H2020 5G-Coral Project

Grant No. 761586

D5.2- Communication, dissemination, standardisation and exploitation achievements in Y2 and cumulated with Y1, along with plan beyond the project duration

Abstract

This deliverable (D5.2) reports on all the activities undertaken in WP5 in the second year of the project, i.e. from 1st of September 2018 to 31st of August 2019. In addition, as the final deliverable from WP5, it also provides a summary of the key achievements throughout the project lifetime and outlines the prospects of future activities after the end of the project.

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Disclaimer

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Executive Summary

To maximize its impact, the 5G-CORAL project has invested significant efforts in project lifetime to communicate and disseminate the project vision, concept, technology and results, to all stakeholders in the wide international community. This deliverable provides a summary of the different activities on Dissemination, Communication and Exploitation performed during the second year of the project and summarizes all cumulative achievements throughout the project lifetime. It also provides an outline of future activities that may be carried after the project end on 31 August 2019.

Amongst the key achievements in Year 2 are (summarised in **Table 1**):

- Active communication and dissemination of the project through 16 public presentations, 6 organized workshops, 5 videos at key events, 1 leaflet at the MWC'19 as part of 5G-PPP, and 1 public summary in the European 5G Annual Journal 2019.

- Proactive open source, standardization, and exploitation of the project through 5 open source contributions, 14 standard contributions feeding into key standardization specifications such as: IETF and ETST, 4 booths with 19 demonstrations.

Cumulatively over the project lifetime from 01 September 2017 to 31 August 2019, the project exceeded on all metrics set for the targeted activities (summarised in Table 2) as highlighted below:

- Active communication and dissemination of the project through 31 public presentations, 8 organized workshops, 9 videos at key events, 2 leaflets at the MWC'18 and '19 as part of 5G-PPP, and 2 public summary in the European 5G Annual Journal 2018 and 2019.

- Proactive open source, standardization, and exploitation of the project through 6 open source contributions, 42 standard contributions feeding into key standardization specifications such as: IETF and ETST, 5 booths with 25 demonstrations.

TABLE 1: SUMMARY OF OVERALL ACHIEVEMENTS IN YEAR 2.

Activities		Achievements
Press and Media	Public Summary	1
	Leaflet	1
	Poster/Slides	6
	Press Release	2
	Videos	5
Public Presentations		16
Education and Training		1
Publication		14
Organized Events		6
Open Source Contributions		5
Co-organisation activities with other 5G-PPP projects		10
Exhibitions	Booth	4
	Demo	19
Standard Contributions		14

Communication, dissemination, standardisation and exploitation achievements
in Y2 and cumulated with Y1, along with plan beyond the project duration

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TABLE 2: SUMMARY OF OVERALL ACHIEVEMENTS IN PROJECT LIFETIME.

Activities		Achievements
Press and Media	Public Summary	2
	Leaflet	2
	Poster/Slides	8
	Press Release	8
	Videos	9
Public Presentations		31
Education and Training		2
Publication		25
Organized Events		8
Open Source Contributions		6
Co-organisation activities with other 5G-PPP projects		10
Exhibitions	Booth	5
	Demo	25
Standard Contributions		42

1   Introduction

This deliverable reports on the achievements of 5G-CORAL project in Year 2 for all communication, dissemination, standardization and exploitation activities and summarizes all cumulative achievements throughout the project lifetime. It also outlines future activities that may be carried after the project end.

The deliverable is structured into five main chapters, namely, (1) communication and public activities, (2) dissemination and collaboration activities, (3) standardization and open source activities (4) exploitation activities, and (5) achievements of a joint exploitation workshop.

Chapter 2 reports on the communication and public activities undertaken in Year 2. These activities are steered towards ensuring an up-to-date communication on the project to the large public through various channels including web portal, social networks, videos, and magazine articles.

Chapter 3 reports on the dissemination activities including talks, workshops, and peer-reviewed scientific articles. It also reports on related collaboration activities undertaken in the framework of the 5G-PPP including its projects and working groups. The goal of such activities is mainly to promote the project to the Research & Development (R&D) stakeholders and raise opportunities for collaboration or synergy with other projects and activities.

Chapter 4 reports on the standardization and open source activities undertaken and presents the standardization roadmap developed in the project. These activities are aimed at creating an influence from/to ongoing or future standardization activities so that the technology developed in the project can have an easier path for exploitation into future products.

Chapter 5 reports on the exploitation activities undertaken with the aim to identify innovations from the project that can find venues for exploitation in products, proof-of-concepts, and services.

Chapter 6 reports on the exploitation workshop performed in conjunction with 5G-TRANSFORMER and the SME 5G-PPP WG during EuCNC 2019. This workshop has been of particular importance to understand how the different innovations of 5G-CORAL could potentially impact the European SMEs.

The deliverable ends with conclusions summarizing the work done in Year 2, and summarizes all cumulative achievements throughout the project lifetime. Moreover, the deliverable insights on the next steps planned in the future.

2 Communication and Public Activities

Communication activities undertaken in Year 2 have been steered towards ensuring an up-to-date communication on the project concept and results to the large public through various tools including web portal, social networks, videos, interviews, leaflets, posters and magazine articles. This chapter provides the Year 2 plan set for communication activities and reports the subsequent achievements.

2.1 Objectives of Project Year 2 (M13-M24)

The focus in Year 2 has been put on raising and fostering awareness of the 5G-CORAL project vision, concept, objectives, and results, amongst the various stakeholders (R&D community, market players, and the public). The following objectives were set:

- Continuous maintenance of the project web portal for an up-to-date communication on all events and milestones from the project to the wide community.

- Continuous maintenance of social networks accounts to complement with the project web portal.

- Delivery of video interviews, posters, and magazine articles for promoting the project vision,   concept and initial results.

- Issuing of a press release announcing related events and our new achievements.

- Preparing a second project leaflet reflecting on the project concept and new achievements in time for communication at the Mobile World Congress 2019.

2.2 Report on Activities Undertaken and Achievements

In the project Year 2, activities have been undertaken towards fulfilling the objectives set above. These are reported in

Table 3,

Table 4, and Table 5, respectively for activities relating to (1) project portal and social networks, (2) press releases, blog articles and magazine articles, and (3) videos, posters, and leaflets.

The leading partner for this task has been UC3M (the project coordinator) and the 5G-CORAL project has appointed a representative (NCTU, WP5 manager) for liaison with the 5G-PPP communication and dissemination working group, where news and events from 5G-CORAL are shared within the 5G-PPP.

TABLE 3: PROJECT PORTAL AND SOCIAL NETWORKS.

#	Month	Description	Lead partners
1	Throughout Y2	Maintenance of 5G-CORAL project web portal http://5g-coral.eu/	UC3M
2	Throughout Y2	Maintenance of twitter @5G_CORAL and 5G-CORAL LinkedIn group	UC3M
3	Throughout Y2	Constant update of the project web portal with contents on the talks, workshops, demonstrations, and events undertaken and planned. It has been given free access to download public presentations and materials from the partners, subject to partner permission.	UC3M
4	Throughout Y2	Synchronicity between project web portal and the social media news shared on the project Twitter and LinkedIn accounts.	UC3M

5	Throughout Y2	Maintenance translation between English and Chinese of contents of the project web portal	NCTU

TABLE 4: PRESS RELEASES, BLOG ARTICLES, AND MAGAZINE ARTICLES.

#	Month	Description	Lead Partners
1	Jan '19	Press release: "5TONIC partners showcase live demonstrations of Edge Robotics technology in Taiwan" relayed by various media channels such as: • IMDEA Networks (EN/ES) • 5TONIC • Blog Madri+d	UC3M
2	Nov '18	Press release: "InterDigital and 5G-CORAL Consortium Complete Their First Trial of Integrated Fog and Edge Virtualized Radio Access Network" relayed by the INTERDIGITAL official media channel: http://ir.interdigital.com/file/Index?KeyFile=395742883	IDCC

TABLE 5: LEAFLETS, POSTERS, AND VIDEOS.

#	Month	Description	Lead partners
1	Jun '19	Video for the booth in EuCNC 2019	UC3M, IDCC, ITRI and AZCOM
2	Jun '19	Video for the booth in Computex 2019	ITRI
3	Apr '19	A poster for WCNC 2019	NCTU, UC3M
4	Feb '19	Second project leaflet along with elevator pitch slides for MWC 2019. The leaflet is shown in **Figure 1**.	NCTU, UC3M
5	Nov '18	3 videos on the demonstrations showcased at Nangang Taipei with Taiwan 5G office	NCTU, UC3M, IDCC, ITRI and AZCOM
6	Nov '18	A poster for the Demonstration at Nangang Taipei with Taiwan 5G office	NCTU, UC3M, IDCC, ITRI and AZCOM

Communication, dissemination, standardisation and exploitation achievements
in Y2 and cumulated with Y1, along with plan beyond the project duration

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Complementary ICT-18-2017
Convergent Technologies Projects

5G-CORAL: A 5G Convergent Virtualised Radio Access Network Living at the Edge

PROJECT COORDINATOR

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Dr. Alain Mourad – European TM
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INCORPORATED (ITRI)

PARTNERS

Universidad Carlos III de Madrid /
Ericsson AB / InterDigital Europe /
Telecom Italia / Telcaria Ideas / RISE
SICS AB / Azcom Technology /
Industrial Technology Research
Institute Incorporated / ADLINK /
National Chiao Tung University

START DATE: 01/09/2017

END DATE: 31/08/2019

COST: 3,856,973.75€ including
2,497,223.75€ from EU H2020

MORE INFORMATION

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MAIN OBJECTIVES

○ Develop a system model including use cases, requirements, architecture, deployment scenarios, and business models to design and validate the 5G-CORAL solution.

○ Design virtualised Radio Access Network (RAN) functions for multiple RATs including Cellular, Wi-Fi and IoT, data services, and users and third party low latency applications for hosting in the 5G-CORAL integrated Edge and Fog computing System (EFS).

○ Design an Orchestration and Control system (OCS) for dynamic integration and federation, and optimised allocation of 5G-CORAL EFS computing resources, including the interworking with other (non-EFS) domains such as the distant Cloud.
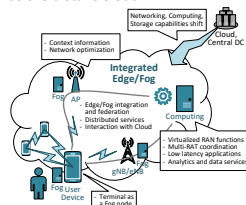
Proof of Concepts (PoCs)

5G-CORAL project be validated in testbeds with PoCs:

1. Augmented Reality Live Navigation in Taiwan shopping mall
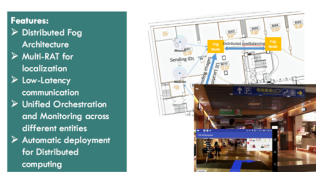
2. Virtual Reality, a showcase of 360 video streaming
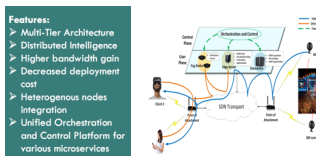
3. Fog Aassisted Robotics
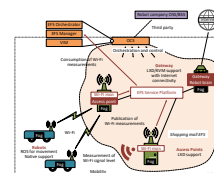
4. Multi-RAT IoT Gateway with Edge server
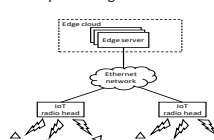
5. Enhanced Safety in Connected Cars
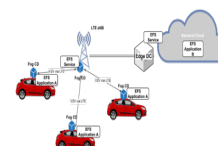
Summary of Overall Achievements

5G-CORAL project also kept focusing on communication, dissemination, standardization and exploitation. We have several significant achievements in Year 1 and Q1 of Year 2 listed in the table below.

