



D5.3

Beyond 5G Forward Error Correction (FEC) Workshop

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Abstract:	This deliverable includes the organization and execution of scientific workshops and special sessions on next generation FEC research within leading conferences.
Keywords:	Workshop, special session, conference



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Executive Summary

This Deliverable provides a description of the different scientific special sessions in conferences and the B5G FEC scientific workshops that have been organized or co-organized by the EPIC project during its two first years. The aim of these events is to promote the results of the project and to further raise awareness among the scientific community, the industry and the policy makers.

Chapter 1 describes the contexts in which these events are organised: some of them were co-organized within the B5G cluster created by seven H2020 European projects and the others were proposed and organized by the EPIC project alone.

Then, Chapter 2 lists the different events co-organized by EPIC within the B5G project cluster and gives information such as the audience reached and the objective of the event.

Finally, Chapter 3 details the events organized by the project EPIC alone. The details of the proposals are provided when appropriate, as well as the event programme and the outcomes.

During the last year of the project, EPIC will continue to organize special sessions and workshops to strengthen the impact of its outcomes.

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Chapter 1 Introduction

After an awareness creation phase which took place during the first months of the project, EPIC has now transitioned into the second phase of its communication and dissemination plan (see D5.1 and D5.2). During this phase, the project pursues to promote its results and further raise awareness among the industry and scientific community. Among the possible dissemination means, EPIC planned the organization of a workshop and a special session in a leading conference in order to facilitate and gather B5G FEC related research and development outcomes and disseminate EPIC research results to a wide academic community.

This deliverable describes the special sessions and the workshops that have been proposed and/or organized by EPIC in international conferences in the field of network communications and systems.

An important action item for the EPIC project is to establish cooperation with active EU projects in related domains to coordinate some dissemination activities in order to maximise the impact of the projects. A B5G project cluster has been created with 5 other EC projects that have been successfully funded by EC under call H2020-ICT9- 2017 and one project from the call EU-Japan. The list of the 6 other projects, with the links to their websites are as follows (see D5.2 for more details): DREAM (<http://www.h2020-dream.eu/>), WORTECS (<https://wortecs.cms.orange-labs.fr>), TERAPOD (<http://terapod-project.eu/>), ULTRAWAVE (<http://www.ultrawave2020.eu/>), TERRANOVA (<https://ict-terranova.eu/>) and ThoR (joint EU-Japan project, <https://thorproject.eu>). The collaboration between the cluster members is ensured, among other things, through the proposal and organization of joint workshops. The list of workshops co-organized by EPIC within the cluster are given in Chapter 2.

Beyond these common workshops, the EPIC project alone has proposed and organized several special sessions and a workshop in order to disseminate its results to the industry and scientific community. The related proposals and outcomes for these are detailed in Chapter 3.

Chapter 2 Workshops organized by the B5G project cluster

This chapter lists the different workshops co-organized by EPIC within the B5G project cluster (see Table 1). These workshops have also been mentioned in deliverables D5.2 and D5.3.

Main Leader in EPIC	Title	Date	Place	Type of Audience ¹	Size of Audience / KPI	Website	Type and goal of the event
IMEC, TUKL	1 st Towards TeraHertz Communications Workshop: co-organization of Session 2 – Physical layer techniques for THz communication	March 2018	Brussels, Belgium	a, b, d	100-150	https://ec.europa.eu/digital-single-market/en/news/agenda-available-and-registrations-are-open-towards-terahertz-communications-workshop	Workshop organized by EC DG CONNECT in order to explore future R&I plans in THz communications technologies for the period beyond 2020. Overview of the state of the art of the research, discussion on the main challenges still to be explored, key research directions for future research and innovation actions and opinions on the potential frequency bands.
IDCC	Co-organization of a special session at EuCNC 2018	June 2018	Ljubljana, Slovenia	a, b, d	35-40	https://www.eucnc.eu/2018/www.eucnc.eu/special-sessions/special-session-3/	The special session was a showcase of the research progress in terabit wireless transport to enable new paradigms for a long term vision of 5G and beyond.
IDCC	Co-organization of the 2 nd Towards TeraHertz Communications Workshop	March 2019	Brussels, Belgium	a, b, d	100-150	https://terapod-project.eu/events/ec-thz-workshop/	This 2 nd workshop aimed at bringing together key actors currently working on, or having interest, in THz communications in order to explore future research and innovation plans for the period beyond 2020.

