D6.4 – Final (third-) year report on standardization, dissemination and exploitation achievements

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Executive Summary

This document outlines the standardization, dissemination and exploitation achievements and activities during the third year of the 5G!Pagoda project. It provides an overview of the main achievements of the Work Package 6.

List of acronyms

Acronym	Full text
3GPP	3rd Generation Partnership Project
DG	Device Gateway
EIP-SCC	European Innovation Partnership on Smart Cities and Communities
FG	Focus Group
ICN	Information-Centric Networking
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
INT	Interoperability Group
IoT	Internet of Things
IRTF	Internet Research Task Force
ITU-T	The study groups of ITU's Telecommunication Standardization Sector
KDDI	KDDI corporation
MI	Mandat International
MVNO	Mobile Virtual Network Operator
NFV	Network Functions Virtualization
OPNFV	Open Platform for NFV
PPP	Public Private Partnership
R&D	Research and Development
RAN	Radio Access Network
SA	System Aspects
SDN	Software-Defined Networking
SDO	Standards Development Organizations
SG	Study Group
TR	Technical Report
TS	Technical Specification
TSG	Technical Specification Groups
TSG SA	The TSG Service and System Aspects
TTC	Telecommunication Technology Committee
UDG	Universal Device Gateway
UT	University of Tokyo
WG	Working Group
WP	Work Package

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1. Introduction

5G!Pagoda is a Horizon 2020 European and Japanese project. Its main goal is to research the possibilities offered by Network Functions Virtualization (NFV) and Software-Defined Networking (SDN) in the frame of the future 5G mobile network. The top objectives of 5G!Pagoda are focused on:

The development of a scalable 5G slicing architecture to create and manage specialized network slices composed on multi-vendor network functions. This is achieved through the development of a scalable network slices management and orchestration framework for the network infrastructures, with control plane and data plane programmability. The integration, the customization, the slices composition and run-time management are made towards different testbeds or markets across Europe and Japan.

The goal of 5G!Pagoda is to develop a coherent architecture enabling research and standardization coordination between Europe and Japan. The proposed developments are based on a common SDN/NFV architecture and provide several improvements to the software network architecture. The developments of the project address the next steps of the evolution beyond the immediate NFV standardization and other advancements. This facilitates the integration within the end-to-end network slices of various software components, using specific network functions flexibility associated to an orchestrator. 5G!Pagoda has developed a coherent proof of concept with several testbeds implemented in Japan and in Europe, using a uniform network orchestration and a set of software features handling the virtualized network. The integration of the different testbeds will demonstrate all the functionalities provided by the 5G!Pagoda's technologies and will assist in the development of an aligned 5G-oriented standardization roadmap for Japan and Europe.

1.1. Purpose and Scope of WP6

As specified in the Description of Work, the Work Package 6 (WP6) is in charge of dissemination and exploitation. It aims to:

- "Develop and maintain online collaboration tools and a website for the project.
- Identify, monitor, and contribute to relevant standardization bodies.
- Introduce 5G!Pagoda testbed at conferences, fairs, organized workshops, and other public events.
- Develop plans for commercial exploitation of the knowledge generated by the project.
- Publish the scientific and technical achievements of 5G!Pagoda at relevant conferences and in magazines / journals."

1.2. Purpose and Scope of the Task 6.1 on Media and Collaboration Tools

The Task 6.1 on Media and Collaboration tools had been led by Aalto and UT. It had sought to guarantee prompt and effective communication in the project through the administration of a common online collaboration platform. Furthermore, Aalto has been responsible for maintaining the 5G!Pagoda official website, the content management system, and other tools for conference calls and collaborative editing. As WP6 leaders, MI and KDDI have been appointed responsible for the dissemination of the 5G!Pagoda updates on social media for three years.

1.3. Purpose and Scope of the Task T6.2 on Dissemination, Communication, and Standardization

During third years of the project, the research sought to build upon the dissemination, communication and standardization achievements. Indeed, the two previous research periods allowed to initiate the dissemination activities and to share the overall findings of 5G!Pagoda, scientific and technical, in both industry and academia. These dissemination measures took various forms including: publications in scientific journals and magazines, participations in international conferences and summits, the presentation of the project in high-level workshops (with the participation of members of the public sector, the industry, the H2020 community and academia), and the promotion of 5G!Pagoda-related activities and events on social media (Facebook, Twitter, LinkedIn).

The Consortium believes that additional contributions in the field of dissemination and communication will further increase the recognition of 5G!Pagoda and expose the project to a broader audience. In the third and last period, all partners have continued their efforts to consolidate these achievements.

Close coordination between research projects and standardization organizations is an essential step for the exploitation of results and for fostering innovation. The first years of the projects allowed for 5G!Pagoda partners to work with various standardization bodies. The second and third years of the project intended to make supplementary contributions to standardization in order to confirm the SDOs take research results into their developed standards (specifications) and to allow the industrial sectors easily to improve interoperability and establish economies of scale for the 5G!Pagoda applications.

1.4. Purpose and Scope of the Present Deliverable

The present deliverable is a continuation of deliverable D6.3. It presents the dissemination, standardization and exploitation achievements and activities during the third year of the 5G!Pagoda project. It is complemented by the deliverable D6.5 on Report on innovation achieved and forthcoming industrial exploitation that will research and present the potential for cooperation, partnerships and exploitation beyond the duration of the project.

2. Dissemination

2.1. Dissemination Objectives

Dissemination and outreach activities are indispensable to guarantee the success of the 5G!Pagoda project. The 5G!Pagoda dissemination activities result from a collective strategy coordinated between the various work packages, with a strong emphasis on creating a wide impact both on the European and the international level.

Furthermore, 5G!Pagoda has advanced a set of measures destined at improving the outreach of the project in an organized way: through an effective integration of dissemination, outreach and promotional activities with standardization work.

The dissemination strategy of 5G!Pagoda seeks to accomplish the following objectives:

- Promote the 5G!Pagoda architecture and research findings among key entities in the value chain and through contributions in terms of standards to different standardization bodies (e.g., ITU-T, 3GPP, ETSI NFV and IETF).
- Engage a broad R&D community to conduct further research into improving and extending the concepts and components of the 5G!Pagoda architecture.
- Promote the creation of the ecosystem that will foster the growth of the 5G!Pagoda vision.

2.2. Dissemination KPIs

In the third year of the project, the following dissemination KPIs can be noted in Table 1.