Activities		Achievement
Press and Media	Public Summary	1
	Leaflet	1
	Poster	2
	Press Release	9
	Videos	6
Public Presentations		20
Education and Training		1
Publication		16
Organized Events		5
Open Source Contributions		1
Exhibitions	Booth	2
	Demo	8
Standard Dissemination		4
Standard Contributions		27

https://twitter.com/5g_coral/   https://www.linkedin.com/in/5g-coral/

FIGURE 1: ILLUSTRATION OF THE SECOND 5G-CORAL LEAFLET

2.3   Summary of Achievements over Year 2

Figure 2 shows that, in the period Jan. 2019 to Jul. 2019, the project portal has attracted 4495 visits and 1036 unique users. That is at least 640 visitors every month (~22 people per day on average), reflecting on a considerable attention globally.
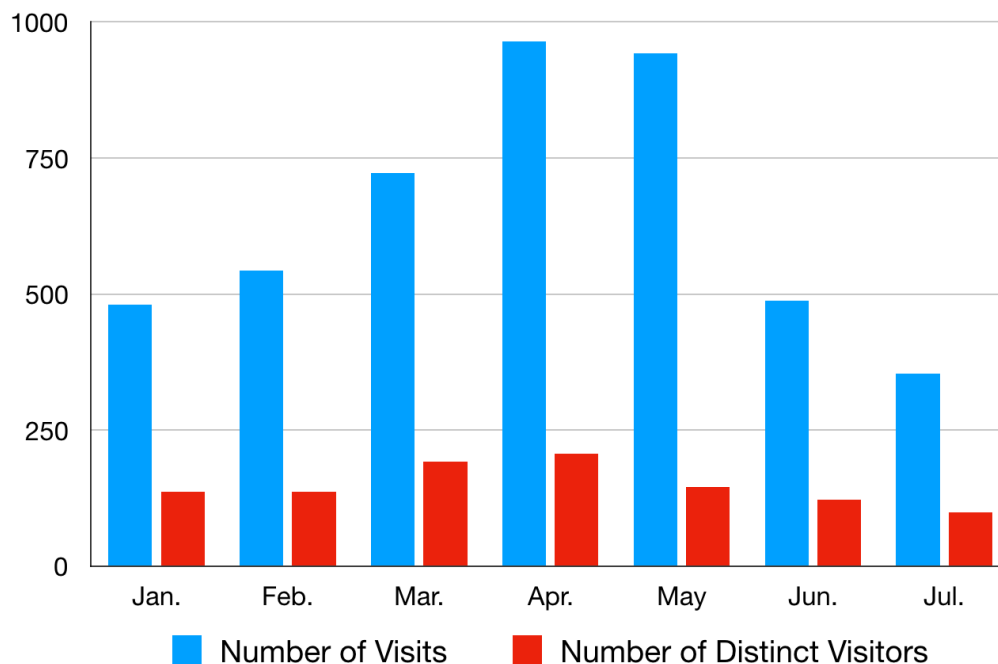
FIGURE 2: STATISTICS ON THE NUMBER OF VISITS TO THE 5G-CORAL PORTAL

Figure 3 shows the different communication activities performed during the project lifetime to disseminate the key values of 5G-CORAL
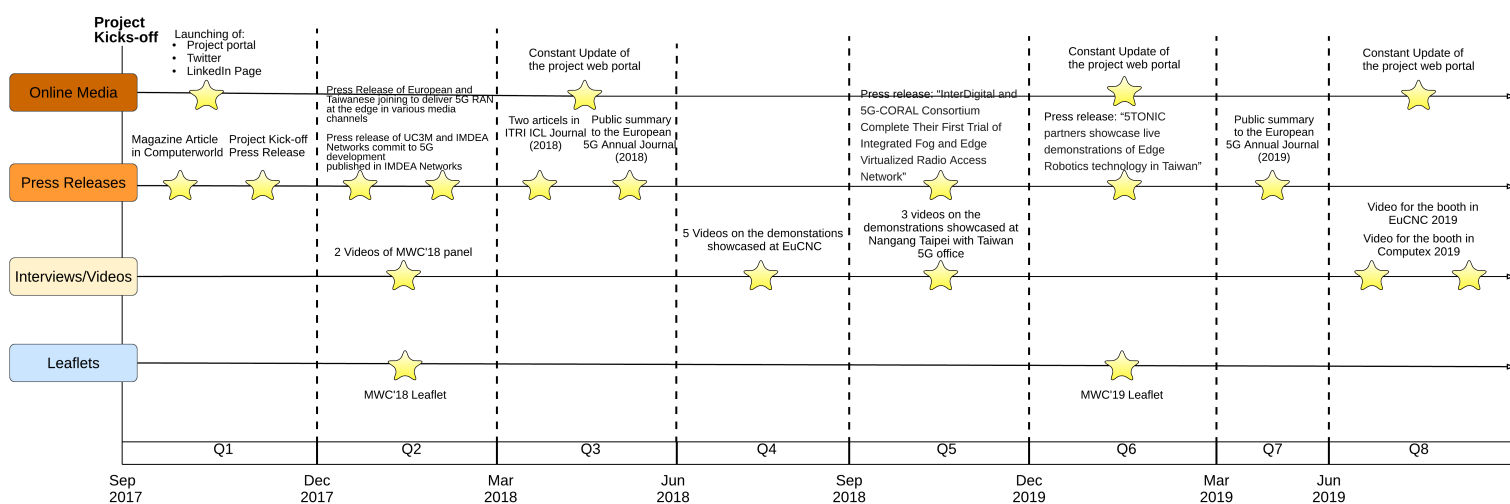
FIGURE 3: OVERVIEW OF THE COMMUNICATION PLAN AS EXECUTED DURING THE PROJECT.

3 Dissemination and Collaboration Activities

Dissemination and Collaboration (primarily within the 5G-PPP) activities have been conducted in Year 2 in order to help promote the project concept and initial results to the International R&D community and raise opportunities for synergy with other projects and activities. This chapter presents the plan set in Year 2 and reports the related achievements for dissemination and collaboration activities respectively. Moreover, an analysis of achievements over entire project duration is provided.

3.1 Objectives of Project Year 2 (M13-M24)

The high-level objectives for dissemination and collaboration activities were defined as follows:

- To raise and foster awareness of the project vision, concept, objectives, and results, amongst the R&D community. The dissemination activities will be steered towards generating impact through peer-reviewed publications, presentations, talks, demonstrations, panels, workshops, and events.

- To establish synergy links with other related projects, within the 5G-PPP program, with the aim of promoting a coherent overall 5G architecture and developing consistent technology building blocks.

From the above high-level objectives, the project has set specific and measurable goals for dissemination and collaboration activities in Year 2. These include:

- Delivery of at least six talks promoting the project vision, concept and project results at selected R&D events and industry summits.

- Demonstration of project related prototypes or solutions at R&D events.

- Organization of at least one R&D event.

- Submission of at least six peer-reviewed scientific articles for publication at reputed conferences and journals.

- Co-organization of at least ten activities with other 5G-PPP projects (UC3M)

3.2 Report on Activities Undertaken and Achievements

The dissemination and collaboration activities and achievements for Year 2, from September 2018 to August 2019, are reported in the following sub-sections.

3.2.1 Peer-reviewed Publications

Table 6 and Table 7 list all peer-reviewed publications in Year 2. Published or accepted for publication materials are reported. The project has published 4 peer-reviewed articles in journals and magazines, and 10 ones in conferences and workshops Year 2, with a few more already accepted for publication at the end of the Year 2.

TABLE 6: PEER-REVIEWED PUBLICATIONS

IN CONFERENCES AND WORKSHOPS IN YEAR 2.

#	Type	Month	Description	Lead Partners
1	Conference	Jun 19	Osamah Ibrahiem Abdullaziz, Samer T. Talat, Chen-Hao Chiu and Li-Chun Wang, "Mobile Service Continuity for Edge Train Networks," IEEE International Symposium on Personal,	ITRI

			Indoor and Mobile Radio Communications (IEEE PIMRC 2019).	
2	Workshop	Apr 19	Giovanni Rigazzi, Jani-Pekka Kainulainen, Charles Turyagyenda, Alain Mourad and Jaehyun Ahn, "An Edge and Fog Computing Platform for Effective Deployment of 360 Video Applications," Seventh Int'l Workshop on Cloud Technologies and Energy Efficiency (CLEEN 2019).	IDCC
3	Workshop	Apr 19	Li-Hsing Yen, Chi-Han Chang, and Yi Chia Chen, "Profit maximization by forming federations of geo-distributed MEC platforms," Seventh Int'l Workshop on Cloud Technologies and Energy Efficiency (CLEEN 2019).	NCTU
4	Conference	Mar 19	Saptarshi Hazra, Simon Duquennoy, Thiemo Voigt, Peng Wang, Chenguang Lu, Daniel Cederholm, "Handling Inherent Delays in Virtual IoT Gateways," 15th International Conference on Distributed Computing in Sensor Systems (DCOSS).	EAB
5	Conference (Poster)	Mar 19	Nuria Molner, Antonio de la Oliva, Ioannis Stavrakakis, Arturo Azcorra, "Optimizing 5G Networks," IV edition of Informática para Tod.	UC3M
6	Conference	Feb 19	Ming-Yi Lin, Li-Hsing Yen, and Hojjat Baghban, "Resource request dispatch in standalone and federated MEC systems: a matching game approach," IEEE Wireless Communications and Networking Conference (WCNC 2019).	NCTU
7	Workshop	Oct 18	Osamah Ibrahiem Abdullaziz, Li-Chun Wang, Shahzoob Bilal Chundrigar and Kuei-Li Huang, "ARNAB: Transparent Service Continuity across Orchestrated Edge Networks," IEEE GLOBECOM 2018 Workshops.	ITRI
8	Workshop	Oct 18	K. Antevski, M. Groshev, L. Cominardi, C.J. Bernardos, A. Mourad, and R. Gazda, "Enhancing Edge robotics through the use of context information," EM-5G 2018: First International Workshop on Experimentation and Measurements in 5G.	UC3M, IDCC
9	Conference	Sep 18	Igor Freire, Ilan Sousa, Pedro Bemerguy, Aldebaro Klautau, Igor Almeida, Chenguang Lu and Miguel Berg, "Analysis of Controlled Packet Departure to Support Ethernet Fronthaul Synchronization via PTP," ISPCS 2018.	EAB
10	Conference	Sep 18	Claudio Fiandrino, Joerg Widmer, Kirill Kogan, and Antonio de la Oliva, "pDCell: an End-to-End Transport Protocol for Mobile Edge Computing Architectures," ICDCN 2019.	UC3M

TABLE 7: PEER-REVIEWED PUBLICATIONS

IN JOURNALS AND MAGAZINES IN YEAR 2.

