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Innovation and excellence in massive-scale communications and information processing

INCOMING (Project No. 856967)

D3.6: Report on 3rd Summer School: 5G Technology Applications[1]

Abstract: This document presents a report on 3rd Summer School organized within the framework of the INCOMING project. The school gathered PhD students and researchers from all partner institutions which received training by leading experts in the field coming both from the partner and external institutions.

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List of Abbreviations

AAU	Aalborg University
CHALMERS	Chalmers University of Technology
COVID	Corona Virus Disease
DLR	German Aerospace Centre
ESR	Early Stage Researcher
EU	European Union
FTN	Faculty of Technical Sciences, University of Novi Sad
ICT	Information and Communication Technologies
IEEE	Institute of Electronic and Electrical Engineers
UNS	University of Novi Sad
WP	Work Package

Executive Summary

During the third and final year of the project, WP 2 and 3 training activities continued by providing intensive training programme to ICONIC researchers through **summer schools and individual on-site training,** complementing ongoing research collaboration via staff exchanges. Expert trainings and summer schools, representing the main collective training experiences in the project, provide platform where experts from EU partners transfer know-how to ICONIC researchers, in particular ESRs, through training sessions.

Training sessions take two forms: Summer schools and Expert trainings as detailed below.

- Summer schools are week-long events gathering gather ESRs from partner institutions where each day participants are provided with tutorial lectures by experts in the field.
- Expert training is a two or three-day event where an expert lecturer visits the University of Novi Sad and delivers in person traning to ICONIC researchers.

In this report, we present the details on the third project Summer School held in Oberpfaffenhofen (Germany) at the German Aerospace Centre during 12th to 16th of June 2023. The report also includes the fifth, sixth and announcement of the seventh Expert Training sessions held by Gianluigi Liva and Balasz Matus in April 2023, Prof. Cedomir Stefanovic (AAU) in July 2023 and Dr Hossam Farag (AAU) held in Novi Sad.

1 Introduction and School Agenda

During the course of the project, three annual summer schools are planned to be organized. The schools gather experts from AAU, CHALMERS, DLR, ICONIC centre and external lecturers to provide a tutorial-style lectures to ESRs from ICONIC and EU partners as well as ESRs external to the project. Each summer school targets the two research domains: i) massive IoT track, and ii) large-scale information processing track, i.e., the research areas corresponding to WP2 and WP3.

The first school has been organised by AAU in online format during COVID pandemic. Postponed for Autumn of 2021, the school's 5 days program has been distributed over 5 consecutive weeks in November and early December 2020. The second Summer school has been organised as a physical event during 13th to 17th of June at the Chalmers University of Technology campus in Gothenburg (Sweden). Finally, the third and final school is organised from 12th until 16th of June by German Aerospace Centre in Oberpfaffenhofen (Germany).

During 5 school days, 8 lecturers delivered their tutorials, 1 from AAU, 2 from DLR and 1 from ICONIC centre, adjoined with 4 external lecturers: Prof. Danijela Cabric and Prof. Lara Dolecek from the University of California, Los Angeles (USA), Prof. Roy Yates from Rutgers University, New Jersey (USA) and Prof. Jean-Francois Chamberlaind from Texas A&M University, College Station (USA). 9 participants from ICONIC, University of Novi Sad, and 3 from AAU travelled to DLR to join the school, along more than 10 DLR staff members, and PhD students from nearby Technical University of Munich (TUM).

In the following, after the final school agenda is presented in Table 1 on the next page, we present more details on the program of each school day.