Table 1 - Key performance indicators and states for the third year

KPI	Year-3 state
Number of website visits	150 page view/month
Number of total publications (in the third year)	18
Number of presentations (in the third year)	1 keynotes, 2 invited speeches, and 6 presentations and tutorials
Number of contributions to SDOs (in the third year)	54
Number of organized events (in the third year)	2
Number of Facebook posts (in the third year)	5
Number of Twitter posts (in the third year)	5
Number of LinkedIn posts (in the third year)	5

2.3. Website

In the third year of the project, the 5G!Pagoda website (see Figure 1) served as the principle source of information about the project. In respect with the objectives of T6.1, the official website is hosted and administered by the University of Aalto. It updates both the Consortium members and the general public about the various work packages, dissemination activities, and 5G!Pagoda related events. There were 150 page views per month in average (see Figure 2)

Figure 1 – 5G!Pagoda website

The project website gained visibility as depicted in Figure 2 and Figure 3 tracking users' activities in the last 30 days and last week of June 2019.

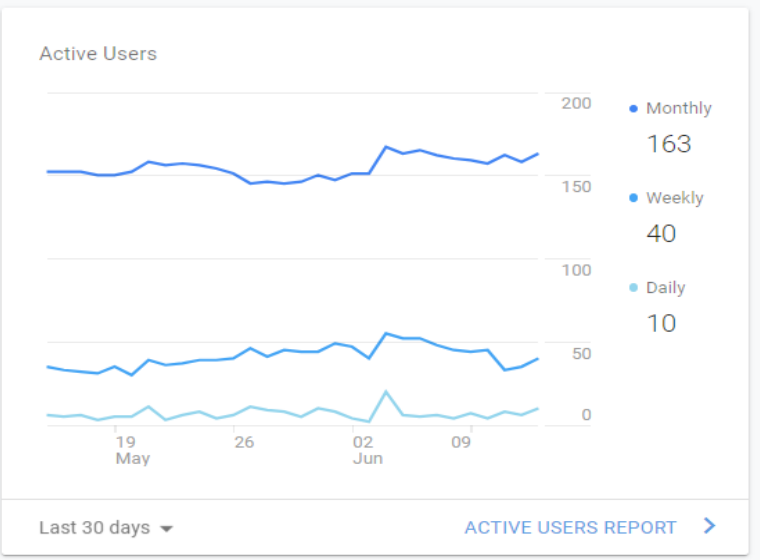


Figure 2 – Active users prior to 14 June 2019

Page	Pageviews	Page Value
/	49	$0.00
/tools	12	$0.00
/consortium	7	$0.00
/workpackages	6	$0.00
/arts	4	$0.00
/events/past	4	$0.00
/confs/details/ieee-js...ftwarization-enablers	3	$0.00
/delivrables	3	$0.00
/events/future	2	$0.00
/keyns	2	$0.00

Last 7 days PAGES REPORT

Figure 3 – Page views in the last 7 days (June 2019)

Figure 4 illustrates the main sources to get access to the project website, with the highest values being related to organic search (e.g., google) and direct access.

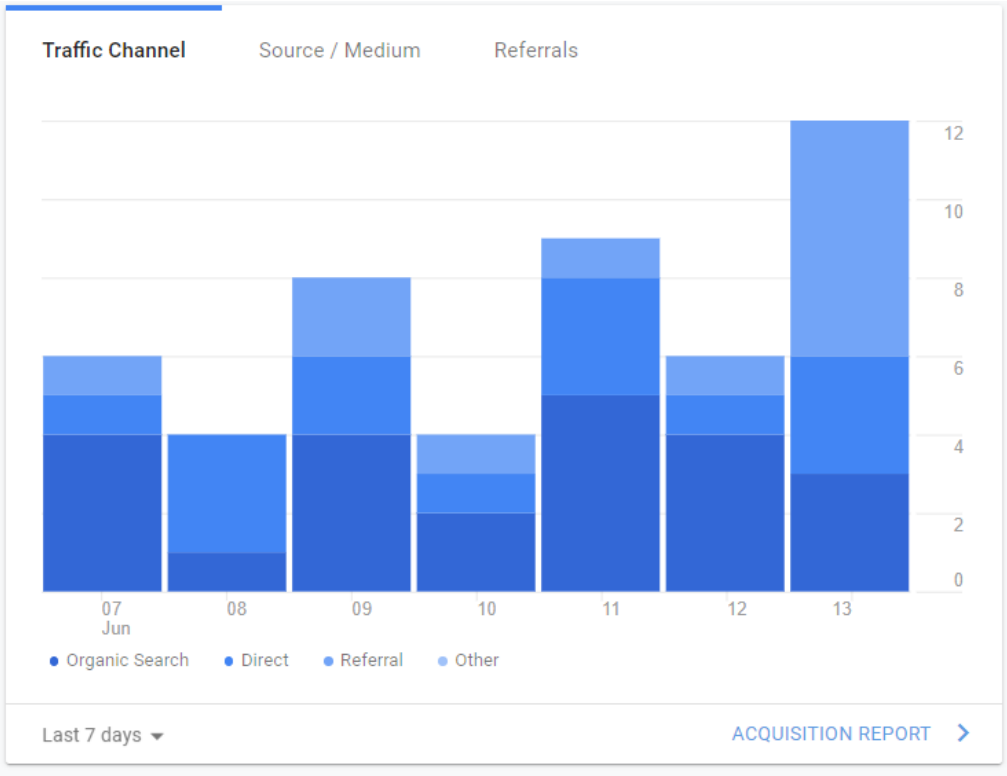


Figure 4 – Main channels to get access to the project website

The overall users' activity during 2019 is captured in Figure 5, with more than 2300 views, and 878 new users.