#	Type	Month	Description	Lead Partners
1	Magazine	Jun 19	Hsu-Tung Chien, Ying-Dar Lin, Chia-Lin Lai, and Chien-Ting Wang, "End-to-end Slicing as a Service with Computing and Communication Resource Allocation for Multi-tenant 5G Systems," IEEE Wireless Communications	NCTU
2	Journal	Feb 19	Jorge MartinPerez, Luca Cominardiy, Carlos J. Bernardos, Antonio de la Oliva, Arturo Azcorra, "Modeling Mobile Edge Computing Deployments for Low Latency Multimedia Services," IEEE Transaction on Broadcasting.	UC3M
3	Journal	Sep 18	Nuria Molner, Antonio de la Oliva, Ioannis Stravakakis, Arturo Azcorra, "Optimization of an integrated fronthaul/backhaul network under path and delay constraints," Elsevier Ad-Hoc Networks.	UC3M
4	Journal	Sep 18	Hsu-Tung Chien, Ying-Dar Lin, Hsien-Wen Chang ; Chia-Lin Lai, "Multi-operator Fairness in Transparent RAN Sharing by Soft-partition with Blocking and Dropping Mechanisms," IEEE Transactions on Vehicular Technology.	NCTU

3.2.2 Talks/Panels/Webinars/Whitepapers

Table 8 lists all presentation activities delivered including talks and panels. As reported, 13 talks and 3 panels were delivered at nine different venues.

TABLE 8: TALKS AND PANELS DELIVERED IN YEAR 2.

#	Type	Month	Venue	Description	Lead Partners
1	Talk	May 19	Chiba Univ.	5G-Coral: Research Roadmap and Results on 5G Mobile Edge Computing	NCTU
2	Talk	May 19	Univ. of Tsukuba	5G-Coral: Research Roadmap and Results on 5G Mobile Edge Computing	NCTU
3	Talk	May 19	Kyoto Univ.	5G-Coral: Research Roadmap and Results on 5G Mobile Edge Computing	NCTU
4	Talk	May 19	Muroran Institute of Tech.	5G-Coral: Research Roadmap and Results on 5G Mobile Edge Computing	NCTU
5	Talk	Mar 19	T3chfest 2019	Leveraging Kubernetes for NFV	UC3M
6	Talk	Feb 19	Koc Univ	5G-Coral: Research Roadmap and Results on 5G Mobile Edge Computing	NCTU
7	Panel	Dec 18	ICT event in Vienna	5G-TRANSFORMER and 5G-CORAL	UC3M

8	Talk	Nov 18	IEEE Conference on Open Systems (ICOS)	5G Mobile Edge Computing: Virtualization, Open Source, and Security Issues	NCTU
9	Talk	Nov 18	Eclipse IoT webinar	Fog Computing with Eclipse fog∅5	ADLINK
10	Talk	Oct 18	NCTU Seminar	An excursion into 5G and the beyond	IDCC
11	Panel	Oct 18	TelecomsRadar	5G-CORAL platform and proofs-of-concept	ITRI
12	Panel	Oct 18	TelecomsRadar	FogRAN: A glimpse into the 5G-CORAL solution	IDCC
13	Talk	Oct 18	REDIMadrid conference	ONOS based multi-domain slicing over white-box switches	Telcaria
14	Talk	Oct 18	Delft University of Technology (TU Delft)	5G-Coral: Research Roadmap and Results on 5G Mobile Edge Computing	NCTU
15	Talk	Oct 18	Hasselt University	5G-Coral: Research Roadmap and Results on 5G Mobile Edge Computing	NCTU
16	Talk	Sep 18	Taiwan MoST 5G Booth	H2020 EU-TW 5G-Coral: Research Roadmap and Results on Mobile Edge Computing	NCTU

3.2.3   Workshops

Table 9 lists the workshops organized in Year 2.

TABLE 9: WORKSHOPS ORGANIZED IN YEAR 2.

#	Event	Month	Status	Workshop	Country
1	EuCNC 2019	Jun 19	Done	Emerging 5G Business Models: Opportunities for SMEs and large companies-lesson from 5G PPP (5G-EBM)	Spain
2	EuCNC 2019	Jun 19	Done	European and Taiwanese Cooperation on 5G	Spain
3	IEEE WCNC 2019	Apr 19	Done	Cloud Technologies and Energy Efficiency in Mobile Communication Networks (CLEEN) 2019	Morocco
4	ETSI MEC meeting	Dec 18	Done	Joint project workshop, 5G-CORAL and 5G-TRANSFORMER	Vienna
5	CONEXT 2018	Dec 18	Done	First International Workshop on Experimentation and Measurements in 5G (EM-5G)	Greece
6	Workshop @Nangang	Oct 18	Done	The workshop to share the first result of the project	Taiwan

3.2.4   Exhibitions and Demonstrations

Table 10 lists the exhibitions and demonstrations showcased in Year 2. A total of 19 demos have been delivered.

TABLE 10: EXHIBITIONS AND DEMOS IN YEAR 2.

#	Type	Month	Venue	Description	Lead partners
1	Demo	Jun 19	EuCNC 2019	Multi-RAT IoT GW	EAB
2	Demo	Jun 19	EuCNC 2019	SD-WAN	TELCA
3	Demo	Jun 19	EuCNC 2019	Fog Assisted Robotics	UC3M
4	Demo	Jun 19	EuCNC 2019	Adaptive 360 video streaming	IDCC
5	Demo	Jun 19	Computex 2019	5G-CORAL showcases	ITRI
6	Demo	Feb 19	MWC 19	5G CORAL in MWC19: Taipei Demo	IDCC
7	Demo	Dec 18	ICT 2018	Fog Assisted Robotics	UC3M, IDCC, ADLINK
8	Demo	Nov 18	Ericsson Innovations Days	Fog Assisted robotics demonstration	EAB
9	Demo	Oct 18	Nangang shopping mall	Edge and Fog-assisted Robotics	UC3M
10	Demo	Oct 18	Nangang shopping mall	Showcase of 360 video streaming	IDCC
11	Demo	Oct 18	Nangang shopping mall	Multi-RAT IoT GW	EAB
12	Demo	Oct 18	Nangang shopping mall	AR navigation	ITRI, NCTU
13	Demo	Oct 18	5G-Office (Taiwan)	Connected Cars	TIM, AZCOM
14	Demo	Oct 18	5G-Office (Taiwan)	Leverage local virtual MME in High-Speed Train	ITRI
15	Demo	Oct 18	5G-Office (Taiwan)	SD-WAN	TELCARIA
16	Demo	Sep 18	Edge congress	Adaptive 360 video streaming	IDCC
17	Demo	Sep 18	IDCC London	360 adaptive video demo to Taiwan delegation	IDCC
18	Demo	Sep 18	EuMW 2018	Fog assisted Robotics	UC3M
19	Demo	Sep 18	EuMW 2018	Adaptive 360 video streaming	IDCC

3.2.5   5G-PPP Cross-projects Collaboration Activities

During the second year of the project, 5G-CORAL has continued its efforts towards the collaboration with other projects of the 5G-PPP, as shown in Table 11.

TABLE 11: 5G-PPP CROSS-PROJECT COLLABORATION ACTIVITIES IN YEAR 2.

#	Venue	Description
1	First International Workshop on Experimentation and Measurements in 5G (EM-5G)	https://conferences2.sigcomm.org/co-next/2018/#!/workshop-em5g CONEXT 2018 workshop in collaboration with MONROE and 5G-TRANSFORMER. December 4, 2018
2	Cloud Technologies and Energy Efficiency in Mobile	https://5g-ppp.eu/cleen2019/

	Communication Networks (CLEEN) 2019	Workshop co-located with WCNC 2019, co-organised by 5G-CORAL, 5G-TRANSFORMER and NGPASS
3	EuCNC 2019	During EuCNC 2019 we had a strong collaboration with other 5G-PPP projects. Activities include: • Shared booth with 5G-TRANSFORMER • Organisation with Clear5G of the workshop "European and Taiwanese Cooperation on 5G" • Organisation of the workshop "Emerging 5G Business Models: Opportunities for SMEs and large companies-lesson from 5G PPP (5G-EBM)" All the information of the EuCNC collaboration can be found in: http://5g-coral.eu/?page_id=1248 Information about the booths can be found in: https://www.eucnc.eu/workshops/
4	Dissemination Cluster Booster	5G-CORAL is participating actively on the Dissemination Cluster Booster created with 5G-Transformer and 5G-Crosshaul. (More information, http://5g-coral.eu/?p=557)
5	Finalisation of the Slicing on ETSI MEC WI	5G-TRANSFORMER and 5G-CORAL through their partners NEC, InterDigital, Telefonica, EURECOM, ITRI and with the support of UC3M, have contributed significantly to create a new ETSI MEC Work ITEM. The Work Item aims to study the support of network slices in MEC, fundamental aspect addressed by both projects. (More information, http://5g-coral.eu/?p=211)
6	Participation on the 5G-PPP Trials WG	Antonio de la Oliva, as coordinator of the Action, is actively participating in the Trials WG, specifically in the International Activities Stream.

3.3 Analysis of Achievements Over Entire Project Duration

Table 12 provides the records of scientific publications, talks/panels, demonstrations, and organized/sponsored workshops throughout the whole execution phase. The record is shown for each period (Year 1 and Year 2) and compared to the target number set in each period. It is crystal clear from Table 13 that the project exceeded by far its targets set in each category of dissemination activities. 24 peer-reviewed publications have been published, 31 talks delivered, 8 workshops co-organized, and 25 demonstrations at conferences and showcases.

Communication, dissemination, standardisation and exploitation achievements
in Y2 and cumulated with Y1, along with plan beyond the project duration

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TABLE 12: SUMMARY OF DISSEMINATION ACHIEVEMENTS THROUGHOUT THE PROJECT.

Activities		Achievement/Target		
		Y1	Y2	Total
Press and Media	Public Summary	1	1	2
	Leaflet	1	1	2
	Poster/Slides	2	6	8
	Press Release	6	2	8
	Videos	4	5	9
Public Presentations		15/6	16/6	31/12
Education and Training		1/1	1/1	2/2
Publication		10/6	14/6	24/12
Organized Events		2/1	6/1	8/2
Open Source Contributions		1/1	5/1	6/2
Exhibitions	Booth	1/1	4/1	5/2
	Demo	6	19	25
Standard Contributions		28	14	42

4 Standardization and Open Source Activities

Maximizing the impact of the project innovations on present and future standardization and industry forums has been set as a key objective in order to help create opportunities for commercial exploitation of the project outcomes. This chapter presents the achievements in Year 1 and Year 2 and describes the prospective impact of 5G-CORAL to the main standardization activities over the next few years.

4.1 Standardization Activities

4.1.1 ETSI White Paper

ETSI MEC published several white papers, among them is worth reporting "MEC Deployments in 4G and Evolution Towards 5G" and "Developing Software for Multi-Access Edge Computing" which have seen the participation of some 5G-CORAL partners.

While the first version of "Developing Software for Multi-Access Edge Computing" was released in September 2017, a second edition was published in February 2019 targeting application developers and presenting some of the standardized APIs. Moreover, it introduces ETSI FORGE, which is an open tool offered to the community to perform initial integration of custom applications with the MEC APIs.