Table 1: List of workshops co-organized within the B5G project cluster

¹ a) Scientific community & higher education, b) Industry, c) Civil Society, d) Policy makers, e) Medias, f) others

Chapter 3 Special sessions and workshops organized and submitted by EPIC

3.1 December 2018: International Symposium on Turbo Codes & Iterative Information Processing (ISTC 2018)

The International Symposium on Turbo Codes & Iterative Information Processing (ISTC) is a leading biennial conference on advanced topics in channel coding theory and applications.

ISTC 2018 was co-organized by the Polytechnic University of Hong-Kong and the City University of Hong-Kong (see <http://www.istc2018.org/>) and was held in Hong-Kong on 3-7 December, 2018. ISTC 2018 featured seven special sessions focused on trends in modern forward error control coding and iterative information processing.

3.1.1 Special session on “FEC for Future Communication Systems – Implementation Issues”: programme

At ISTC 2018, the EPIC project organized a special session dedicated to implementation of FEC for future communication systems. The special session organization was agreed upon as a result of a direct contact with the TPC chairs of the conference (there was no call for special session proposal).

This objective of the special session was to provide an overview of the latest trends in the field of FEC implementation and, more specifically, to focus on implementation issues related to ultra-high throughput decoding and present the very first implementation results of the EPIC project.

The programme of the special session is given in Figure 1.

Thursday, December 6, 2018			
SS5: FEC for Future Communication Systems: Implementation Issues			Chairperson: Catherine Douillard, IMT Atlantique, France
11:10-11:40	Keynote	Norbert Wehn Tech. Univ. Kaiserslautern	When Channel Coding Hits the Implementation Wall
11:40-12:00		Stefan Weithoffer; Charbel Abdel Nour; Norbert Wehn; Catherine Douillard; Claude Berrou	25 Years of Turbo Codes: From Mb/s to beyond 100 Gb/s
12:00-12:20		Pascal Giard; Alexios Balatsoukas-Stimming; Andreas Burg	On the Tradeoff Between Accuracy and Complexity in Blind Detection of Polar Codes
12:20-12:40		François Leduc-Primeau; Elsa Dupraz; Francois Gagnon	Low-Latency LDPC Decoding Achieved by Code and Architecture Co-Design
12:40-13:00		Chris Winstead; Emmanuel Boutillon; Fakhreddine Ghaffari; Tasnuva Tithi	Recent Advances on Stochastic and Noise Enhanced Methods in Error Correction Decoders

Figure 1: Excerpt of ISTC 2018 programme featuring the special session SS5 organized by EPIC.

The special session was chaired by Catherine Douillard, TB, and started with a keynote talk given by Norbert Wehn, TUKL, who described the project goals as well some results from WP2 “B5G FEC Design” (see Figure 2).



Figure 2: Keynote talk of SS5 at ISTC 2018, given by Norbert Wehn, TUKL.

The keynote talk was followed by a second presentation given by Stefan Weithoffer and describing the parallel hardware architecture for turbo decoding developed in EPIC and achieving a throughput higher than 100 Gb/s (see Figure 3).



Figure 3: Talk given by Stefan Weithoffer, TUKL, describing the implementation of an ultra-high throughput decoder developed in EPIC.

3.1.2 *Special session on “FEC for Future Communication Systems – Implementation Issues”: audience*

At ISTC conferences, all the sessions are plenary sessions, including the special sessions. This means that the special sessions also offer the opportunity to attract all the conference attendance. The **audience at ISTC'2018 was estimated at over 150** academic researchers and industry stakeholders.

3.1.3 *ISTC 2018: others*

EPIC also co-organized with Huawei special session SS7 dedicated to ultra-high throughput coding for fibre-optical and B5G wireless communications. Erdal Arıkan, POL, was invited to give a keynote talk entitled “Polar Codes for Terabit/s Data Rates”.