	June 12th Monday	June 13th Tuesday	June 14th Wednesday	June 15th Thursday	June 16th Friday
09:30 – 10:30		**Jean-Francois Chamberland (Texas A&M University)** *„Notions of Approximate Message Passing in Communication Systems" – Part 1*	**Roy Yates (Rutgers University)** *„Age of Information: Status Updates for Real-time Systems"*	**Lara Dolecek (University of California, Los Angeles)** *"Channel Codes for Decentralized Adversarial Networks: Applications to Blockchains" – Part 1*	**Andrea Munari (DLR)** *"Remote Estimation of Two-State Markov Sources: Age of Information and State Estimation Entropy"*
10:30 – 11:00		Coffee Break	Coffee Break	Coffee Break	Coffee Break
11:00 – 12:00		**Jean-Francois Chamberland (Texas A&M University)** „Notions of Approximate Message Passing in Communication Systems" – Part 2	**Roy Yates (Rutgers University)** *„Age of Information in Networks"*	**Lara Dolecek (University of California, Los Angeles)** *"Channel Codes for Decentralized Adversarial Networks: Applications to Blockchains" – Part 2*	
12:00 – 13:30	Lunch + **Welcome** (Dejan, Estefania, Federico)	Lunch	Lunch	Lunch	Lunch + **End oF School**
13:30 – 14:30	**Aleksandar Minja (Novi Sad University)** *"On Product and Polar Codes"*	**Francisco Lázaro Blasco (DLR)** *** "An introduction to the Set Reconciliation Problem"	**Beatriz Soret (Alborg University)** *"Routing and edge computing in LEO satellite constellations"*	**Daniela Cabric (University of California, Los Angeles)** *„Deep Learning Approaches for Spatial Prediction, Spectrum Sensing, and RF Fingerprinting" – Part 1*	
14:30 – 15:00	Coffee Break	Coffee Break	Coffee Break	Coffee Break	
15:00 – 16:00	15:00 -15:30 Presentation of PS 15:30-16-30 **Poster Session**	15:30 - 16:15 **German Space Operations Center - visit** (only externals)	*** **Poster Session**	**Daniela Cabric (University of California, Los Angeles)** *„Deep Learning Approaches for Spatial Prediction, Spectrum Sensing, and RF Fingerprinting" – Part 2*	
From 19:00			Social Dinner : **Augustiner am Wörthsee** and Technical Discussions		

Table 1. 3rd INCOMING School Agenda

2 School Day 1 (12th June 2023)

The first school day started on Monday afternoon. We continued the practice of INCOMING schools to give floor to young and promising researchers from partner institutions to practice tutorial lecturing activities to a demanding audience. The lecturer was Dr Aleksandar Minja, an assistant professor from ICONIC centre, UNS. He presented a lecture entitled On Product and Polar Codes. Dr Minja has a strong expertise in the domain of coding and information theory. His research focus is in the domain of decoding algorithms design and analysis for various classes of error correcting codes.

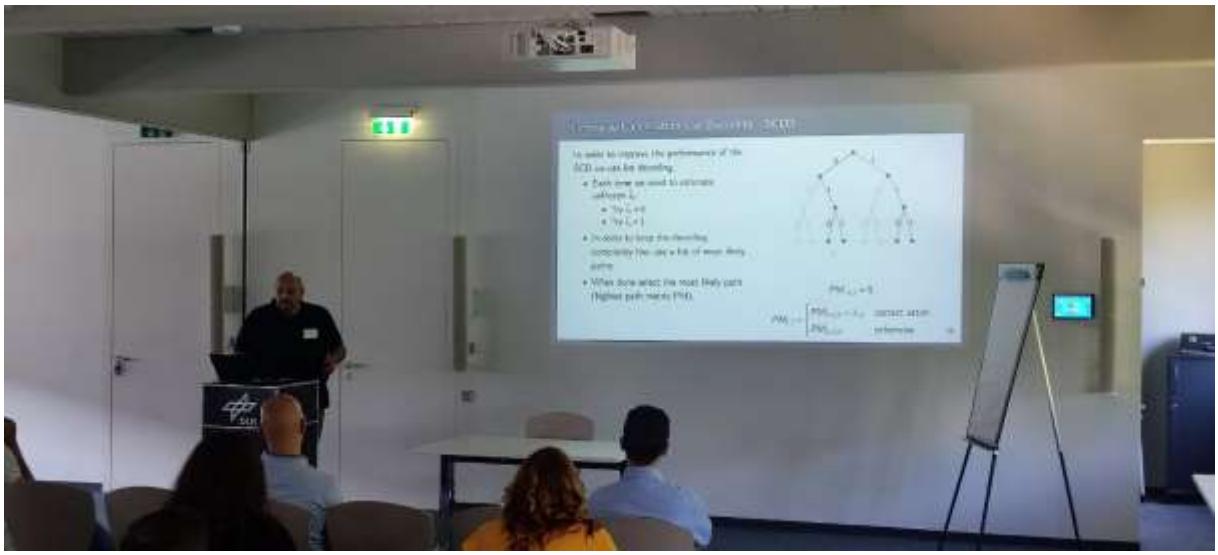

Figure 1. Dr Aleksandar Minja (UNS) – Tutorial lecture on product and polar codes

After the lecture on Monday afternoon, PhD students from different institutions are offered to present their research during a dedicated poster session. The following posters are presented:

- **Mieszko Jan Ferens Michalek (AAU)** ”Defensive Adversaria Technique for PUF“
- **Vukan Ninkovic (UNS)** „A Weighted Autodecoder-Based Approach to Downlink NOMA Costellation Design**“**
- **Ognjen Kundacina (UNS)** “State Estimation in Electrical Power Systems Using Graph Neural Networks”
- **Tijana Devaja (UNS) “**Error Probability Analysis of LP WAN Networks in Asymptotic and Finite Block-Length Regime”
- **Srdjan Sobot (UNS)** “Two-Tier UAV Low Power Wide Area Networks: a Testbed and Experimentations Study”
- **Sohail Sarang (UNS)** “Prediction based Adaptive Duty Cycle MAC Protocol for Solar Energy Harvesting Wireless Sensor Networks”
- **Farnaz Khodakhah (AAU)** “NOMA or Puncturing for Uplink eMBB-URLLC Coexistence from an AoI Perspective?”
- **Stefano Tinelli (DLR)** “Enhanced Decoders for Quantum Error Correction”
- **Jessica Bariffi (DLR)** “Codes in the Lee Metric and their Application in Post-Quantum Cryptography”
- **Alexander Sauter (DLR)** “Error Detection Strategies for CRC-Concatenated Polar Codes“

- **Ayman Zahr (DLR)** "Rate-Adaptive Protograph MacKay-Neal Codes'"

Figure 2. Monday afternoon poster session

3 School Day 2 (13th June 2023)

Figure 3. Prof Jean-Francois Chamberland (Texas A&M University) – Lecture on fundamentals and applications of Approximate Message Passing

The second school day started with the lecture entitled Notions on Approximate Message Passing in Communication Systems, presented by Prof. Jean-Francois Chamberland, from Texas A&M University, College Station (USA). The lecture covered fundamentals of Approximate Message Passing (AMP) algorithms widely applicable in signal processing domain and their applications in massive random access communication system design and analysis.

In the afternoon session, Francisco Lazaro Blasco, researcher at DLR, presented a lecture on Set Reconciliation Problems. After the lecture, the participants of the school made a visit to German Space Operations Centre which is located at the grounds of DLR institute.

Figure 4. Visit to German Space Operations Centre

5 School Day 3 (14th June 2023)

The third school day consisted of a tutorial lecture presented by Prof. Roy Yates, Rutgers University, New Jersey, USA. Prof. Yates presented a tutorial on Age of Information, a new performance metric relevant for real-time IoT systems and the associated fundamental theory that emerged during the past five years.

Figure 5. Prof. Roy Yates (Rutgers) – lecture on age of information

The second lecture during the day was provided by Prof. Beatriz Soret (AAU) who presented an interesting lecture on routing and edge computing in satellite low earth orbit (LEO) constellations.

Figure 6. Prof. Beatriz Soret (AAU) – lecture on satellite LEO constellations

Wednesday 16th of June afternoon was devoted to visit to lake Worthsee and social event at the restaurant near the lake.

6 School Day 4 (15th June 2023)

The fourth school day introduced two lecturers, Prof. Danijela Cabric and Prof. Lara Dolecek, both from the University of California, Los Angeles (USA).

Prof. Dolecek presented a lecture on channel codes for decentralised adversarial networks including coding for blockchain based systems.

Figure 7. Prof. Lara Dolecek (UCLA) – lecture on coding for blockchains

The second lecture is presented by Prof. Danijela Cabric (UCLA). Her lecture, entitled Deep Learning for Spatial Prediction, Spectrum Sensing and RF Fingerprinting, presented a range of fundamental and experimental topics in modern wireless communications that has been investigated recently at Prof. Cabric lab at the UCLA.

Figure 8. Prof. Cabric (UCLA) –overview of deep learning applications in wireless systems

7 School Day 5 (16th June 2023)

The fifth school day is concluded by a lecture presented by Dr Andrea Munari (DLR) whose talk focused on remote state estimation of Markov sources with special emphasis on age of information.

Figure 9. Dr Andrea Munari (DLR) – Lecture on remote state estimation

Finally, after lunch, the school is concluded and the final INCOMING school has been delivered as a successful event.

The report from INCOMING school also appeared in September 2023 in IEEE Information Theory Society Newsletter, informing the wider audience about H2020 INCOMING project activities. The link of the report in the ITSoc newsletter is available here:

https://www.itsoc.org/newsletter/article/report-2023-incoming-dlr-phd-summer-school

8 Expert Trainings

Expert On-Site Training: The expert training is envisaged in the form of short and intensive courses on a selected topic.

During the project COVID years (2020-2021), two online expert trainings were delivered. The online expert training by DLR experts Dr Andrea Munari and Dr Federico Clazzer was organized between 28th October and 30th October 2020 and the online expert training is provided by Dr Sokol Kosta, an Associate Professor from AAU between 27th and 31st of May 2021.