4.1.2 ETSI MEC

ETSI MEC is concluding Phase II and initial works on requirements on Phase III are started. In addition to addressing the challenges arising when the MEC host is mobile (e.g. in vehicle), ETSI MEC recently started targeting multi-domain aspects.

A tighter coordination between ETSI MEC, ETSI NFV and 3GPP is underdoing towards a closer integration of the two systems in the context of 5G deployments. To that end, ETSI initiated concrete actions to fill the remaining gaps of MEC into NFV.

ETSI MEC continued his work on the API definition. Of particular interest for 5G-CORAL is the work on the V2X API and the Fixed/WLAN APIs which allow to extract context information from the access network and make it available to the applications.

In addition, the Work Item on the Network Slicing (MEC024) requirements of the ETSI MEC platform has been finalized and published in September/October 2019. Luca Cominardi (5G-CORAL WP3 leader) is the current rapporteur of this WI.

In order to better encompass all the testing and certification activities, ETSI created a dedicated group (ETSI MEC DECODE). The goal of such new-born group is to provide procedures and tools for certification, testing and a playground for application developers to get familiar with ETSI MEC APIs.

4.1.3 ETSI NFV

ISG NFV has developed over 80 different reports and specifications for the virtualisation of network functions. NFV publications describe and specify virtualisation requirements, architecture framework, functional components and their interfaces, as well as the protocols and the APIs for these interfaces. ISG NFV also studies VNF performance, reliability, and resiliency matters, analyses the security challenges linked to virtualisation (trust, attestation, regulation). NFV specifies requirements for Management and Orchestration, for hardware acceleration, etc.

5G-CORAL is not contributing per-se to ETSI NFV, but is more focused on how the ETSI MEC platform is run within a ETSI NFV platform. 5G-CORAL has prepared some scientific works that are in review process handling this issue and providing some solutions.

4.1.4   IETF 6TiSCH

The IETF working group 6TiSCH is defining IPv6 over TSCH, a time-slotted channel hopping mode for IEEE 802.15.4 wireless networks proving the service needed for industrial automation and process control. Most of the 5GCORAL use-cases fall into these classes of IoT applications, and thus 6TiSCH is an important technology for the project to consider. For these classes of IoT applications, we anticipate that 6TiSCH is run in the EFS as a EFS function.

The previously submitted internet-drafts have received several updates during the year:

* draft-chang-6tisch-msf-02, "6TiSCH Minimal Scheduling Function (MSF)", was adopted by the IETF 6TISCH WG and published as draft-ietf-6tisch-msf-00 on August 21, 2018. It has then been updated to -01 on October 22, 2018, and lately to -04 on July 2, 2019 and is on the path to becoming an IETF standard.
* draft-tiloca-6tisch-robust-scheduling, "Robust Scheduling against Selective Jamming in 6TiSCH Networks", was updated to version -01 on December 17, 2018 and to -02 on June 10, 2019.

4.1.5   IETF SFC

The focus of the SFC working group moving forward is on aspects of the architecture and/or protocol that need to be addressed to enable effective deployment and usage of service function chains. The working group is working in the following 4 items:

* Metadata - Define the common type-length-value encoded metadata types with Standards Track RFCs, and produce Informational RFCs to describe common fixed-length (MD-1) metadata usages.
* Security and Privacy - Mechanisms and guidance for securing metadata via authentication, integrity protection, confidentiality, and/or data minimization are not yet defined. What can be effectively provided, for which scenarios, and how those tools can be provided need to be determined and the tools standardized.
* OAM and Operations & Management - In order for operators to use these tools in production networks, they need Operations, Administration, and Maintenance tools, as well as management mechanisms. This includes YANG models, OAM frameworks, and specific OAM mechanisms to address operational needs.
* Transport Considerations - This will capture the expectations SFC places on transport behaviour, including dealing with issues such as congestion indications and responses. This should define how NSH works on standardized transports that are expected to see widespread use.

Within this WG, 5G-CORAL is contributing with different mechanisms for the use of SFC within the CORAL architecture. In particular we have proposed the following works:

* draft-bernardos-sfc-fog-ran-05: Service Function Chaining Use Cases in Fog RAN, where we presented some of the use cases within the EFS that may benefit of SFC technologies.
* draft-bernardos-sfc-discovery-02: Service Function discovery in fog environments, where we present a mechanism for discovering functions which can be nested to form SFCs in a Fog environment.

4.2   Open Source Activities

4.2.1   FogO5

Eclipse fog05 aims at providing and full Management and Orchestration stack for the Fog Computing environment, thus it needs to interact with heterogeneous resources in an heterogeneous infrastructure.

In particular one of the main goal of fog05 is the unification of different frameworks coming from Telco and Industry, in particular ETSI MEC, ETSI NFV and the OpenFog Consortium, there three framework deals with applications, but from different perspectives and focusing on different aspects of the application.

5G-CORAL contribution to Eclipse fog05 was compose by two mains contributions, providing a set of functional and non-functional requirements for a edge/fog infrastructure and identity the gap between the those three framework in order to provide and unified descriptor model for applications in the edge/fog environment.

More information on fog05 can be found: http://www.fog05.io

GitHub: http://github.com/eclipse/fog05

4.2.2   f0rce – fog orchestration engine

f0rce is a python-based fog orchestration engine for distributed environments developed in 5G-CORAL WP3. f0rce plays the role of the Orchestrator in the ETSI NFV MANO architecture. f0rce is based on a distributed key-value store (i.e., YAKS) to share data across the network and along the cloud-to-thing continuum. The implementation effort in f0rce resulted also in ykon (i.e., abbreviation of YAKSON), a python framework developed to make more agile the development of a distributed application based on YAKS by providing a set of APIs and abstractions. ykon is currently provided as a submodule on the f0rce repository, which is now hosted as a branch on the fog05 repository: https://github.com/eclipse/fog05/tree/f0rce

4.2.3   5G infrastructure generator

5GEN is an R package to generate operator infrastructure graphs (including MEC locations) based on point processes. This package considers the reference 5G transport infrastructure as proposed in the papers listed below, which is composed of (i) access, (ii) aggregation, and (iii) core. The resulting infrastructure graph can be used to run a multitude of simulations, such as placement algorithms, traffic optimization, infrastructure planning, etc. The code of the R package is available on GitHub: https://github.com/MartinPJorge/mec-generator/tree/5g-infra-gen.

Folowing are the 5G transport infrastructure papers:

(1) L. Cominardi, L. M. Contreras, C. J. Bernardos and I. Berberana, "Understanding QoS Applicability in 5G Transport Networks," 2018 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), Valencia, 2018, pp. 1-5. doi: 10.1109/BMSB.2018.8436847 URL: https://e-archivo.uc3m.es/handle/10016/27393

(2) J. Martín-Pérez, L. Cominardi, C. J. Bernardos, A. de la Oliva and A. Azcorra, "Modeling Mobile Edge Computing Deployments for Low Latency Multimedia Services," in IEEE Transactions on Broadcasting. doi: 10.1109/TBC.2019.2901406 URL: https://e-archivo.uc3m.es/handle/10016/28273

4.2.4   Contiki-NG

Contiki-NG is an operating system for resource-constrained IoT devices. One of the lead developers of Contiki-NG, Simon Duquennoy, was with the 5GCORAL project until December 2018, and another developer, Joakim Eriksson, is also with the project. Contiki-NG is one important basis for the experimental work in the Multi-RAT PoC using the IEEE 802.15.4 RAT. One Contiki-NG feature needed and implemented in 5GCORAL is the ability to selectively include parts of the communication stack in order to interface to SDR. In order to support the multi-channel implementation, a Radio Manager module was introduced in Contiki-NG. Both of these features are planned to be up streamed to Contiki-NG.

More information on Contiki-NG can be found at http://www.contiki-ng.org/ and https://github.com/contiki-ng.

4.3   Standardization Roadmap

To conveniently present the updated 5G-CORAL standardization roadmap, we first refer to the Year-1 classification of what 5G-CORAL relevant technology development areas have been addressed within which standardization projects. This is reported in Table 13 below.

TABLE 13: CLASSIFICATION OF STANDARDIZATION ACTIVITIES FOR 5G-CORAL.

No.	Technology Development Area of the Project	Standard Bodies (Contributed)
1	Initial Requirements, Gaps Identifications, Use Cases, Architecture	ETSI
2	Orchestration and Management of virtualization resources and computing tasks deployment	IETF
3	Mobility and Volatility Management	IETF, ETSI
4	Service function chaining (SFC), Network slicing and multi-tenancy	IETF, ETSI
5	Multiple access technologies	IETF

Based on the above classification, we present an updated standardization roadmap in Figure 4 which includes a prediction of the impact of 5G-CORAL activities to the main standardization bodies in the next future.

As shown in Figure 4, we anticipate a further development of the key technologies areas of 5G-CORAL. Specifically, new orchestration and management solutions are expected to be developed, targeting virtualized and volatile resources. Similarly, we point out that the activity on service function chain and network slicing will continue and will impact IETF and ETSI, respectively. On the multi-RAT convergence side, we expect that ETSI MEC will be one of the most active standardization working group along with 3GPP, which will finalize Release 16 in 2020 and start working on Release 17.

We also predict that 5G-CORAL achievements will set the stage for the standardization activity on Intelligent Operation and Management via AI-based technologies. In this respect, 5G-CORAL system architecture can be a facilitator for a new spectrum of intelligent frameworks that leverage on machine learning to deploy, manage, operate and maintain networking, computing and storage platforms. As a result, the major impact will focus on 3GPP and ETSI Experiential Networked Intelligence (ENI) and ETSI Zero-touch network and & Service Management (ZSM).
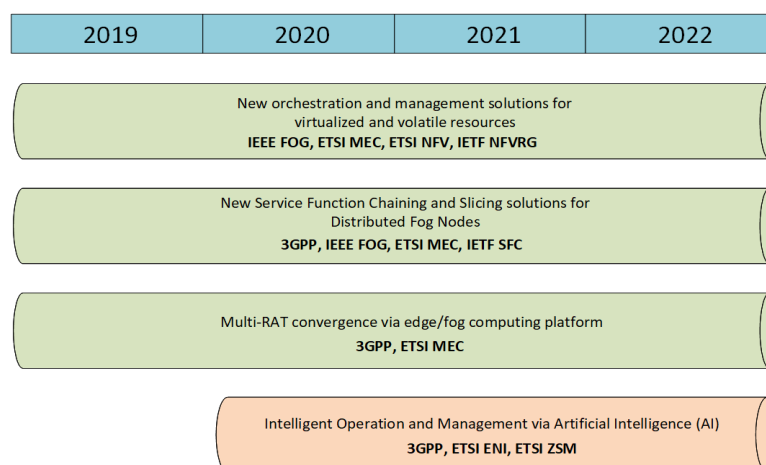

FIGURE 4: PROSPECTIVE STANDARDIZATION ACTIVITY ROADMAP TOWARDS 2022.

4.4 Standardization Achievements

Following on the above standardization roadmap, the 5G-CORAL partners have undertaken several standardization activities, mostly focusing on ETSI MEC and IETF. Table 14 reports on these standardization activities in Year 2.

TABLE 14: STANDARDIZATION ACHIEVEMENTS IN YEAR 2.