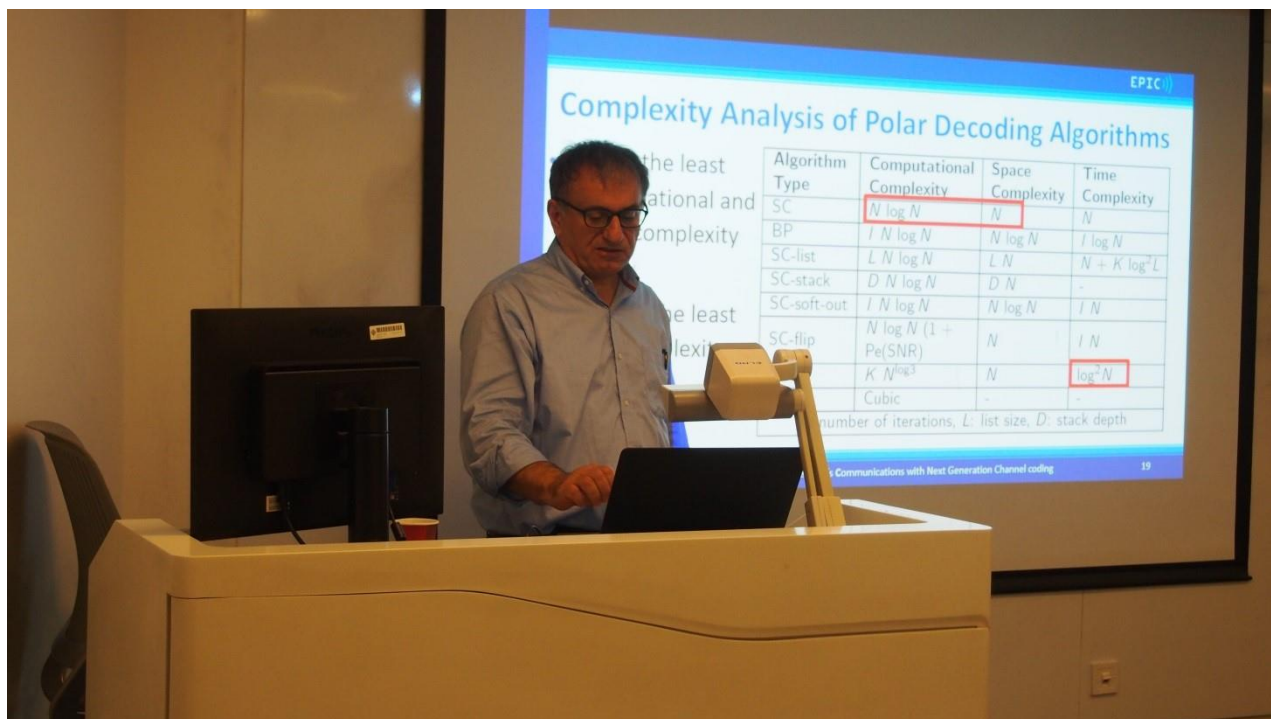


Figure 4: Keynote talk given by Erdal Arıkan at ISTC 2018.

3.2 European Conference on Networks and Communications (EuCNC 2019)

EuCNC is a conference in the field of telecommunications, sponsored by the IEEE Communications Society and the European Association for Signal Processing, and supported by the European Commission (<https://www.eucnc.eu/>). This conference is one of the most prominent communications and networking conferences in Europe, which brings together every year world academics and representatives of major organisations in the domain of network communications and systems.

EuCNC 2019 issued a call for special sessions (<https://www.eucnc.eu/call-for-special-sessions/>) and a call for workshops (<https://www.eucnc.eu/call-for-workshops/>) to allow projects or groups of projects to present their work and results.

In February 2019, the B5G project cluster – including EPIC – submitted a workshop proposal (duration: half-day) entitled “THz communications for systems beyond 5G: Use cases, accelerators, and challenges” while the EPIC project alone submitted a special session proposal (duration: one session slot) entitled “Next-generation channel coding towards terabit/s wireless communications” (see Section 0).

At the end of March 2019, the Special Sessions Chair of EuCNC 2019 sent an email to the two persons in charge of the above-mentioned workshop and special session asking **to merge both proposals into one single special session proposal**. We then learned that this request was due to the last-minute decision of co-locating the 7th Global 5G Event with EuCNC 2019, which reduced the number of available slots for workshops and special sessions.

Finally, the B5G project cluster, involving 7 EU projects including EPIC, and the EPIC project itself proposed a common special session entitled “Advanced THz technologies towards terabit/s wireless communications” (see Section 3.2.2).

3.2.1 EuCNC 2019: EPIC special session proposal

This section describes the initial proposal submitted to EuCNC 2019 for the organization of a special session entitled "Next-generation channel coding towards terabit/s wireless communications".



European Conference on Networks and Communications | Valencia, Spain

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Special Session Proposal

<u>Proposer's Name</u>	Catherine Douillard
<u>Proposer's Institution</u>	IMT Atlantique (https://www.imt-atlantique.fr/en , formerly Telecom Bretagne)
<u>Proposer's Email</u>	catherine.douillard@imt-atlantique.fr
<u>Proposer's Phone Number</u>	+33 229001383
<u>Proposer's CV</u> (text up to 300 words)	<p>Catherine Douillard received the engineering degree in telecommunications from the Ecole Nationale Supérieure des Télécommunications de Bretagne, France, in 1988, the Ph.D. degree in electrical engineering from the University of Western Brittany, France, in 1992, and the accreditation to supervise research from the University of Southern Brittany, France, in 2004.</p> <p>She is currently a full Professor in the Electronics Department of IMT Atlantique where she is in charge of the Algorithm-Silicon Interaction research team of the Lab-STICC laboratory (https://www.labsticc.fr). Her main research interests are error correcting codes, iterative decoding, iterative detection, coded modulations, diversity techniques and multi-carrier, multi-antenna and multiple access transmission systems.</p> <p>Since 2007, she has been participating to DVB (Digital Video Broadcasting) Technical Modules for the definition of DVB-T2, DVB-NGH and DVB-RCS NG standards. She served as the chairperson of the "Coding, Constellations and Interleaving" task force for the DVB-NGH TM group from 2010 to 2012.</p> <p>In 2009, she received the SEE/IEEE Glavieux Award for her contribution to standards and related industrial impact.</p> <p>She served as the technical program committee co-chair of the</p>