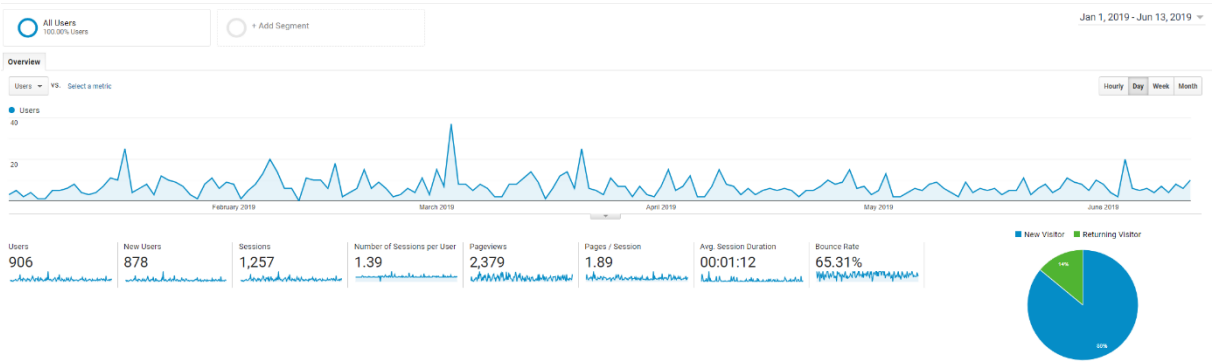


Figure 5 – Overall activity during 2019

2.4. Social Media

In the first year of the project, three social media channels have been created in order to promote 5G!Pagoda-related activities: Twitter, Facebook and LinkedIn. These platforms are managed by MI and KDDI, and seek to update the general public on important events and on the research progress.

As specified in the first year report (D6.2), the objective behind the use of social media is to promote the project to the general public. Due to the highly technical and specialized nature of the 5G!Pagoda, the Consortium decided to post non-technical information only, such as current activities related to the project, as well as news about conferences and events that the Consortium members participate in. The majority of followers and posts for the project's social medias had been coming from KDDI and MI.

2.4.1. Twitter

5G!Pagoda's Twitter account (see Figure 6) seeks to promote related events and activities to the target audiences through social media. In the third year, KDDI and MI were responsible for updating the Twitter page. The Twitter account for 5G!Pagoda project can be found by searching for the username "5GPagoda".

Figure 6 – 5G!Pagoda Twitter account

2.4.2. Facebook

The 5G!Pagoda Facebook page (see Figure 7) disseminates the project information and event activities to the target audiences in an interactive manner. In the second and third years of the project, KDDI and MI updated the Facebook page. The 5G!Pagoda Facebook page can be found by typing "5G Pagoda" into Facebook's search bar. The direct link of 5G!Pagoda Facebook Page is: https://www.facebook.com/5GPagodaProject/.

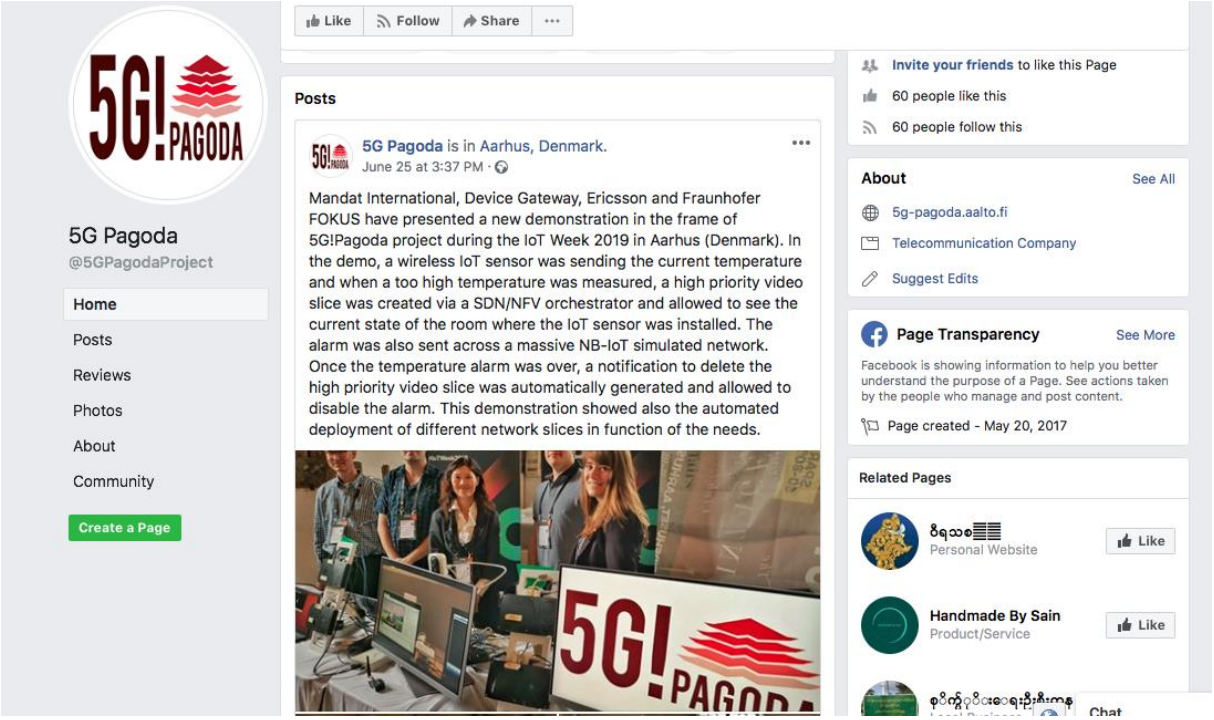


Figure 7 – 5G!Pagoda Facebook account

2.4.3. LinkedIn

The LinkedIn page for 5G!Pagoda (see Figure 8) aims at promoting the project's activities to the general public through one of the leading professional platforms. The LinkedIn page for 5G!Pagoda project can be found at https://www.linkedin.com/company-beta/13310719/.

Figure 8 – 5G!Pagoda LinkedIn account

2.5. Conference and Events Outreach

The following section reports the key activities relevant to 5G!Pagoda in terms of outreach. The most notable ones include the FUSECO Forum 2018, the Berlin5GWeek 2018 and the IoT Week 2019.

2.5.1. FUSECO Forum 2018

The 9th FUSECO Forum took place on November 15 to 16, 2018, at the Fraunhofer FOKUS institute and was a tremendous success. Over 180 experts from more than 30 countries participated in workshops and tutorials all about 5G technologies including the R&D directions for RAN, core network as well as for the management layer and a large consideration of testbeds and practical deployments. 2018 speakers and audience included a very large number of operators such as Vodafone, Deutsche Telekom, Telefonica, KDDI, NTT DoCoMo as well as the representatives of large industry verticals interested into their own on premise networks such as Siemens, Bosch, Volkswagen and German Edge Cloud.

Figure 9 – Live demos at FOKUS FUSECO Forum 2018

From industrial IoT applications via 5G to a working live 5G core network, 8 demonstrations were shown by the experts from the Fraunhofer FOKUS institute. In particular, the benefits and risks of the emerging disruptively agile network and service environment were demonstrated through prototypes developed within the 5G Playground Testbed concentrating on the aspects of software 5G networks as well as on the on premise nomadic deployments as illustrated by the van-centered edge network from Figure 10 including the 5G!Pagoda lightweight core network, the edge central split and the interconnection between the edge and the central unit.