#	Month	Standardization Item	Leading Partners	Related WP
1	Jun '19	Contribution to IETF: "Link-Layer Addresses Assignment Mechanism forDHCPv6"	UC3M	WP2/3/4
2	Apr '19	Contribution to IETF: "draft-bvtm-dhc-mac-assign SLAP quadrant selection options for DHCPv6"	UC3M	WP2/3/4
3	Apr '19	Contribution to IETF: "draft-bernardos-dhc-slap-quadrant SLAP quadrant selection options for DHCPv6"	UC3M	WP2/3/4
4	Apr '19	Contribution to IETF: "draft-ietf-dmm-distributed-mobility-anchoring Distributed Mobility Anchoring"	UC3M	WP2
5	Apr '19	Contribution to IETF: "draft-ietf-dmm-pmipv6-dlif Proxy Mobile IPv6 extensions for Distributed Mobility Management"	UC3M	WP2
6	Apr '19	Contribution to ETSI MEC: "MEC(19)000122 MEC024 - Efficient E2E multi-slice support for MEC-enabled 5G deployments"	UC3M	WP3
7	Mar '19	Contribution to ETSI MEC: "MEC(19)000068 Scope text proposal (Section 1)"	UC3M	WP3
8	Mar' 19	Contribution to ETSI MEC: "MEC(19)000067r1 Editorial changes and references formatting"	UC3M	WP3
9	Mar '19	Contribution to IETF: "draft-bernardos-sfc-discovery Service Function discovery in fog environments"	UC3M, IDCC	WP3
10	Mar '19	Contribution to IETF: "draft-bernardos-anima-fog-monitoring Autonomic setup of fog monitoring agents"	UC3M, IDCC	WP2/WP3

11	Feb '19	Contribution to ETSI MEC: "MEC(19)000039 Section 7 - Conclusions and recommendations"	UC3M	WP3
12	Feb '19	Contribution to ETSI MEC: "MEC(19)000038 Draft v2.0.6 - Editorial Changes"	UC3M	WP3
13	Jan '19	Contribution to IETF: "draft-irtf-nfvrg-gaps-network-virtualization Network Virtualization Research Challenges (passed conflict review Expected to be published as RFC early in 2019)"	UC3M	WP3
14	Oct '18	Contribution to IETF: "draft-mcbride-edge-data-discovery-overview Overview of Edge Data Discovery"	UC3M	WP2/WP3

4.5 Analysis of Achievements Over Entire Project Duration

Table Table **15** provides a record of activities of informative nature into the different standardization bodies. Some 42 standard contributions are reported in SDOs noticeably IETF and ETSI.

TABLE 15: RECORD OF INPUT CONTRIBUTIONS TO SDOS.

SDO	Year 1	Year 2	Total
IETF	7	8	**15**
ETSI	21	6	**27**
		Total	**42**

5   Exploitation Activities and Updated Plans

For a research project, it is important that the results achieved are effectively exploited during the project time and a further exploitation plan after the project ends is laid out per partner. While Chapter 4 focuses on the exploitation on standardization and open-source activities, this chapter presents the identified exploitation opportunities in terms of 7 PoCs developed in 5G-CORAL and 3 existing or new commercial products/services in section 5.1, summarizes the key innovations in the areas of EFS and OCS achieved in 5G-CORAL in section 5.2, and 4 patent applications done in the project duration are also presented. Finally, a substantial exploitation plan of 5G-CORAL results by each individual partner is presented, showing how 5G-CORAL results will be further exploited after the project ends.

5.1   Activities Related to Commercial Exploitation

In the following, the exploitation activities and further plans regarding 7 pre-commercial PoCs developed are first described. Then, 3 commercial products/services from the project partners are identified, which may be related to and have impacts from the 5G-CORAL innovations.

5.1.1   Proof of Concepts

The following describes the exploitation activities regarding the 7 PoCs developed in 5G-CORAL, e.g. the impacts of 5G-CORAL technologies to these PoCs and how PoCs are exploited and will be further exploited in the future to make impacts.

5.1.1.1   Augmented Reality Navigation

Stemming from the AR Navigation system developed in 5G-CORAL, Askey and ITRI proposed a project and have successfully gotten the approval from Smart City Office funded by the Taiwan government. The smart city project aims at developing and deploying into the Taipei Main Station the AR navigation system which provides services about shop logo recognition and user localization. Currently, the shop logo recognition has been improved since 5G-CORAL so that a shop logo can be recognized from different directions within a reasonably short time period. In addition, this project now is focusing on the image-based localization at a granularity of center-meters.

5.1.1.2   Virtual Reality

Virtual reality is one of spotlighted services supported by 5G systems, since high data rate communication and low latency are required for service without motion sickness. For instance, assuming High Efficiency Video Coding (HEVC), a live 360° video streaming service with 60 frames-per-second and 8K resolution requires 361 Mbps in order to ensure smooth content play. Further, high processing power is essential in order to support complex processing as encoding and decoding of high-quality video streaming data.

In Year 1, we demonstrated that the EFS framework of CORAL platform can provide flexible and heterogeneous resources in a multi-tier system architecture. The processing chain of live 360° steaming service is modularized and split into three different computing substrates, i.e. cloud data centre, hosting powerful processing units and located on cloud provider premises; edge server, located closer to the end user equipment (UE) and providing limited compute capabilities; and fog computing devices (CD), resource-constrained devices operating in the UE proximity. Computing tasks are offloaded by the edge server/fog CD from the cloud data centre and the UE and, hence, energy efficiency of cloud data centre can be improved and the power consumption of the UE reduced. We carried out a successful demonstration in MWC'19, with many attendees showing particular interest in our PoC.

In Year 2, we have enhanced features of CORAL system for live 360° video streaming service. We adopted FogO5 as open source platform for OCS implementation. FogO5 platform consists of FogO5 entities and FogO5 agent (or node). FogO5 agent manages a FogO5 entity through an

interface conveying abstractions of computing and networking resources, which can be atomic, such as a virtual machine, a container or a binary executable. The agent can discover another FogO5 agent with Pub/Sub protocol and handle various OS with plugin. Through Fog05, we showed that zero-touch configuration and instantiation of the VR end-to-end service can be supported by OCS.

In the EUCNC 2019 event, the interoperability between CORAL system and another open-source system, i.e. 5G TRANSFORMER vertical slicing platform, was shown. A robot was remotely controlled by a UE, while the operator was able to watch the live 360˚ video streaming through head-mounted display (HMD) set generated by a 360˚ video camera on top of the moving robot. In this demo, two services with different QoS requirements are supported by means of the 5G-Transformer vertical slicer, where live 360˚ video streaming belongs to the class of eMBB services and the remote robot control to UR-LLC services, respectively. Basic computing tasks for each service are provided through CORAL system on multi-tier architecture, which enables low-latency and energy-efficient service. Simultaneously, 5G-TRANSFORMER platform provides sliced transport for each service, where 5GT-VS (5G TRANSFORMER vertical slicer) and 5GT-SO (5G TRANSFORMER service orchestrator) interoperate with CORAL OCS implemented by FogO5.

5.1.1.3 Edge Robotics

The Fog Robotics application is a key pillar of the exploitation plans for UC3M in the following years. First, the plan is to extend this application towards a full fledge Digital Twin application, which will be integral part of the 5G-DIVE project. In addition, UC3M is currently working in the ICT-19 5Growth project, and the plan is to use the Fog assisted application as a leverage to start collaborations with INNOVALIA and Ericsson in the area of industry 4.0. The knowledge gathered in the development of the Fog assisted robotics use case is also fed up to the industry through a new Master on Connected Industry we are starting this year. Finally, this use case is going to be also used by UC3M in a follow up research project with the Imdea Networks institute, where we will study the best allocation of resources when the robots use 180 mmWave arrays to communicate among them.

5.1.1.4 Multi-RAT IoT

This PoC is a key achievement in 5G-CORAL, demonstrating the feasibility for the convergence of multiple IoT RATs leveraging the resources in the Edge, as well as the value creation from EFS services. The PoC is co-developed by Ericsson Research and RISE SICS. It will be exploited by both parties, respectively. First, the PoC will be further developed with orchestration and machine learning features in the coming EU-Taiwan 5G-DIVE project. Second, the PoC is planned to be used as a testbed platform providing IoT connectivity for other research projects in both parties. Third, the PoC will be used in both internal and external demo events, which would help transfer the technologies internally and externally.

5.1.1.5 Connected Cars

This PoC developed by Azcom and Telecom Italia shows how the 5G-CORAL technical solution is able to fulfil the requirements of the Connected Cars use case in terms of reduced end-to-end latency and system reliability. After the good results of the laboratory experiments and the real field trial done in Turin, Azcom and TI will continue their collaboration in the development of the OBU used in the PoC in a more focused automotive project. First of all, the Wi-Fi secondary RAT will be substituted to one more reliable as the Dedicated short-range communications (DSRC) or Cellular Vehicle to everything (C-V2X). Then some software will be further developed to increase the localization estimation accuracy and the collision avoidance algorithm. In addition, this OBU is also used as starting point in the development of a new testbed for the EU C-ROADS project.

5.1.1.6 SD-WAN

The results from the SD-WAN Proof-of-Concept, have had a direct impact in Telcaria SD-WAN Alviu product, which manages large enterprise and academic networks, dispersed around the

world. The results obtained in 5G-CORAL impacted in this product as the lessons learned from offloading and roaming capabilities across domains that this PoC has demonstrated during the project time. Enhancing the experience Telcaria has in mobility scenarios which can be mapped to real problems which Telcaria has foreseen to face in the near future when extending its Alviu product not only to manage enterprise-grade cabled networks but also WIFI access networks, where mobility is a must. And as demonstrated in 5G-CORAL it can be solved by leveraging from the roaming functionalities which the SD-WAN platform has managed to add during the span of this project. Additionally, in the medium to long term, Telcaria could leverage from the experience learned from the federation and offloading techniques envisioned in 5G-CORAL, to offer novel services to companies and universities in order to increase its product portfolio and even integrate them into Alviu product as a new feature.

5.1.2   Existing or New Products and Solutions

The following 3 products/services from the partners that will (or may) get impacted by 5G-CORAL technologies and innovations. In addition, as described in section 4.2, Adlink is the main maintainer and key contributor of fog05 and f0rce open-source projects, which have direct impacts from 5G-CORAL results. The future products using these projects will therefore be impacted from 5G-CORAL results.

5.1.2.1   Ericsson Radio System

Ericsson Radio System (ERS, https://www.ericsson.com/en/portfolio/networks/ericsson-radio-system) includes hardware, software, and related services to build modular and scalable radio access networks. Its portfolio includes products in the areas of radio, RAN Compute, site solutions, MINI-LINK for microwave transmission, a fully-integrated IP router portfolio, and fronthaul solutions – all managed by a common management system. Ericsson Radio System is designed to fit all site types and traffic scenarios, even as networks grow in scale and complexity, from 2G, 3G, 4G, and 5G – delivering industry-leading performance on the smallest site footprint with the lowest energy consumption.

ERS supports cellular IoT solutions, i.e. NB-IoT and LTE-M, which are the leading LPWA technologies specified in 3GPP. The multi-RAT IoT concept and technologies developed in 5G-CORAL can be used to extend ERS portfolio with Edge Cloud capability, which can offload the IoT processing from RAN. Radio products can be also extended to support unlicensed IoT technologies like LoRa, Sigfox, 802.15.4, Bluetooth etc. For example, in the indoor radio system (e.g. Ericsson Radio Dot System), short-range IoT technologies like 802.15.4 can be supported while the macro radio system can support unlicensed LPWA technologies like Sigfox and LoRa.