	<p>International Symposium on Turbo Codes and Iterative Information Processing, ISTC in 2010 and 2018, as the general chair of ISTC'2016 and she will serve as general co-chair of ISTC'2020.</p> <p>Since 2015, she has been involved in the H2020 European project FANTASTIC-5G, aiming to develop a new multi-service 5G air interface for below 6 GHz through a modular design, and since 2017 in EPIC, focusing on the development of a new generation of forward error correcting codes to enable practical wireless Tb/s technology.</p>
<p>Project (indicate the project, if the proposal is associate to one)</p>	<p>EPIC (Enabling Practical Wireless Tb/s Communications with Next Generation Channel Coding), H2020-ICT-09-2017, Grant agreement No. 760150</p> <p>Website: https://epic-h2020.eu/</p>
<p>Special Session Title</p>	<p>Next-generation channel coding towards terabit/s wireless communications</p>
<p>Motivation and Context (describe the motivation and background for the Special Session, up to 300 words)</p>	<p>In 2017, the European Commission issued call ICT-09-2017 addressing networking research beyond 5G. This call specifically includes perspectives for the exploitation of the terahertz frequency band to bring wireless systems to the speed of optical technologies, as well as advanced signal processing, antenna processing, information theory and coding to optimize and reach Tbit/s in wireless communications.</p> <p>More recently, in July 2018, the International Telecommunication Union launched a new focus group, FG NET-2030, to study the capabilities of networks for the year 2030 and beyond, which are expected to support novel forward-looking scenarios, such as holographic multimedia, instantaneous data delivery and movement, remote surgery, humanoid robots, or fully autonomous transportation systems. In the study of these network architectures, new communication requirements are expected to emerge, including very-high throughput to support explosive bandwidth-intensive future applications beyond the limitation of near future 5G networks.</p> <p>In this context, the H2020 EPIC project EPIC aims to make a major contribution to the realization of a practical wireless Tb/s link technology by developing a core technology enabler of such links, namely, the forward error correction (FEC), a.k.a. channel coding, component in a manner that will serve as a fundamental enabler of practicable beyond 5G wireless Tb/s solutions. EPIC targets to achieve this goal by developing a disruptive FEC design framework, novel channel codes and their enabling algorithms, and a chipset design to validate this new generation of FEC.</p> <p>This special session brings together experts in information and coding theory, in advanced hardware design and ASIC integration to present the main implementation challenges to be faced for the current most advanced channel coding techniques, i.e. turbo codes, low-density parity-check codes and polar codes, and to describe specific code designs, decoding algorithms and decoder</p>

	architectures, designed towards Tb/s throughputs.
<p>Structure (text describing the content of the Special Session, identifying the existence of an invited speaker (if relevant), and topics and authors (name, affiliation and country) of papers)</p>	<p>The duration of the talks will be 30 min plus 5 min for questions for the invited talk and 17-18 min + 3-4 min for questions for the regular presentations.</p> <ul style="list-style-type: none"> • Invited talk: Channel Coding for Tb/s Communications – An Implementation Centric View, Norbert Wehn (TU Kaiserslautern, Germany) • Regular papers: <ul style="list-style-type: none"> - Turbo code design and decoder architectures for ultra-high throughput, C. Abdel Nour, C. Douillard (IMT Atlantique, France), S. Weithoffer, N. Wehn (TU Kaiserslautern, Germany) - Polar codes for Tb/s communications, Erdal Arıkan (Polaran, Turkey), C. Kestel, N. Wehn (TU Kaiserslautern, Germany) - Towards Tb/s LDPC Decoders, M. Li (IMEC, Belgium) M. Herrmann (TU Kaiserslautern, Germany), T. Lehnig-Emden (Creonic, Germany)
<p>Conference Track(s) (indicate the conference Track(s) that are mapped by this Special Session)</p>	PHY – Physical Layer and Fundamentals (Beyond 5G, Terahertz communication)
<p>Specific Promotion (provide any specific plans that you may be considering for announcing the Special Session)</p>	<p>The participation in the special session would be announced on the EPIC project’s official website, as well as on social media channels. Furthermore, since EPIC will participate in the upcoming Oberpfaffenhofen Workshop on High Throughput Coding, which will be held in Germany at the end of February 2019 (see https://www.lnt.ei.tum.de/events/2019-oberpfaffenhofen-workshop-on-high-throughput-coding-owhtc/), mails for advertising the special session will sent to the participants of this workshop.</p>