2.5.2. Berlin5GWeek 2018

The 2nd Edge Computing Forum, the 2nd Industrial IoT Forum, and the 9th FUSECO Forum (as described in Subsection 2.5.1) were held in Berlin on November 12-16, 2018 as part of the Berlin5GWeek organized by partners of 5G!Pagoda, with the Fraunhofer FOKUS being the main organizer of the event (see Figure 11).

The Berlin5GWeek was an excellent networking and publicity event with strong presence of industry. It offered a great opportunity for academics and industrial people to meet and exchange ideas and information. Representatives of all main stakeholders in the future 5G ecosystem took part in the Berlin5Gweek, ranging from network vendors and operators to several expected 5G verticals: Nokia, Ericsson, Huawei, AT&T, DoCoMo, Telenor, Orange, ABB, etc.

Berlin5GWeek also delivered an extremely rich technical program discussing the emerging 5G mobile communications systems, vertical services and softwarization, offering a dozens of technical sessions.

Figure 10 – Active discussions at Berlin5GWeek 2018

2.5.3. IoT Week 2019

The IoT Week 2019, along with the 3nd Global IoT Summit, was held in Aarhus (Denmark) from the 17th to 21st of June 2019. With over 170 sessions and activities delivered over 5 days, over 1600 participants would be able to listen to and interact with IoT experts, industry practitioners and policy makers on a number of IoT topics, challenges and future trends.

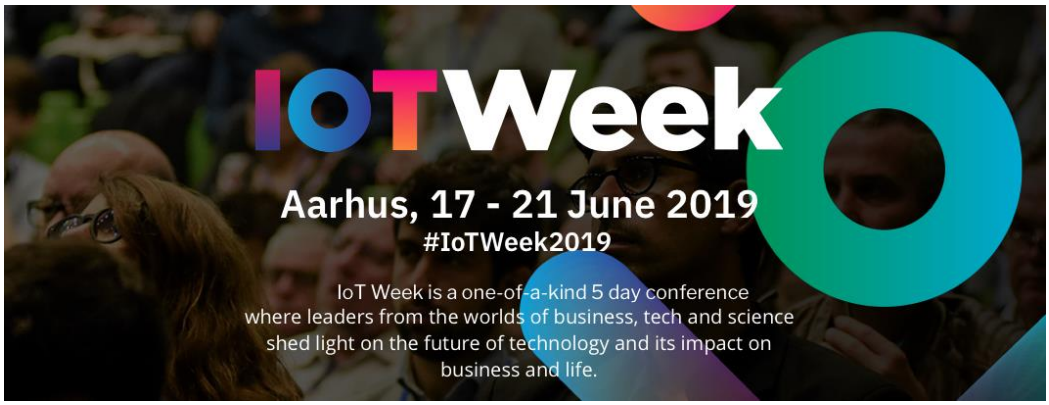


Figure 11 – IoT Week 2019

<u>5G!Pagoda Booth and Demo</u>

During the IoT Week 2019 Aarhus event, Mandat International, Device Gateway, Ericsson and Fraunhofer FOKUS have put in place a 5G!Pagoda demonstration in the building dedicated to the public booths prepared by the IoT Week exhibitors. The event participants were about 1,600 people from diverse IT areas including IoT, 5G, Smart Cities, Smart water, etc. The booth presented IoT use case from the project, which demonstrate inter-national IoT service via 5G slice technology. The demo shows how IoT service from Geneva (IoT service provider) can be provided to Aarhus (IoT customer site) through Berlin (core orchestrator) for designated services. The demonstration is basically a new evolution of the demonstration

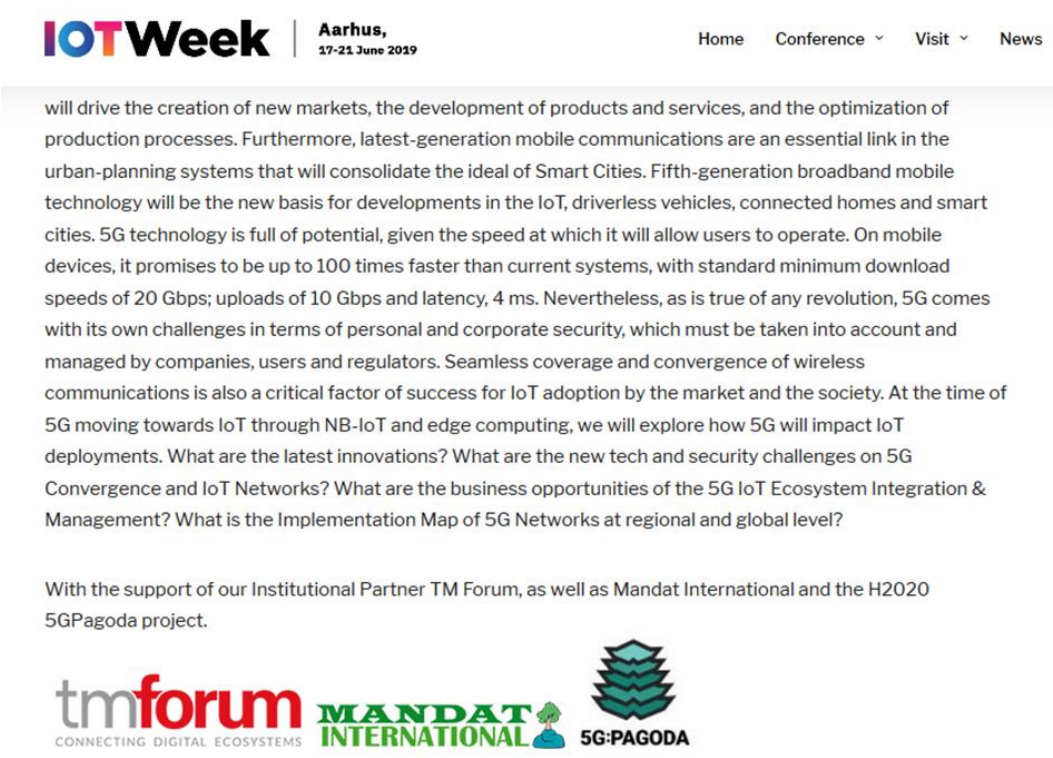
presented during the latest project review. Mandat International and Device Gateway closely worked together to provide an IoT slice deployed remotely in automated way. This IoT slice is used to retrieve the temperature measured by 6LoWPAN/CoAP sensors. Device Gateway has provided the Universal Device Gateway (UDG) platform which collect the data of the wireless sensors and communicate with the other components of the demonstration. Ericsson was responsible of the slice orchestrator and also provided the video file stream slice and the emergency live video slice. FOKUS has provided the secured VPN to their datacentre in Berlin. MI and DG have brought to the IoT Week booth an OpenStack mobile instantiation and also an eNodeB instance. The part of eNodeB is used to obtain a local 4G network.