5.1.2.2   Connected Cars Framework

As already mentioned in the previous section, Azcom – in collaboration with Telecom Italia – intends to use the OBUs also in other projects focused on connected cars' applications. The first step will be the substitution of the RATs with ones more suitable, i.e. vehicular communications module based on e.g. Cellular V2X (C-V2X) or Dedicated Short Range Communication (DSRC) might be taken into account. The studies done in the context of WP4 leads Azcom to substitute thee encoder protocol with one that guarantees lower E2E latency performance. Correspondingly, the software used in the PoC are updated. Further, discussions with TI leads to an evolution of the collision avoidance software with one more robust and more precise localization algorithm, i.e. using Kalman Filter.

5.1.2.3   Alviu SD-WAN Platform

Telcaria Alviu SD-WAN product has had a direct impact from the results of the SD-WAN PoC, which will allow the product to technologically evolve by leveraging some of the key technologies of 5G-CORAL. 5G-CORAL technologies will impact specifically in the orchestration and management of the product, enabling the SD-WAN platform to extend its presence deep into the

computing stratum, which could further be developed into novel deployment models and consequently into new business models, where Telcaria foresees new revenue streams.

5.2 Key Innovations Identified in Year 2

The innovations of 5G-CORAL project are mainly in the areas of EFS and OCS and Table 16 shows the identified innovations in each area.

1) EFS: the innovations are mainly about EFS functions, applications and services designed for different 5G-CORAL use cases and developed in 7 corresponding PoCs.
2) OCS: the innovations are mainly about the OCS software components and information models, as well as federation.

TABLE 16: MAPPING BETWEEN PROJECT INNOVATIONS AND RELEVANT PARTNERS' POCS, PRODUCTS, SERVICES AND APPLICATIONS

Innovation area	PoC, Product, Service, Tech Transfer or software components/features	Partner
EFS	Multi-RAT IoT PoC: • LoRa stack implemenation with multi-channel capability and improved preamble detection • 802.15.4 stack implementation with multi-channnel capability • NB-IoT stack implementation with fronthaul compression • Multi-RAT integration with dockerized LoRa, 802.15.4 and NB-IoT stacks running simultaneously on the same Edge server • IQ/Data service publishing (exposing) IQ samples to EFS • Interference Analyzer application utilizing the received IQ samples from the subscribed IQ/Data service	Ericsson/SICS
	VR PoC: • Solution to decompose the 360-video streaming into multiple microservices (EFS Apps and functions) • Agile and automatic EFS stack deployment over three different tiers by 5G-CORAL OCS • VR orientation service adapted to run on low-end fog devices • Adaptive-tile encoding solution to reduce the bandwidth required by the VR streaming • Multi-camera and multi-user support	IDCC
	Fog-based AR PoC: • iBeacon Localisation Service • low latency distribution (neural-network based) solution for real-time coordinated processing across neighbouring Fog nodes for IR	ITRI/NCTU
	Cleaning/Delivery by Robot PoC: • Virtual Wi-Fi access point	UC3M/IDCC

	• Fat BSS transition between on-demand instantiated virtual APs • LTE Radio Network Information Service (RNIS) • Wi-Fi Network Information Service (WNIS) • Centralisation of robotics intelligence at public Cloud and migration to Edge on demand • D2D communication to enhance coordination and increase reliability of control data	
	Enhanced safety in connected cars: • Virtual Wi-Fi access point on the RSU; • Update of the EFS application on the OBU to manage the multi RAT architecture.	AZCOM
	SD-WAN PoC: Wi-Fi Host Mobility Service	TELCA
OCS	Information model for unification of ETSI NFV, ETSI MEC, and TOSCA descriptors	UC3M/ADLINK/IDCC
	Information model for common resource discovery across multiple radio access technologies	UC3M/TELCA/ITRI/IDCC
	Control and management of resource-constrained and heterogeneous devices	ADLINK/UC3M
	Dynamic migration of virtualized applications and functions in distributed environment	ITRI/ADLINK/TELCA
	Federation of edge and fog systems: • Modelling and numerical result of profit maximization in a federated environment • Modelling and numerical result of advanced resource provisioning in federated EFSs	NCTU
	fog05 PoC: IaaS for managing the Fog Computing environment	ADLINK
	Development of fully distributed state OCS orchestration	UC3M/ADLINK
	Management of the Wi-Fi access point on the Road Side Unit.	AZCOM

5.3 Patent Applications

The following 4 patent applications related to 5G-CORAL innovations have been regularly filed by the corresponding partners as shown below.

1. ITRI: "HIERARCHICAL REGISTRATION METHOD FOR CONNECT UE TO 5G NETWORK AND RELATED APPARATUSES USING THE SAME", US patent application ID: 16226660, filed: July 2019.
2. IDCC: METHOD AND PROCEDURES FOR RESOURCE SOLICITATION FOR FOG-RAN, European Patent Application No. 19181339.3
3. EAB and RISE SICS: "MULTI-RAT IOT C-RAN DESIGN", submission Number: PCT/IB2018/056655, filed: March 2018.
4. ITRI: "SYSTEM AND METHOD FOR DECENTRALIZED AD-HOC NETWORK ARCHITECTURE SECURITY", US patent application ID: 16/198, 879, Taiwan patent application ID: 107141776, EPC patent application ID: EP18207932.7, filled: November 2017.

5.4 Updated Per-Partner Exploitation Plan for 5G-CORAL Results

The following presents the detailed plan how each individual partner will further exploit the 5G-CORAL results after the project ends.

5.4.1 EAB

The main results achieved in 5G-CORAL are the multi-RAT IoT concept and PoC, and the knowledge, technologies, hands-on experiences and insights obtained during the process of concept development, PoC design, software development and lab tests. These results will be exploited internally in the company. First, the PoC will be further developed with new features like orchestration and will be used as a research platform in Ericsson Research in other internal and external projects. Second, we plan to use the 5G-CORAL results for internal technology transfer from research to products regarding the developed technologies and concepts. The PoC will be demonstrated to our R&D and product units in big internal events like Ericsson Research Day and small sessions dedicated to relevant products. Third, Ericsson is one of the leading companies in 3GPP standardization. The results are related to 5G massive IoT design. They can be exploited in the relevant standard discussion and contributions.

5.4.2 SICS

SICS is actively promoting innovation through industrial partners and spin-offs. An innovation perspective is an integral part of all research groups, making SICS active in various external innovation activities and is a core member of ICT Labs of the European Institute of Technology (EIT). SICS' track record includes more than a dozen spin-offs, several of which are now bigger than SICS itself.

SICS has continued its practical industry-lead approach to innovation and exploitation in 5GCORAL in close collaboration with Ericsson. 5GCORAL results on softwarized Multi-RAT communication are being contributed to the open source Contiki-NG operating system for constrained IoT devices. These contributions include flexible communication stack configuration in order to interface to SDR, and a radio manager in order to support the multi-channel implementation. The results and experience with SDR in the context of IoT will be exploited in future projects together with industrial partners. SICS will also further support Ericsson with exploitation of results from the Multi-RAT proof-of-concept.

5.4.3 ITRI

ITRI had utilized the obtained results and technologies from 5G-CORAL in real testbeds. In particular, the AR distributed computing to the community through the technology transfer to smart city project deployed in Taipei Main Station. Indeed, the experience and knowledge will be considered for more advanced services in the smart city project in the future. The distributed computing of AR has transferred to Taiwanese Manufactory successfully and currently deploying the solution into Taipei Train station. Besides, the full distributed Fog Computing System had impacted the industry in different perspectives such as providing a new solution for indoor navigations and providing a new business model by AR Advertisements. Also, the potential technologies for the Fog Computing can be adopted for Car Fleet and UAV Fleet. For example, the drone fleet communication and management on top of 5G-CORAL platform is one of the potential candidates for exploration and deliver new services especially the one related to public safety. In addition, several graduate students take part in 5G-CORAL research and implementation toward their electrical engineering and computer science degree. Last but not least, as a non-profit organization, ITRI will continue cooperate with the academics in Taiwan, and use knowledge and IPR created in 5G-CORAL to transfer the 5G-technology to large industrial partners and SMEs in its environment, particularly companies located in the Hsinchu Science Park.

5.4.4   IDCC

IDCC intends to utilize its VR PoC as a reference platform to develop novel ideas and inventions in line with its IPR strategy. Specifically, the exploitation plan will consist of multiple platform upgrades which will be instrumental in assessing and validating the impact of the new technologies integrated into the PoC. As an example, IDCC has already showcased a combination of VR and robotics technologies during the MWC'19, with the goal of demonstrating the ability of managing two different network slices in 5G-CORAL. Future activities will be directed towards developing inventions to further reduce the E2E latency in order to meet the strict requirements dictated by next-generation industrial applications.

Moreover, being IDCC constantly active in standardization activities, any potential technology gap will be evaluated and possibly bridged by developing and discussing technical contributions within the standardization communities. In this respect, IDCC is monitoring a relevant 3GPP study item entitled "Extended Reality (XR) over 5G", whose objective is to analyze different technologies, collect use cases and identify requirements, features and system aspects to enable XR applications through the 5G network. Based on the results obtained in our VR PoC, new standard contributions may be developed by considering the 5G-CORAL architecture and its interfaces.

Finally, IDCC is also keen on using the knowledge and know-how developed in 5G-CORAL to engage in new international R&D initiatives and seize new opportunities for collaborating with industry, academia and innovation centers.

5.4.5   UC3M

UC3M main business is to transfer research know how to the Spanish society by impacting on the syllabus and topics of the different high education degrees it offers. As such, the main impact of the 5G-CORAL project is the direct impact in three different Bachelors and two Masters, where new topics dealing with Industry 4.0 and Fog infrastructure have been included. These bachelors are the Telematics, Audiovisual systems and Telecommunications systems degrees. In addition, the concepts developed in 5G-CORAL will also impact the SDN/NFV master programme in collaboration with Ericsson imparted by UC3M and a new Master recently created to cover Industry 4.0 topics, including the Fog Assisted Robotics topic.

In addition, UC3M exploits the results of research projects to develop further cooperation with the industry and other academics. Highlights of this collaboration are the collaboration in 5TONIC, a research testbed for the validation of 5G through experimentation in vertical scenarios and the collaboration with IMDEA Networks.

In terms of technology, the skills learnt through the development of 5G-CORAL will be used to continue the development of more advance fog assisted robotics scenarios, where the Fog/MEC are able to process and provide intelligence in more realistic scenarios. In addition, we will focus in pushing AI/ML functionality into the Fog, being able to use this newly developed intelligence in a plethora of scenarios, as a service available at the network.