3.2.2 EuCNC 2019: Final EPIC/B5G cluster special session proposal

Due to the above-mentioned changes in the EuCNC 2019 programme, a modified common special session entitled “Advanced THz technologies towards terabit/s wireless communications” was proposed, consisting of three invited talks: one dedicated to the B5G project cluster, the second to our EPIC project and the third one to the regulatory aspects of THz communications (Thor project).

Special Session

Special Session Title	Advanced THz technologies towards terabit/s wireless communications
Special Session chairs	Angeliki Alexiou, University of Piraeus (alexiou@unipi.gr), Catherine Douillard, IMT Atlantique (catherine.douillard@imt-atlantique.fr)
Projects Involved	<p>ICT Beyond 5G Cluster</p> <p>Six projects from the H2020 call ICT-09-2017 and one project from the call EU-Japan 2018 have been funded:</p> <p style="text-align: center;">DREAM www.h2020-dream.eu EPIC epic-h2020.eu</p>

	<p>TERAPOD terapod-project.eu TERRANOVA ict-terranova.eu ULTRAWAVE ultrawave2020.eu WORTECS wortecs.eurestools.eu THOR thorproject.eu</p>
<p><u>Abstract</u></p>	<p>While the wireless world is moving towards the 5G era and many technological advances have been proposed, there seem to be significant limitations in the capability to efficiently and flexibly handle the massive amount of QoS/QoE-oriented data that will be exchanged in a future Big-Data-driven society along with the super-high data rate and almost zero latency requirements. Thus, wireless Tb/s communications and the supporting backhaul network infrastructure are expected to become the main technology trend within the next ten years and beyond. Terahertz (THz) transmission as a wireless backhaul extension of the optical fibre is an important building block to close this gap and guarantee high-speed internet access everywhere beyond 5G. Moreover, the increasing number of mobile and fixed users in the private sector as well as in the industry and the service sector will require hundreds of Gb/s in the communication to or between cell towers (backhaul) or between cell towers and remote radio heads (fronthaul). In such scenarios, apart from the high data rates on the order of Tb/s the critical parameter is range.</p> <p>Together with extraordinary promises, THz communication brings unique and novel challenges that require rethinking classic communications and networking mechanisms. The root cause for these challenges is the ultra-wideband and extremely directional nature of THz communications links and other THz communications peculiarities in terms of signal and antenna design, and channel modelling, taking into account contributions of line-of-sight/non-line-of-sight, reflected and scattered components as well as molecular noise and blocking probabilities inherent in such high frequency regimes. Medium access control and radio resource management protocols now have to operate with pencil beams and thus have to be based on completely new principles, fast handover procedures have to include the time required for discovery, localization and tracking functionalities. The Tb/s data rates create significant challenges for the transceiver processing including algorithm and architecture design as well as hardware implementation.</p> <p>Motivated by the potential of THz technologies to transform the future of ICT, this Special Session aspires to reveal and discuss the critical technology gaps as well as the appropriate enablers, in terms of baseband processing RF frontend, channel models and waveforms, signals and coding, beam-patterns and medium access schemes.</p> <p>This special session brings together experts in information and coding theory, in advanced hardware design and ASIC integration and wireless access technologies and algorithms to present the main implementation challenges to be faced and to describe specific designs, algorithms and architectures, designed towards Terabit/s</p>