Figure 12 – 5G!Pagoda booth at IoT Week 2019

As Figure 12 shows, Engineers and decision makers from IoT, telecom, and vertical sectors visited the booth. Especially, top decision level of participants such as the European Commission, head of TM Forum showed strong interests on the work.

<u>A dedicated track of sessions on 5G and IoT</u>

Furthermore, MI and the 5G!Pagoda project organized a dedicated track of sessions on 5G and IoT networks, with the participation of Ericsson. The sessions were supported by the TM Forum as well.



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will drive the creation of new markets, the development of products and services, and the optimization of production processes. Furthermore, latest-generation mobile communications are an essential link in the urban-planning systems that will consolidate the ideal of Smart Cities. Fifth-generation broadband mobile technology will be the new basis for developments in the IoT, driverless vehicles, connected homes and smart cities. 5G technology is full of potential, given the speed at which it will allow users to operate. On mobile devices, it promises to be up to 100 times faster than current systems, with standard minimum download speeds of 20 Gbps; uploads of 10 Gbps and latency, 4 ms. Nevertheless, as is true of any revolution, 5G comes with its own challenges in terms of personal and corporate security, which must be taken into account and managed by companies, users and regulators. Seamless coverage and convergence of wireless communications is also a critical factor of success for IoT adoption by the market and the society. At the time of 5G moving towards IoT through NB-IoT and edge computing, we will explore how 5G will impact IoT deployments. What are the latest innovations? What are the new tech and security challenges on 5G Convergence and IoT Networks? What are the business opportunities of the 5G IoT Ecosystem Integration & Management? What is the Implementation Map of 5G Networks at regional and global level?

With the support of our Institutional Partner TM Forum, as well as Mandat International and the H2020 5GPagoda project.

tmforum CONNECTING DIGITAL ECOSYSTEMS MANDAT INTERNATIONAL 5G:PAGODA

Figure 13 – Track description on the IoT Week website

There were four sessions in the track dedicated to 5G and IoT networks as shown in Figure 14:

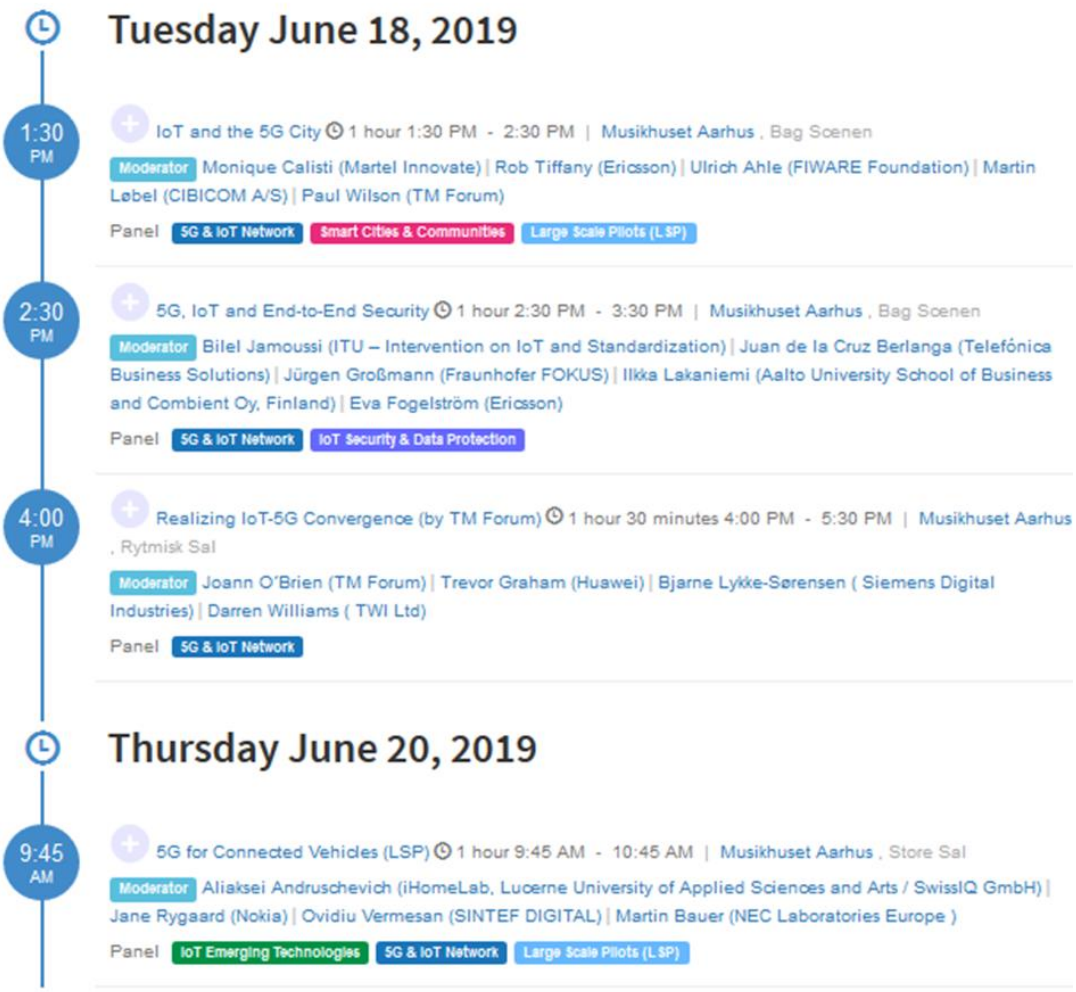

Figure 14 – Four sessions in 5G and IoT networks track

2.6. Scientific Publications

As we have seen in the first stage of the research, scientific publications play an essential role in the dissemination of 5G!Pagoda. In the third year of the project, the consortium members have submitted 18 scientific publications. Table 2 below summarizes their contributions.

Scientific publications in the first and second year are also summarized in Table 3 and 4.