5.4.6   Telcaria

As a young SME in the area of advanced network service virtualization, Telcaria has benefited from the technology advances and results generated from 5G-CORAL project. Telcaria has acquired the know-how for applying 5G-CORAL technologic achievements for rapid prototyping, design, validation, and direct deployment of Edge and Fog computing platforms including 5G technologies. Telcaria foresees exploitation potential of 5G-CORAL from the innovations in orchestration mechanisms to assist offloading and roaming scenarios of edge and fog computing domains and the federation across these platforms. So in a near future, Telcaria will be capable of adapting and integrating these technologies into the operation and lifecycle management inside large enterprise networks, across all their domains. In addition, Telcaria has leveraged in 5G-CORAL innovations to increase its knowledge in SDN, NFV, MEC architectures and distributed data

center platforms. Overall this knowledge could directly impact on the development and commercialization of a unified SD-WAN platform which could be deployed across the whole computing stratum.

5.4.7   AZCOM

By considering the good performance of the OBU achieved during the field test trial and improved year over year during the 5G-CORAL project lifetime, Azcom – in collaboration with Telecom Italia – intends to use the OBUs also in other projects focused on connected cars' applications. Consequently, further upgrades both from hardware and software point of view might be required. For instance, a more suitable vehicular communications module based on e.g. Cellular V2X (C-V2X) or Dedicated Short Range Communication (DSRC) might be taken into account. Then an evolution of the software might be considered, for example more precise localization algorithms could be evaluated.

5.4.8   TI

Based on the tight collaboration with AZCOM in testing the Connected Cars' application by using our laboratory network – being very similar to a commercial one – TI intends to exploit the Project results to influence the activities in the context of V2X and other latency-sensitive applications described in the Group Technology Plan, an internal document listing the most promising and innovative technologies which is then used to develop the investment plan together with the strategy plan. Furthermore, the project's outcome could be highly exploited and properly extended in order to develop prototypes of new service, i.e. by taking the 5G-CORAL ones as a baseline. The overall activity within the project will also be exploited to show to the investor community the sensitivity of TI with respect to the innovation and forerunner research, by also contributing to the ongoing standardization activity in international contexts such as 3GPP.

5.4.9   ADLINK

ADLINK Technology's main goal is to supply data connectivity solutions, tools and professional services they need to build systems with the required: platform coverage, performance, scalability, efficiency, flexibility and robustness. For that reason, it is important to have an impact in innovative sectors as the virtualized Cloud Radio Access Network, which would help to integrate LTE and 5G RAN gear onto a virtualized cloud server.

This impact is achieved by creating open source technologies and collaborating in the EU/Taiwam projects, such as 5G-CORAL. In particular, the Eclipse fog05 project aims at providing and full Management and Orchestration stack for the Fog Computing. One of the main goals of fog05 is the unification of different frameworks coming from telco and industry, in particular ETSI MEC, ETSI NFV and the OpenFog Consortium.

5G-CORAL impact to Eclipse fog05 is compose by two mains contributions, providing a set of functional and non-functional requirements for an edge/fog infrastructure and identity the gap between those three frameworks in order to provide and unified descriptor model for applications in the edge/fog environment. More information on fog05 can be found at http://www.fog05.io and in the source code repository http://github.com/eclipse/fog05.

5.4.10 NCTU

NCTU seeks to exploit our results about an edge-enabled localization solution and an edge computing testbed for three major goals. First, NCTU disseminates the results to the Chinese society and the research community, in order to make impacts. We build new applications and generate research results to attend some competitions and conferences. For example, we have been awarded the Best Demo in the Mobile Computing Workshop 2019 with our edge computing testbed. Second, NCTU develops further collaboration with the industry and other academics based on our edge computing prototype and the extensions of our localization results. For example,

we have released our testbed at http://nems.cs.nctu.edu.tw/release/. Third, NCTU applies the results to the training of Bachelor and Master students. We encourage the Bachelor students to build new applications that require low-latency localization services based on our current results for their term projects. The Master students aim to advance our current prototype and performance results.

6 Summary of the Exploitation Workshop: "Emerging 5G Business Models Opportunities for SMEs and large companies – lessons from 5G-PPP"

6.1 Introduction

As part of the Communication, Dissemination, and Exploitation Plan (CoDEP) of the project, one of its dissemination goals of 5G-CORAL is to organize technical and exploitation workshops in relevant events. An important stakeholder for the exploitation of the project results is SMEs. Because of this, we decided to give SMEs a key role on the technical and exploitation workshop that we organized in EuCNC 2019, which took place in Valencia from June 18 to June 21. This section briefly presents the "Emerging 5G Business Models: Opportunities for SMEs and large companies-lessons from 5G PPP (5G-EBM)" workshop, proposed by 5G-CORAL, and co-organized by the 5G-PPP SME Working Group (WG) and several 5G-PPP phase 2 and 3 projects.

The organization of an SME-focused workshop was first proposed by the 5G-CORAL project in an 5G-PPP SME WG call on Feb. 1st, 2019. Initially, it was also discussed in the framework of the Common Dissemination Booster group led by 5G-TRANSFORMER. As a consequence, it was integrated in its dissemination plan to be implemented as part of Service 5 (Dissemination Campaign in Practice), which covered EUCNC19.

After the presentation in the 5G-PPP SME WG call, the idea was very well received, and some other projects present in the call expressed their interest to join our initiative, such as 5G-EVE, among others. Thanks to this interest, our initiative was accepted, and the 5G-PPP SME WG prepared a workshop proposal, co-organized by several 5G-PPP Phase 2 and 3 projects.

Our proposal was finally accepted (out of 18 submitted proposals, 8 were accepted), and it became the Workshop 5: "Emerging 5G Business Models: Opportunities for SMEs and large companies-lessons from 5G PPP (5G-EBM)"[1]. The main motivation of our workshop is the following:

"The imminent arrival of 5G will bring disruption in business models for incumbent operators and verticals alike. While opportunities will surely arise for large, well-positioned market participants, the real winners may well be those SMEs who have mastered the key technologies and services enabling the new business models emerging from the inevitable disruption not only in the telecommunications ecosystem but also in the vertical sectors making use of 5G including automotive, manufacturing, health, energy, and others.

This interactive workshop will explore the new playing field that is emerging with the advent of 5G, and the opportunities for SMEs to be at the leading edge. Key practical outcomes include ensuring exploitation potential for 5G PPP phase 2 and Phase 3 projects and concrete innovation opportunities for SMEs."

The workshop took place in June 2019, in the afternoon sessions (from 14h to 17:30h). A workshop leaflet (in the form of a triptych) was prepared and distributed to foster the audience participation (shown in Figure 5 and Figure 6).

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[1] https://www.eucnc.eu/2019/www.eucnc.eu/workshops/workshop-5/

Communication, dissemination, standardisation and exploitation achievements
in Y2 and cumulated with Y1, along with plan beyond the project duration

38

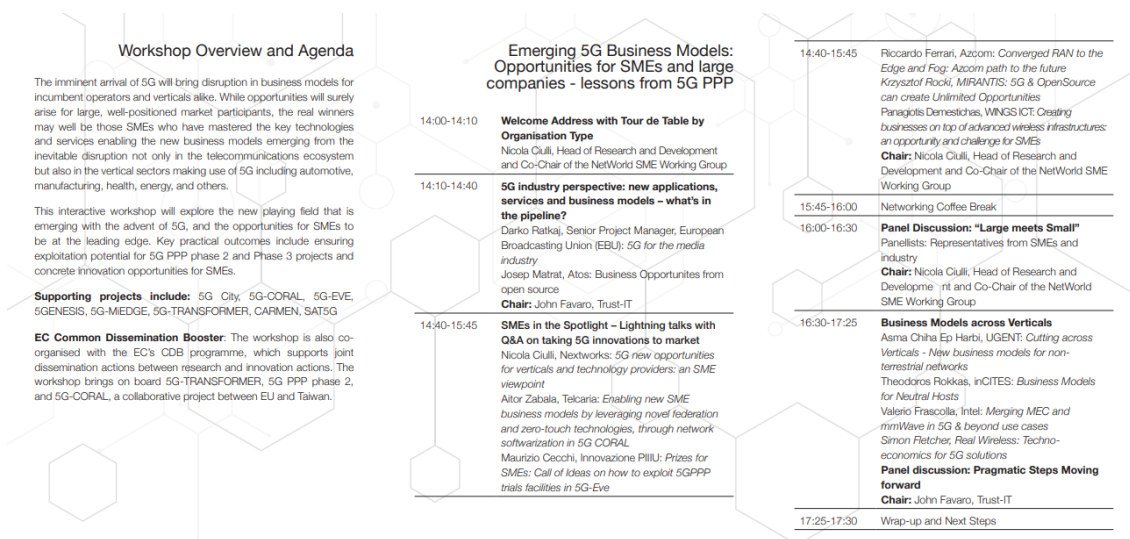**FIGURE 5: WORKSHOP LEAFLET (PART ONE)**

FIGURE 6: WORKSHOP LEAFLET (PART TWO)

The workshop programme had a very nice mix of presentations from different stakeholders, many of them bringing the SME perspective. As an example, we show in Figure 7 a presentation from a participant.

FIGURE 7: WORKSHOP PRESENTATION

A lot of people attended the workshop, with the room fully packed and several people coming in and out. A 360 picture taken at a one moment of the workshop is shown in Figure 8, where more than 40 people is present. We counted a total of 52 different attendees in total during the workshop[2].

FIGURE 8: 360-DEGREE PICTURE

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[2] Note that this is an approximate number, as several attendees entered and left the room at different moments.

6.2   Position Paper

The imminent arrival of 5G will bring disruption in business models for incumbent operators and verticals alike. While opportunities will surely arise for large, well-positioned market participants, the real winners may well be those SMEs who have mastered the key technologies and services enabling the new business models emerging from the inevitable disruption not only in the telecommunications ecosystem but also in the vertical sectors making use of 5G including automotive, manufacturing, health, energy, and others.

6.2.1   Market disruptions and 5G

Whenever disruption has upended a market, incumbent players have often been caught without access to the key capabilities needed to play a role in the aftermath. This is where SMEs have an advantage – traditionally agile, close to the leading edge of technological innovation, without legacy baggage to slow them down. SMEs with expertise in Network Function Virtualization and service orchestration will become key partners to their larger counterparts in the drive toward full Network Slicing, a foundational capability in the new business models. SMEs pioneering vehicular connectivity and secure mobile data transfer will benefit from the emergence of new forms of monetisation ranging from media streaming to usage-based mobile commerce. 5G will open up technology gaps that the SMEs can rush in to fill. SMEs are leaders in technologies needed to solve the spectrum allocation problem (e.g. beamforming) for mobile business models; technologies for supporting new services in areas like stadia (edge computing, small cells); new forms of data mining and analytics to support usage-based business models (e.g. machine learning, Big Data). SMEs well introduced in vertical sectors may also find new opportunities for offering new services to their customers via 5G. This workshop will explore the new playing field that is emerging with the advent of 5G, and the opportunities for SMEs to be at the leading edge.

To explore these opportunities, Global5G.org co-hosted a workshop with NetWorld2020 SME Working Group and To-Euro 5G at EuCNC 2019 in Valencia on Emerging 5G Business Models: Opportunities for SMEs and large companies-lesson from 5G PPP.

The workshop brought together nine projects from 5G PPP phases 2 and 3 along with their European SME partners and other small business that can benefit from 5G market opportunities. The workshop zoomed in on what kind of business models really were poised to emerge from the inevitable disruption of 5G, and what opportunities this disruption was really bringing for SMEs.