	throughputs.
<p>Workshop TPC (identification of the key people for the Workshop Technical Programme Committee)</p>	<p>ICT Beyond 5G Cluster Steering Committee Alan Davy, Waterford Institute of Technology, Ireland Angeliki Alexiou, University of Piraeus, Greece Bruce Napier, Vivid Components Ltd., Germany Claudio Paoloni, Lancaster University, UK Mir Ghoraiishi, pureLiFi, UK Onur Sahin, InterDigital, UK Thomas Kürner, TU Braunschweig, Germany Vladimir Ermolov, VTT Technical Research Centre, Finland</p> <p>Technical Programme Committee Catherine Douillard, IMT Atlantique, France Thomas Kürner, TU Braunschweig, Germany Andre Bourdoux, Imec, Belgium Andrea Mazzanti, University of Padova, Italy Colja Schubert, Fraunhofer HHI, Germany, Germany Dominic O’Brien, Oxford University, UK Olivier Bouchet, Orange, France Viktor Krozer, Goethe University Frankfurt, Germany Thomas Merkle, Fraunhofer IAF, Germany Rodolphe Legouable, IRT B-com Norbert Wehn, TUK, Germany Marion Habernig, TECHNIKON, Austria Nikola Serafimovski, pureLiFi Ltd, UK Ravinder Singh, Oxford University, UK Tetsuya Kawanishi, Waseda University, Japan</p>
<p>Previous Editions (in case it’s not the first edition, give information on previous ones, e.g., people involved, number of participants, number of submitted and accepted papers, among other)</p>	<ul style="list-style-type: none"> • Special Session on THz Comms organised by the Cluster at EuCNC 2018 • 1st “Towards TeraHertz Communications” workshop, EC, Brussels (07-Mar-2018) • 2nd “Towards TeraHertz Communications” workshop, EC, Brussels (07-Mar-2019)
<p>Programme</p>	<ul style="list-style-type: none"> • “H2020 ICT Beyond 5G Cluster: from millimeter waves to Tb/s”, Claudio Paoloni, (Lancaster University, UK) • “Channel Coding for Tb/s Communications – An Implementation Centric View”, Norbert Wehn (TU Kaiserslautern, Germany) • “Regulatory Aspects of THz Communications and Activities towards WRC 2019”, Thomas Kuerner, (TU Braunschweig, Germany)

3.2.3 Special session SS2 at EuCNC 2019, Valencia, Spain, 19 June 2019: “Advanced THz technologies towards terabit/s wireless communications”

The second proposal was successful and the special session was held on Wednesday, 19 June 2019, see <https://www.eucnc.eu/special-sessions/special-session-2/> (see Figure 5).



Figure 5: Invited talks of the special session at EuCNC 2019, Valencia, Spain, 19 June 2019.

Norbert Wehn, TUKL, gave an invited talk, entitled “Channel Coding for Tb/s Communications – An Implementation Centric View”, giving an overview and first results of EPIC: he highlighted implementation challenges for the studied advanced channel coding techniques, i.e. Turbo codes, Low-Density Parity-Check (LDPC) codes and Polar codes and presented decoder architectures for all three code classes that were designed for highest throughput.

The session was well attended, **around 40 participants**, and the presentations raised many questions.

3.3 IEEE Conference on Communications, ICC 2020

The IEEE International Conference on Communications (ICC) is one of the IEEE Communications Society's two flagship conferences dedicated to driving innovation in nearly every aspect of communications. Each year, around 3,000 researchers submit proposals for paper presentations and program sessions to be held at the annual conference. ICC 2020 will be held in Dublin, Ireland, in June 2020 (see <https://icc2020.ieee-icc.org/>). ICC 2020 issued a call for workshop proposals in order to emphasize emerging topics not specifically covered in the main symposia of the conference (<https://icc2020.ieee-icc.org/call-workshop-proposals>).

In early August 2019, the EPIC project submitted a proposal for a half-day workshop, entitled "FEC4Tb/s: Forward Error Correction Coding for Tb/s Communications":

Title of the workshop: FEC4Tb/s: Forward Error Correction Coding for Tb/s Communications

Workshop Organizers:

- Catherine Douillard, IMT Atlantique, FR, catherine.douillard@imt-atlantique.fr
- Onur Sahin, InterDigital, UK, onur.sahin@interdigital.com

Scope and topics of the workshop:

This workshop aims to bring experts in information and coding theory together with experts in advanced hardware design and ASIC integration, in order to jointly tackle the encountered challenges for advanced channel coding techniques when throughputs up to Tb/s are targeted. Such data rates will be required for future wireless communications (beyond 5G) or for optical networks.

For several decades, improvement in silicon process technology has provided better performance, lower cost per gate, higher integration density and lower power consumption. However, we have now reached a point where Moore's law is slowing down and microelectronics alone can no longer keep pace with the increasing requirements of communication systems. Therefore, the Tb/s data rate target creates significant challenges for the design of transceivers. In particular, forward error correction is a foundational component of almost all wired and wireless link technologies, constituting the most complex and computationally intense component in the baseband chain. As a consequence, silicon implementations of advanced channel coding schemes require a cross-layer approach covering information theory, algorithm development, parallel hardware architectures and semiconductor technology.

This workshop aims at presenting the state-of-the-art on the fast evolving research on forward error correction coding for high throughput transmissions.