Table 2 - Summary of articles and papers for dissemination purposes in the third year

Document Title	Document Type	Publication Date	Conference / Journal	5G!Pagoda related %	Consortium Contributors
owards Application Specific RAN Slicing Through In-Network Deep Learning	Conference paper	2018/9/11	IEICE Society Conference 2018	50%	UT
Deep Learning-based Application Specific RAN Slicing for Mobile Networks	Conference paper	2018/10/22	IEEE CloudNet 2018	50%	UT
owards Application Specific RAN Slicing Through In-Network Deep Learning	Conference paper	2018/11/1	Joint ETSI -OSA Workshop	50%	UT
A Survey on the Placement of Virtual Resources and Virtual Network Functions	Journal paper	2018/12/3	IEEE COMST	50%	Aalto
Integrated ICN and CDN Slice as a Service	Conference paper	2018/12/9	IEEE Globecom' 18	50%	Aalto, Waseda
A Queuing based Dynamic Auto Scaling Algorithm for the LTE EPC Control Plane	Conference paper	2018/12/9	IEEE Globecom' 18	30%	Aalto
Traffic Steering for Service Function Chaining	Journal paper	2019/2/1	IEEE COMST	50%	Aalto
PPCS: A Progressive Popularity-Aware Caching Scheme for Edge-Based Cache Redundancy Avoidance in Information-Centric Networks	Journal paper	2019/2/2	Sensors	60%	Waseda, Aalto
Context-aware UE Slicing Leveraging Deep Learning and Software-Defined RAN	Conference paper	2019/3/19	IEICE General Conference 2019	50%	UT
The Implementation of Integrated ICN and CDN as a Video Streaming Service	Conference paper	2019/3/19	IEICE General Conference 2019	50%	Waseda
A Fuzzy Logic-based Mechanism for An Efficient Cloud Resource Planning	Conference paper	2019/4/16	IEEE WCNC 2019	30%	Aalto
Key Performance Indicators for 5G network slicing	Conference paper	2019/5/26	IEEE NetSoft 2019	100%	Orange
Design and Implementation of Integrated ICN and CDN as a Video Streaming Service	Conference paper	2019/6/17	International Conference on Wired & Wireless Internet Communications	60%	Waseda, Aalto, Univ. Tokyo, Hitachi
Network Slicing-based Customization of 5G Mobile	Journal paper	to appear	IEEE Network Magazine	30%	Aalto
Modeling and Dynamic Provisioning of a Scalable E2E Network Slicing Orchestration System	Journal paper	to appear	IEEE/ACM Trans. Mobile Computing	30%	Aalto
CDN Slicing over a Multi-Domain Edge Cloud	Journal paper	to appear	IEEE/ACM Trans. Mobile Computing	30%	Aalto
On Multi-domain Network Slicing Orchestration Architecture & Federated Resource Control	Journal paper	to appear	IEEE Network Magazine	30%	Aalto
A Complete LTE Mathematical Framework for the Network Slice Planning of the EPC	Journal paper	to appear	IEEE/ACM Trans. Mobile Computing	20%	Aalto

Table 3 - Summary of articles and papers for dissemination purposes in the first year

Document Title	Document Type	Publication Date (Month Year)	Conference / Journal	Consortium Contributors
Anything as a Service for 5G Mobile Systems	Article	December-16	IEEE Network Magazine	AALTO
Application-Specific End-to-End Network Slicing for Mobile Networks	Paper	March-17	IEICE Gen. Conference 2017	UT
Content Delivery Network Slicing: QoE and Cost Awareness	Article	May-17	IEEE ICC 2017	AALTO
End-to-End Network Slicing for 5G Mobile Networks	Article	January-17	Journal of Information Processing Vol.25, No.1	UT, AALTO
Lightweight Service Replication for Ultra-Short Latency Applications in Mobile Edge Networks	Article	May-17	IEEE ICC 2017	AALTO
Low Latency MEC Framework for SDN-based LTE/LTE-A Networks	Article	May-17	IEEE ICC 2017	EURECOM
Mobile Edge Computing Potential in Making Cities Smarter	Article	March-17	IEEE Communications Magazine	AALTO
Network Softwarization and Slicing Technologies for 5th generation mobile networks	Article	January-17	ITU Journal	UT
Optimizing Service Replication for Mobile Delay-sensitive Applications in 5G Edge Network	Article	May-17	IEEE ICC 2017	AALTO
PERMIT: Netwrok Slicing for Personaliazed 5G Mobile Telecommunications	Article	May-17	IEEE Communications Magazine	AALTO, FOKUS, UT
QoE estimation-based server benchmarking for virtual video delivery platform	Article	May-17	IEEE ICC 2017	AALTO
Thinking Networks	Article	September-16	Niikei Communications	UT
Towards 5G Network Slicing over Multiple-Domains	Article	May-17	IEICE Transactions on Communications	AALTO
Towards enforcing Network Slicing on RAN: Flexibility and Resources abstraction	Article	June-17	IEEE Communications Magazine	EURECOM
Towards Mobile Edge Computing: A Survey of the Emerging 5G Network Edge Architecture	Article	May-17	IEEE COMST	AALTO

Table 4 - Summary of articles and papers for dissemination purposes in the second year