As a featured workshop by the 5G PPP during EuCNC, it gathered a full room of participants, coming from enterprises large and small, public and private, including EC representatives. Co-Chair Nicola Ciulli highlighted the complex environment faced by SMEs, giving the participants much to keep in mind as they listened to the presentations.

6.2.2   Perspectives on European Broadcasting and 5G

Darko Ratkaj from the European Broadcasting Union (EBU) expects enormous disruption in the services of broadcasting coming from the advent of digital broadband, which is destined to reach higher levels with the coming deployment of 5G. But even more to the point of the workshop, he explained at length the role that SMEs will be able to play in this disruptive environment. Broadcasting is first of all a creative activity; secondly, it is invariably a local activity, reflecting local culture and mores. As such, it needs local, creative talent, which is difficult to nurture, and difficult to replace. SMEs are the ideal entities to provide this creative talent in their local environments.

6.2.3   Perspectives on Open Source Software

Perspectives on the intriguing concept of Open Source Software Networks and 5G came from Josep Martrat of Atos. The open source business model has made huge advances in software, and it is not unreasonable to be curious about its possible relationship to 5G technologies. Josep

coordinates the 5G PPP 5Gtango project, where much open source development is being used and consolidated. Since the well-known "some additional development needed" maxim of open source is operative here, there are opportunities for third-party, specialised SME actors to play key roles in the introduction of open source into the 5G mainstream.

6.2.4   SMEs in the Spotlight

A key feature of the workshop was a series of Lightning Talks from SMEs looking at what innovations they are planning to take to market.

- Nicola Ciulli, Nextworks srl:explained the challenge to an SME of deciding which market sectors to enter, considering that the choice of market sector can be literally a matter of life and death for a small enterprise, given the few resources available to them. He described their presence in two major sectors (mainstream 5G technology and Smart Buildings), and outlined their plans to establish a presence in Industry 4.0, in subareas such as process monitoring and predictive maintenance), while noting the risks and opportunities involved for SMEs when entering new markets.

- Aitor Zabala, CTO of Telcaria: experiences in the 5G CORAL project, where they are exploring novel federation and zero- touch technologies through network softwarisation. SMEs can play a potential role as novel service providers by leveraging these new technologies. Even more intriguing is the role of SMEs as 5G network operators for verticals — for example, managing the distributed edge and fog facilities in shopping malls, airports, train stations, and the like.

- Maurizio Cecchi of 5G EVE presented an innovative instrument targeted at motivating the use of the results of the project: a set of prizes to be awarded for contributing new use cases, with specific emphasis on the inclusion of SMEs. SMEs bring great added value through their innovative solutions all along the value chain, and especially with respect to verticals. SMEs will likely be the early adopters of 5G services, he pointed out, and therefore will build the future market (more on that concept later).

- Riccardo Ferrari of Azcom is a representative of a typical SME involved in building such a future 5G market, in particular through involvement in several 5G PPP projects including 5G CORAL, where he elaborated on their proof of concept development for connected cars.

- Panagiotis Demestichas of WINGS ICT, an SME specialising in AI-powered solutions for various vertical sectors, presented a surprising and fascinating 5G use case involving "smart aquaculture". Opportunities and challenges facing SMEs in the 5G business include the garnering of support from legislative and regulatory bodies and from well-designed support programmes.

- Nicola Ciulli presented an initiative from Canada called ENCQOR involving a 5G innovation platform spanning Canadian provinces, with an emphasis on offering work spaces for SMEs to get involved and connect to innovation hubs in the participating provinces. This is yet another perspective for the participants on the possibilities for SMEs in the 5G ecosystem.

6.2.5   5G Business Models across Vertical Industries

- John Favaro of Trust-IT outlined the many services of Global5G.org on behalf of 5G verticals and SMEs, ranging from intelligence gathering through dissemination in popular White Papers and reports. He outlined also the specific services and tools developed in Global5G.org such as the verticals cartography15 covering a very diverse set of use-case experiments across verticals, as well as a user-friendly guide to issues in spectrum allocation and management16, and a standardization tracker helping verticals to orient themselves in the thicket of 3GPP standardization activities.

- Asma Chiha from the University of Ghent presented a textbook case of emerging 5G business models, within the overall context of the SAT5G PPP project and satellite communications. Non-terrestrial communication technology has an enormous potential to solve some of the thorniest problems on the way to the Digital Single Market, such as conquering the digital divide – the lack of connectivity in poorly served areas. However, there are also challenges posed by that same potential: the problems of risk-sharing, demand forecasting, managing multi-operator networking situations, and much more. Against that background, SAT5G is working towards a new business model involving a broker, mediating between network operators, handling negotiations, and simplifying overall relationships.

- Simon Fletcher of independent wireless experts Real Wireless, zooming in on his work in 5G-MONARCH The existing B2C business model of the tradition MNO is on its last legs, and new business models must replace it. Companies do not want to manage complex networks, leading to opportunities for Mobile Virtual Network Operators to step in and shift the CAPEX of setting up a network to pure OPEX for the customer. Innovative public-private partnership models are also perfectly possible in this context, creating often-overlooked but equally important public value across the entire ecosystem.

- Theodoro Rokkas of inCITES brought to the table one of the more important new models, the neutral host, within the context of smart cities in particular, based on the experiences in the 5G PPP project 5GCity. Several features of the neutral hosting model characterise a whole new set of emerging relationships, ranging from new businesses with enterprise customers to new types of commercial relationships with MNOs.

- Valerio Frascolla, Director of Research and Innovation at Intel, brought fascinating international perspectives in the context of the 5G-MiEdge project, an EU-Japan co-funded research project whose purpose is to propose new 5G enabling technologies to be showcased at the Tokyo 2020 Olympics. The business modelling efforts include using the popular business canvas methodology and related cash flow analysis, including CAPEX and OPEX projections, illustrating the kind of analyses that are involved in business case development in a 5G context.

- Mikael Fallgren of Ericsson and the 5GCAR project presented the results of a recent White Paper produced by the 5G PPP Automotive Working Group consisting of a variety of industry players (including workshop co-organizer Trust-IT), with the results of a cost-benefit analysis that the authors carried through to support a feasibility study on pan-European deployment of automotive connectivity.

6.2.6   Conclusions: Challenges and Opportunities moving forward

The workshop participants queried the maturity of 5G today, both in terms of technology and business model development. For example, technologies like W-iFi still retain a high level of "stickiness", and are themselves evolving at the same time as mobile generations, thus retaining also a strong value proposition.

Caution is key. Some parts of the 5G community are pushing the classic "hype cycle", which mismatches marketing messages with deployment realities, thus creating undue expectations that are inevitably but unfairly dashed. We must recognize that current research and innovation will not have a return on investment that is coincident with the peak of the hype cycle (where we are now), but rather within some years. 5G today is a bit like a Swiss army knife – designed to do many things, but too many forget that it is only a tool to enable real applications. However, the newly launched ICT-19 projects may well have an opportunity to exploit this Swiss army knife in real, realised applications. All agreed that when 5G arrives in full, it will also bring in new value chains and players, which will surely impact current SMEs one way or another – for better and for worse.

What should SMEs do in the meantime? Should they just wait for 5G to eventually arrive in full deployment at some unspecified time? The unanimous response of SMEs and others in the group was a decisive No. On the contrary, it is the other way around, they observed: SMEs can and should exploit their expertise and capacity for innovation to work with the state of the market as it stands now. They will be the generators of new business models capable of exploiting the advantages of 5G when it has fully matured. The future won't create them — rather, they will create the future.

The workshop was organized by Jacques Magen, Interinnov and chair of the SME WG, and Stephanie Parker, Trust-IT and Coordinator of Global5G.org. It was co-chaired by John Favaro of Trust-IT, who is the Deputy Director of Global5G.org, and Nicola Ciulli, Head of R&D at Nextworks, a leading SME in 5G technologies and Co-Chair of the SME WG. The workshop was also organized in the context of the European Commission's Common Dissemination Booster with project group 5G-TRANSFORMER and 5G-CORAL.

7   Conclusions

This deliverable reported the achievements of 5G-CORAL in terms of communication, dissemination, collaboration, open source, standardization, and exploitation activities, both in Year 2 (from 1 September 2018 to 31 August 2019) and cumulatively throughout the project lifetime (from 1 September 2017 to 31 August 2019). It is crystal clear that the project has exceeded all targeted objectives for Year 2 and throughout the project lifetime. An impressive record across a diverse set of activities has been achieved.

Specifically, for Year 2, the main achievements are: (1) 14 standard specification contributions to IETF and ETSI from 5G-CORAL partners; (2) the boosting of the publications and dissemination record with additional 14 publications, 16 talks, and 6 events organized; and (3) producing videos and video interviews on 19 demonstrations showcasing the technological innovations developed within the project.

Cumulatively throughout the project execution, the project developed technological innovations reported in this deliverable and deployed a wide range of communication, dissemination and exploitation tools to maximize the impact of these innovations on all stakeholders. This can be appreciated from the highlights below:

- Over 42 normative contributions feeding into key standardization specifications such as IETF and ETSI.
- 25 peer-reviewed publications in IEEE, ACM, and others proceedings, journals and magazines, over 31 talks and panels delivered at key events, and 8 workshops and special sessions (co-) organized.
- Over 25 demonstrations exhibited at various events including at the flagship Mobile World Congress (MWC) both in 2018 and 2019 and at the EC conference EuCNC in 2018 and 2019.
- Proactive communication through blogs, press releases, video interviews, and leaflets, all actively promoted through various channels.

5G-CRAOL will continue to push our proposed innovations on all stakeholders. Here we summarize the future plans for further dissemination, open source, standardization, and exploitation activities after the completion of the project.

For dissemination and collaboration, we anticipated further activities after the project end, including:

- Additional scientific publications in reputed (e.g. IEEE and ACM) journals and conference proceedings.
- Additional exhibition of demonstrations noticeably integrated demonstrations finalized in Q4'19.
- Continuous collaboration with 5G-PPP projects and working groups to reflect 5G-CORAL results into the 5G-PPP programme.

For open source and standardization activities, they are worth pointing out that the innovations by 5G-CORAL project have great potentials to bring further impacts to various open source communities and standard bodies even after the end of the project. Notably, as for open source activities, these are dependent on the develop roadmap of the open source communities. Later, standardization activities are dependent on the standardization timeline of a given SDO. Hence both of open source communities and standard bodies do not stop when the 5G-CORAL project stops. Therefore, we anticipate further open source and standard contributions from the project partners wherever and whenever a relevant activity occurs. Continuous monitoring of the open source communities and the SDOs in technology areas relevant to 5G-CORAL is therefore expected after the project end to identify such future opportunities. Furthermore, as the deployment of 5G infrastructures is expected to roll out in the coming years, the consortium partners who have

prototypes developed in 5G-CORAL may leverage such opportunity to apply the integrated Fog and MEC technologies stemmed from this project.

Further exploitation activities will continue beyond the project lifetime noticeably in terms of communication for the shorter term for example to accompany MWC'20, and in terms of standardization and exploitation activities in the medium and longer terms. Partners within the consortium will also make use of the EU free services for disseminating project results provided by the Common Dissemination Booster (CDB) to maximize the reach and impact of the innovations developed in the project.