The considered topics of interest are mainly the following ones:

- Channel coding for high-throughput wireless communications
- Channel coding for optical networks
- Coding for higher-order modulations
- Techniques and designs for length and rate adaptation
- Decoding algorithms
- Quantization schemes for high-throughput decoders
- High-throughput decoders for LDPC, turbo, polar, product-like codes
- Advanced high-throughput hardware architectures
- Advanced high-throughput software decoders
- High-throughput ASIC and FPGA implementations of decoders

Rationale:

While the wireless world is moving towards the 5G era and many technological advances have been proposed, there seem to be significant limitations in the capability to efficiently and flexibly handle the massive amount of QoS/QoE-oriented data that will be exchanged in a future Big-Data-driven society along with the super-high data rate and almost zero latency requirements. Thus, wireless Tb/s communications and the supporting backhaul network infrastructure are expected to become the main

technology trend within the next ten years and beyond.

For several decades, improvement in silicon process technology has been able to largely contribute to the achieved increase in throughput at a lower cost in area and power consumption. However, we have now reached a point where Moore's law is slowing down and microelectronics alone can no longer keep pace with the increasing requirements of communication systems. Therefore, the Tb/s data rate target creates significant challenges for the design of forward error correcting codes, considered as a foundational component of almost all wired and wireless link technologies. As a consequence, future silicon implementations of advanced channel coding schemes require a cross-layer approach covering information theory, algorithm development, parallel hardware architectures and semiconductor technology.

This workshop on Forward Error Correction Coding for Tb/s Communications aims to present the state of the art on the fast evolving research in forward error correction coding for high throughput communications. Its specificity and novelty lies in its holistic approach, since it jointly covers all the different aspects of high-throughput coding, including coding theory (code design), efficient decoding algorithms, corresponding hardware architectures and their implementation.

A short biography of the organizers:

Catherine Douillard is a full Professor at IMT Atlantique, Brest, France, where she is in charge of the Algorithm-Silicon Interaction research team of the Lab-STICC laboratory. Her main research interests are error correcting codes, iterative decoding and detection, coded modulations, diversity techniques and multi-carrier/antenna transmission systems. Since 2007, she has been participating to DVB (Digital Video Broadcasting) for the definition of DVB-T2, DVB-NGH and DVB-RCS NG standards. She served as the chairperson of the "Coding, Constellations and Interleaving" task force for the DVB-NGH TM group from 2010 to 2012. In 2009, she received the SEE/IEEE Glavieux Award. She was also involved in the organization and/or technical chairing of the International Symposium on Turbo Codes and Iterative Information Processing, ISTC, in 2010, 2016, and 2018.

Onur Sahin received his B.S. degree in electrical and electronics engineering from Middle East Technical University, Ankara, Turkey, in 2003 and Ph.D. degree in electrical engineering from the Polytechnic Institute of New York University, USA in 2009. He is currently a Senior Staff Engineer at Innovation Labs, InterDigital Europe. His primary research and development interests are on the next generation telecommunication and wireless systems (including 5G and beyond). Dr. Sahin has held technical lead positions at multiple projects on next generation cellular and Wi-Fi systems including 5G NR, LTE-A and IEEE 802.11 standards. He currently leads Beyond-5G ultra-high throughput (Tbps/THz) wireless technology design and development at InterDigital. Dr. Sahin is the co-author of over 50 peer-reviewed scientific articles and co-inventor of 25 patents and patent applications. He is co-recipient of the 2018 IEEE Signal Processing Society Best Paper Award, 2016 Journal of Communication Networks Best Paper Award, and InterDigital Innovation Awards in 2012 and 2015.

Names of potential participants:

- *Invited speaker:* Prof. Norbert Wehn, University of Kaiserslautern, DE (accepted), tentative title: "Channel coding for Tb/s wireless communications: insights into implementation".
- *Technical Program Committee (TPC) chairs:*
 - o Prof. Charbel Abdel Nour, IMT Atlantique, FR,
 - o Dr. Claude Desset, IMEC, BE
- *TPC members:*
 - o Leefke Grosjean, Ericsson, SE
 - o Stefan Weithoffer, University of Kaiserslautern, DE
 - o Emmanuel Boutillon, University of Western Brittany, FR
 - o Meng Li, IMEC, BE
 - o François Leduc-Primeau, Polytechnique Montreal, CA
 - o Robert G. Maunder, University of Southampton, UK
 - o Guido Montorsi, Politecnico di Torino, IT

Planned format of the workshop:

- Duration of the workshop: **1 half-day**
- Tentative schedule:
 - o Welcome and opening statement (5 min)

- Keynote talk (40 min, incl. questions): Norbert Wehn, University of Kaiserslautern
- Oral session 1 (4 presentations, ~18 min/pres.):
- Coffee break (15 min)
- Oral session 2 (4 presentations, ~18 min/pres.)