Document Title	Document Type	Publication Date	Conference / Journal	5G!Pagoda related %	Consortium Contributors
On Evaluating Different Trends for Virtualized and SDN-ready Mobile Network	Scientific publication	01/07/2017	IEEE Conference on Cloud Networks (CloudNet) 2017	80	EURECOM
Network Slices Towards 5G Communications: Slicing the LTE Network	Scientific publication	01/09/2017	IEEE Communications Magazine	50	EURECOM
End-to-End Network Slicing Enabled Through Network Function Virtualization	Scientific publication	01/09/2017	IEEE CSCN'17	100	AU
Network Virtualization and 5G Mobile	Scientific publication	07/09/2017	IEICE Communications Society Confernece on SIG-NV	100	UT
Application Specific IoT Suite Leveraging Deeply Programmable Network and IoT	Scientific publication	12/09/2017	IEICE Society Conference 2017	80	UT
A Game-theoretical Green Networking Approach for Information-centric Networks	Scientific publication	18/09/2017	2017 IEEE Conference on Standards for Communications and Networking (CSCN)	100	WU
5G Ready Testbeds: Enabling Early Prototyping and Experimentation	Scientific publication	24/09/2017	IEEE VCT 2017	80	FOKUS
Evaluation of Pre-Standard 5G Technology - A Hands-on Excursion Through Open5G Toolkits	Scientific publication	17/10/2017	GWS 2017	80	FOKUS
Towards 5G Network Slicing over Multiple-Domains	Scientific publication	01/11/2017	IEICE Transactions on Communications	100	AU, EURECOM
SDN based 5G Core Network Architecture Enhancements Towards Flexible Slice Orchestration	Scientific publication	29/11/2017	IEEE 4th International workshop on Management of SDN and NFV Systems (ManSDN/NFV)	100	FOKUS, UT
Balancing Between Cost and Availability for CDNaaS Resource Placement	Scientific publication	01/12/2017	IEEE Global Conference on communications (Globecom) 2018	80	EURECOM
Efficient Transcoding and Streaming Mechanism in Multiple Cloud Domains	Scientific publication	04/12/2017	IEEE GLOBECOM 2017	80	AU
Ensuring End-to-End Qos Based on Multi-paths Routing Using SDN Technology	Scientific publication	04/12/2017	IEEE GLOBECOM 2017	80	AU
Towards Edge Slicing: VNF Placement Algorithms for a Dynamic & Realistic Edge Cloud Environment	Scientific publication	04/12/2017	IEEE GLOBECOM 2017	100	AU
On the scalability of 5G Core Network: the AMF case	Scientific publication	07/01/2018	IEEE Conference on Consumer and Network Communications (CCNC) 2018	80	EURECOM
Conformal Mapping for Optimal Network Slice Planning Based on Canonical Domains	Scientific publication	12/03/2018	IEEE JSAC	80	AU
Optimal VNFs Placement in CDN Slicing over Multi-Cloud Environment	Scientific publication	12/03/2018	IEEE JSAC	80	AU
FlareLTE: A Cost-efficient Platform for Deploying Large-scale Experimental Mobile	Scientific publication	20/03/2018	IEICE General Conference 2018	80	UT
Network Slicing & Softwarization: A Survey on Principles, Enabling Technologies & Solutions	Scientific publication	21/03/2018	IEEE COMST	80	AU
Canonical domains for Optimal Network Slice Planning	Scientific publication	15/04/2018	IEEE WCNC 2018	80	AU
Efficient Virtual Evolved Packet Core Deployment Across Multiple Cloud Domains	Scientific publication	15/04/2018	IEEE WCNC 2018	80	AU
Performance Benchmark of Transcoding as a Virtual Network Function in CDN as a Service Slicing	Scientific publication	15/04/2018	IEEE WCNC 2018	80	AU
DASMO: A Scalable Approach to Network Slices Management and Orchestration	Scientific publication	27/04/2018	IEEE NOMS 2018 - 5GMan	100	Orange
A Novel Compact Header for Traffic Steering in Service Function Chaining	Scientific publication	20/05/2018	IEEE ICC 2018	50	AU
On Enabling 5G Automotive Systems Using Follow Me Edge Cloud Concept	Scientific publication	01/06/2018	IEEE Transactions on Vehicular Technology	50	EURECOM, AU
A reference architecture for network slicing	Scientific publication	26/06/2018	IEEE Netsoft 2018	100	Orange, FOKUS, EURECOM

2.7. Presentations

Keynotes, presentations and tutorials also play an important role in the project's dissemination. In the third year of the project, the partners have delivered 1 keynote and 2 invited speeches, and 6 presentations and tutorials. Table 5 below summarizes their contributions.

Presentations in the first and second year are also summarized in Table 6 and 7.

Table 5 - Summary of presentations for dissemination in the third year

Document Title	Document Type	Publication Date	Conference / Journal	5G!Pagoda related %	Consortium Contributors
Deep Learning-based Application Specific RAN Slicing for Mobile Networks	Presentation	2018/10/22	IEEE WCNC2019, Marrakesh, Morocco	50%	Univ. Tokyo
Network Softwarization Stays to Become A Reality	Keynote	2018/11/6	ETSI - OSA Workshop	50%	Univ. Tokyo
On Network Slicing and Network Softwarisation in 5G Mobile Systems	Tutorial	2018/12/9	IEEE Globecom 2018	60%	Aalto
Integrated ICN and CDN Slice as a Service	Presentation	2018/12/13	GLOBECOM2018, Abu Dhabi, UAE	50%	Aalto, Waseda
Context-aware UE Slicing Leveraging Deep Learning and Software-Defined RAN	Presentation	2019/3/22	IEICE General meeting	100%	Univ. Tokyo
The Implementation of Integrated ICN and CDN as a Video Streaming Service	Presentation	2019/3/22	IEICE General meeting	100%	Waseda
Status of network slicing	Invited Speech	2019/6/14	IEEE 5G Summit Istanbul	100%	Orange
Business dimension of network slicing	Invited Speech	2019/6/24	IEEE 5G-IoT Summit Tangier	100%	Orange

Table 6 - Summary of presentations for dissemination in the first year

Document Title	Document Type	Publication Date (Month -	Conference / Journal	Consortium Contributors
Action for the slice management and industrial use case	Presentation	March-17	TTC Workshop	Hitachi
A Network Function Virtualization framework for Network Slicing of 5G Networks	Presentation	June-17	22. VDE/ITG Fachtagung Mobilkommunikation	FOKUS
Application Driven End-to-End Network Slicing, From UE To Cloud	Keynote	October-16	IEEE CloudNet 2016	UT
Applications in 5G era and ICN	Presentation	February-17	Waseda GITI Forum	Waseda
Challenges and Issues for 5G End-to-End Slicing and its Orchestration	Panel	May-17	IEEE IM Conference 2017	AALTO
Introduction of 5G!Pagoda Project	Presentation	October-16	6th EU/Japan Joint R&D Symposium	UT, NESIC, Hitachi, KDDI, Waseda
Network Slicing for 5G Mobile Network	Keynote	October-16	IEEE 5G Summit	UT
Network Slicing in 5G Mobile Networks	Keynote	November-16	IEEE CS-SIG-CS	UT
Network Softwarization	Panel	May-16	IEEE ICC 2016	AALTO
Network Softwarization and Slicing technologies for 5th generation mobile networks	Presentation	November-16	TTC Workshop	UT
Network Softwarization and Slicing technologies for 5th generation mobile networks	Presentation	December-16	ICT seminar in Kyshu-University	UT
Network Softwarization and Slicing: Ongoing Developments in Standard Developing Organizations	Keynote	November-16	IEEE CSCN 206	UT
Network softwarization on MVNO service	Presentation	November-16	TTC Workshop	NESIC
Network Softwarization Open Source Software	Presentation	September-16	IEICE Communictions Society Conference 2016	UT
On Network Slicing and Network Softwarisation: Enablers for 5G Mobile Systems	Tutorial	May-17	IEEE ICC 2017	AALTO
On Network Slicing in 5G Mobile Systems	Tutorial	December-16	IEEE Globecom 2016	AALTO
On Network Softwarization	Tutorial	September-16	IEEE PIMRC 2016	AALTO
Softwarized LTE in FLARE network slices	Presentation	December-16	ITU FG-IMT2020 Workshop Demo Day	UT
The Next Steps:Design Application-Driven and Apply Right Technologies to Right Place	Keynote	September-16	NV Symposium 2016	UT
Toward Enabling Smart Cities: 5G Mobile Network and Mobile Edge Computing	Presentation	July-16	GEOSMART	UT
Towards 5G: On Network Softwarization	Keynote	June-16	IEEE HPSR/iPOP 2016	AALTO
5G!Pagoda and its study on 5G-IoT integrated business challenges and opportunities.	Presentation	June-17	EU-Taiwan 5G Workshop	DG