The third and fourth expert training are delivered physically starting from 2022 in Novi Sad, Serbia. The first in-person expert training is provided by Prof. Cedomir Stefanovic (AAU) between 11th and 14th of April 2022 at the University of Novi Sad. The fourth expert training was provided in person by Prof. Alexandre Graell i Amat between 26th and 29th of April 2022 in Novi Sad. The topic was Statistical Machine Learning and it covered important aspects of WP3 research, including probabilistic graphical models and variational and Monte Carlo inference methods.

The fifth expert training is provided by Gianluigi Liva and Balasz Matus (DLR) on 19th and 20th April of 2023 in Novi Sad. The training topic was on fundamentals and applications of coding for erasure channels. The training agenda and photo is provided below.

Figure 10. Balasz Matus (DLR) – 5th Expert Training on erasure codes

The sixth expert training is provided by Prof. Cedomir Stefanovic (AAU) on 19th and 20th April of 2023 in Novi Sad. The training topic was on fundamentals and applications of coding for erasure channels. The training agenda and photo is provided below.

Wednesday 19.04	Thursday 20.04
DLR Expert Training on Coding for Erasure Channels - Day 1 **Lecturers: Gianluigi Liva, Balázs Matuz**	**DLR Expert Training on Coding for Erasure Channels - Day 2** **Lecturers: Gianluigi Liva, Balázs Matuz**
09:00 – 09:45 **Lecture 1**: Introduction, channel capacities, decoding problem	**09:00 – 09:45** **Lecture 1**: Performance bounds III
09:45 – 09:55 **Short 10-mins Break**	**09:45 – 09:55** **Short 10-mins Break**
09:55 – 10:40 **Lecture 2:** Introduction to low-density parity-check (LDPC) codes I	**09:55 – 10:40** **Lecture 2:** Performance bounds IV
10:40 – 11:00 **Coffee Break**	**10:40 – 11:00** **Coffee break**
11:00 – 11:45 **Lecture 3**: LDPC codes II	**11:00 – 11:45** **Lecture 3**: LDPC code design
11:45 – 11:55 **Short 10-mins break**	**11:45 – 11:55** **Short 10-mins break**
11:55 – 12:40 **Lecture 4:** LDPC codes III	**11:55 – 12:40** **Lecture 4**: Applications of erasure codes
12:40 – 14:00 **Lunch break**	**12:40 – 14:00** **Lunch break**
14:30-15:15 **Lecture 5:** Performance bounds I	**14:00-14:45** **Assignment:** LDPC erasure code design I
15:15-15:25 **Short 10-mins break**	**14:45-14:55** **Short 10-mins break**
15:25-16:10 **Lecture 6:** Performance bounds II	**14:55-15:40** **Assignment:** LDPC erasure code design II

Table 2. 5th Expert Training Agenda

Figure 11. Prof. Cedomir Stefanovic (AAU) – 6th Expert Training on 5G and Beyond 5G Standardization

Thursday 06.07	Friday 07.07
AAU Expert Training on 5G and Beyond 5G Standardization - Day 1	**AAU Expert Training on 5G and Beyond 5G Standardization - Day 2**
09:00 – 09:45 Introduction to 3GPP standardization	**09:00 – 09:45** Release 17 5G New Radio Standardization overview
09:55 – 09:55 **Short 10-mins Break**	**09:55 – 09:55** **Short 10-mins Break**
09:55 – 10:40 5G service based architecture and 5G next generation radio access network	**09:55 – 10:40** Release 18 5G New Radio Standardization overview
10:40 – 11:00 **Coffee Break**	**10:40 – 11:00** **Coffee break**
11:00 – 11:45 Release 15 5G New Radio Standardization overview	**11:00 – 11:45** Open Radio Access Network (O-RAN) Standardization
11:45 – 13:00 **Lunch Break**	**11:45 – 13:00** **Lunch break**
13:00 – 14:30 Release 16 5G New Radio Standardization overview	**13:00 – 14:30** ML and AI in 5G and beyond

Table 3. 6th Expert Training Agenda

The final and 7th expert training will be delivered by Hossam Farag, an assistant professor from AAU on 15th and 18th September 2023. The details will be provided to participants in a timely manner.

9 School Attendance and Conclusions

The ICONIC summer school attracted participants both from the institutions in the project consortium (FTN, AAU, CHALMERS, DLR) and the external institutions (Technical University of Munich). The summer school had a very satisfactory reception by the participants. The school is featured in September issue of IEEE Information Theory Society newsletter available on this link: https://www.itsoc.org/newsletter/article/report-2023-incoming-dlr-phd-summer-school