunication Networks” in February 2024.

- Maryam Bandali presented a research proposal for Telenor in December 2023 titled “Data-driven Network Control and Automation - proposal of ideas for Telenor systems”

- Klearchos Palias presented his work titled “AR Assisted, GPS-Free Indoor Positioning” at the *1st Industry Tech* which took place at the M.E.C Exhibition Center (Paiania Athens, GR) on 24-26 November 2023.

- Klearchos Palias (ESR-08), presented his work titled “AR Assisted, GPS-Free Indoor Positioning” at the *University Of Athens* (Dpt. Of Digital Industry Technologies, Evripos Complex, Euvoia GR) on 2-3 April 2024.

  Abstract: Indoor Positioning Systems have become an essential technology in various fields today, including healthcare, logistics, retail, transportation, navigation and more. Numerous benefits such as, improved safety, enhanced security and increased productivity, are offered by the ability to track and locate objects and users accurately in Indoor environments in real-time. Our proposed solution (custom Android App) is a Hybrid IPS approach, combining both the Fingerprinting and a Visual-Based technique (3D Cloud Anchor capabilities - Hosting / Resolving), more precisely the Augmented Reality (AR) technology, in order to successfully map an Indoor space for our positioning and localization purposes. On top of that, different kinds of Machine Learning algorithms (KNN, wKNN, RF and more) were used and tested while focusing on achieving the highest possible accuracy. Our approach exploits an algorithm that combines the signal measurements gathered from the Wireless Networks (i.e WiFi & Cellular APs) and from Visual Data, resulting from “resolving ”CAs in the indoor space. Thereafter, finding the Client’s location can result from the combination of these collected information (RSSI in dbm, distance computation etc). Our real-life scenarios (1. BestServer, 2. WiFiBased, 3. CellularBased, 4. Hybrid, 5. VisualN, 6. WiFiCellularVisual)

examined on a specific Indoor Space (Lab 206) at the UoA Campus, showed a high degree of accuracy, having a margin of error less than 30cm from a Reference Point.

5.11 Semantic hackathon

The SEMANTIC partners will adapt the context of existing Hackathons events organized by them (e.g. POLITO organizes the MEC ETSI Hackathon in Turin, NOKIA has its own Hackathon event) to organize two comprehensive events on MEC-empowered service provisioning and 5G network automation with wide participation of programmers, engineers, students and others.

The SEMANTIC hackathon on "**Multi-access Edge Computing**" took place virtually on Thursday, February 24, 2022. This event was organized by Politecnico di Torino. All the ESRs actively participated in the event and gained knowledge on the concept of virtualization, container-based applications, and container orchestration. The ESRs performed various activities on Crownlab, a platform developed at Politecnico di Torino that allows immediate access to remote computing labs, using Kubernetes as a reference container orchestration system. Figure 13 shows all the participating ESRs and the hosts of SEMANTIC hackathon 2022.

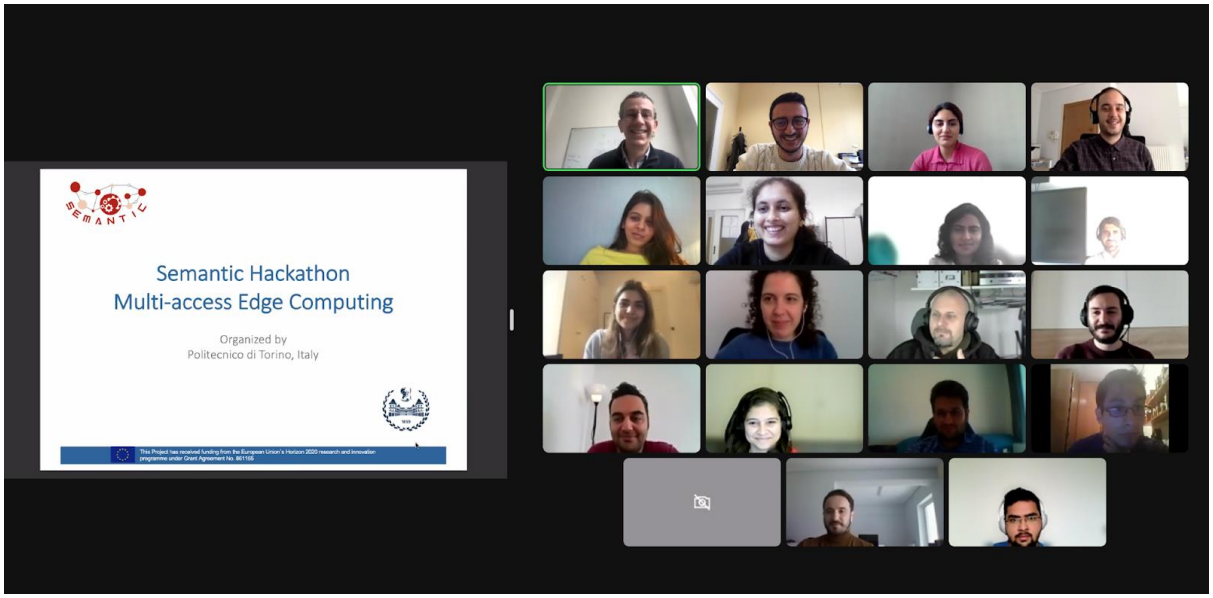


Figure 20: SEMANTIC Hackathon 2022

5.12 Café science

Four cafe science events will be scheduled along with some training activities (e.g. workshops, plenary meetings) in informal setting at public areas (e.g., cafe, pubs, etc.) where the ESRs will make a short presentation about their work

6. Conclusion

The central aim of this deliverable was to give a detailed view of the dissemination activities that will be undertaken by the SEMANTIC project. This not only includes the tradition dissemination routes, but also wider exploitation of results, including standardisation, and engagement of the general public.

The report is a living document, i.e., it will evolve during the course of the project, providing additional information on both overall and individual dissemination/exploitation activities. This deliverable includes the main achievements until M55.