Draft Call for Papers:

The Workshop on Forward Error Correction Coding for Tb/s Communications will be held in Dublin, Ireland, in conjunction with the IEEE ICC 2020, June 7-11, 2020.

This workshop aims to bring together experts in information and coding theory as well as in advanced hardware design and ASIC integration to present the main challenges to be faced for advanced channel coding techniques when throughputs up to Tb/s are targeted. Such data rates will be required for future wireless communications (beyond 5G) or in optical networks.

For several decades, improvement in silicon process technology has provided better performance, lower cost per gate, higher integration density and lower power consumption. However, we have now reached a point where Moore's law is slowing down and microelectronics alone can no longer keep pace with the increasing requirements of communication systems. Therefore, the Tb/s data rate target creates significant challenges for the design of transceivers. In particular, forward error correction is a foundational component of almost all wired and wireless link technologies, constituting the most complex and computationally intense component in the baseband chain. As a consequence, silicon implementations of advanced channel coding schemes require a cross-layer approach covering information theory, algorithm development, parallel hardware architectures and semiconductor technology.

This workshop aims at presenting the state-of-the-art on the fast evolving research in forward error correction coding for high throughput communications. The workshop will provide a platform for the dissemination of research. Topics of interest include but not limited to:

- Channel coding for high-throughput wireless communications
- Channel coding for optical communications
- Coding for higher-order modulations
- Techniques and designs for length and rate adaptation
- Decoding algorithms
- Quantization schemes for high-throughput decoders
- High-throughput decoders for LDPC, turbo, polar, product-like codes
- Advanced high-throughput hardware architectures
- Advanced high-throughput software decoders
- High-throughput ASIC and FPGA implementations of decoders

Important Dates:

- Deadline for paper submission: **27 January 2020**
- Acceptance/rejection notification: **11 March 2020**
- Final papers due: **25 March 2020**

Publicity and promotion plan

The workshop will be announced on the H2020 EPIC project's official website (<https://epic-h2020.eu/>), as well as on social media channels (Twitter, LinkedIn). Mails for advertising the workshop will also be sent to the mailing list of the International Symposium on Turbo Codes and Iterative Information Processing (ISTC), a biennial conference on advanced research in iterative information processing and its application to information theory and digital communications (<https://istc2020.org/>).

Workshop potential website address: A webpage will be created for the workshop on the EPIC website (<https://epic-h2020.eu/>).

There is no past version of this workshop.

The notification of acceptance for this workshop proposal is scheduled for the end of August 2019.

Chapter 4 Conclusion

This Deliverable describes the different special sessions in conferences and the workshops organized or co-organized by the EPIC project during its two first years. On the one hand, one special session at the EuCNC conference and two specific workshops on THz Communications supported by the EC were organized as a member of the B5G project cluster. On the other hand, the EPIC project alone organized a special session at a leading conference on FEC coding, proposed another special session at EuCNC, which was finally merged with another session proposed separately by the B5G project cluster and submitted a workshop proposal at ICC 2020. The outcome of the latter submission will be known at the end of August 2019.

During the last year of the project, EPIC will continue to organize special sessions and workshops to strengthen the impact of the results obtained. These events will continue to promote the project results and raise awareness among the scientific and industrial stakeholders, in order to contribute to the dissemination of the project outcomes in the most relevant standardization bodies.

Chapter 5 List of Abbreviations

Abbreviation	Translation
5G	5 th Generation of wireless communication systems
5G NR	5G New Radio
ASIC	Application-Specific Integrated Circuit
B5G	Beyond the 5 th Generation of wireless communication systems
DG CONNECT	Directorate-General for Communications Networks, Content and Technology
DVB	Digital Video Broadcasting
DVB-NGH	Digital Video Broadcasting - Next Generation Handheld
DVB-T2	Digital Video Broadcasting – 2 nd generation Terrestrial
DVB-RCS NG	Digital Video Broadcasting – Return Channel via Satellite Next Generation
EC	European Commission
EU	European Union
EuCNC	European Conference on Networks and Communications
FEC	Forward Error Correction
FPGA	Field-Programmable Gate Array
Gb/s	Gigabit per second
ICC	International Conference on Communications
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
ISTC	International Symposium on Turbo Codes and iterative information processing
LDPC	Low-Density Parity-Check
LTE-A	Long Term Evolution - Advanced
Mb/s	Megaabit per second
QoE	Quality of Experience
QoS	Quality of Service
RF	Radio Frequency
SS	Special Session
Tb/s	Terabit per second
THz	TeraHerz
TPC	Technical Programme Committee