Table 7 - Summary of presentations for dissemination in the second year

Document Title	Document Type	Date	Conference / Journal	5G!Pagoda related %	Consortium Contributors
Core network in 5G Mobile era and ICN	Keynote	04/07/2017	ICTF2017	100	WU
Network slicing for IoT in 5G networks	Keynote	04/07/2017	Senzations 2017	100	Orange
Distinguished Expert Panel: "Moving Frontiers in Network Softwarization"; frontier topic: "Why we shouldn't replicate hardware in software?"	Distinguished experts panel	06/07/2017	IEEE Netsoft 2017	100	Orange
IoT/5G Network Softwarization and In-Network Deep Learning	Keynote	18/09/2017	Helsinki 5G Week	70	UT
From OpenEPC to Open5GCore – enabling flexible 5G core network prototyping	Keynote	22/09/2017	Informa Evolved Packet Core World Forum	70	FOKUS
App-Specific Edge Computing and In-Network Deep Learning	Keynote	29/09/2017	APNOMS2017	70	UT
Network Slicing - open issues	Keynote	29/09/2017	APNOMS 2017	100	Orange
Towards a virtualized communications world – Challenges and Opportunities	Presentation	18/10/2017	7th IEEE Gobal Wireless Summit	70	FOKUS
Getting 5G ready – How to cope with the radical network transformation	Keynote	24/10/2017	Broadband World Forum	70	FOKUS
Cloud in the loop and In-Network Machine Learning	Keynote	26/10/2017	GEFI (Global Experimentation for future Internet) Workshop	70	UT
Research and Developmenton End-to-End Network Slicing	Keynote	08/11/2017	OpenAirInterface Workshop (OAI Workshop)	70	UT
Towards Programmable Telcos	Keynote	10/11/2017	Korea-EU Coordinated Calls R&D Conf. Seoul	80	AU
Network Softwarization for Driving, Data Analytics, In-Network Machine Learning and Edge Computing	Keynote	29/11/2017	IEEE CNSM 2017	70	UT
On Network Slicing and Network Softwarization: Enablers for 5G Mobile Systems	Tutorial	04/12/2017	IEEE Globecom 2017	80	AU
SDN and Future Network Deployment in CATV internet	Presentation	24/01/2018	Network Committee in Chuo Coridor Consotium	60	NESIC
Distinguished Expert Panel: "Theme: Future Management Challenges"	Distinguished experts panel	26/04/2018	IEEE/IFIP Network Operations and Management Symposium 2018	100	Orange
Distinguished Expert Panel: "How to design smart softwarized networks to meet the challenges of low-latency services?"	Distinguished experts panel	26/06/2018	IEEE Netsoft 2018	100	Orange

3. Standardization

This chapter provides an overview of the standardization strategy. As an initial step (Year-1), standardization work plan had been established, identifying what partner will contribute to what standardization process. The strategy design started by taking into account all Standards Development Organizations (SDOs) mentioned in the Description of work, yet the contributions were majorly submitted to ITU-T, IETF and 3GPP as the first phase.

In this process, all partners had been invited to indicate their interests for standardization activities. Six partners had completed the survey form and identified topics to be worked on and contributed to. Their interests were eventually aggregated into specific working or study groups of the three SDO's: ITU-T, IETF and 3GPP.

The individual SDOs among them have different roles towards for exploiting results from their standards:

- ITU-T indicates the direction of incorporating new technologies. They forecast the various future use cases, and ITU-T analyses the interoperable issues to realizes the uses cases, they mention the roles of technology. Because their use case forecasts sometimes see the far future, the delegates come from academic research fields as well as vertical sectors. In 5G!Pagoda project, Univ. of Tokyo, Waseda Univ., Orange and Mandat International joined to ITU-T and tried to contributes standard specification from our 5G!Pagoda project results
- IETF specifies the protocol details, and standard outcome becomes ready to be used promptly for communication products. Originally, the IETF focused on driving the expansion of Internet technologies, However, they currently produce various specifications adopted in vendor products and network operators' services, and which results that the various vendors and network operators lead IETF standards instead of only academic researchers. In the 5G!Pagoda project , Waseda Univ., Orange and Mandat International joined to IETF. Waseda Univ. contributes the new communication architecture: Information Centric Networking discussed in IRTF, and Orange and Mandat International joined WGs treating network slicing (e.g., Networking Working Group) in IETF.
- 3GPP develops standards specialized mobile communications. Originally, the mobile communication had been developed for persons' uses: telephone, messaging, and data communications, and therefore, the mobile systems (the first, second and third generations) was able to be developed with 3GPP-proprietary technologies. However, the communication environments with 4G generation mobile system grows, and 5G newly targets, the communications various IoT devices as well as persons' devices (smartphones). This results that the utility requirements to 5GS dramatically expanded, and therefore, 3GPP emerges to adopts the IETF standards as users. The ITU-T standards were referred for the use cases leading the requirements. In the 5G!Pagoda project, KDDI, Orange and Ericsson joined to a working group discussing service and system architecture aspects (SA WG2), and has been contributing to develop specifications with research results.

3.1. Standardization Achievements

The following subsections describe the individual standardization achievements. The third year of 5G!Pagoda project actively work to ITU-T SG13, SG20, 3GPP SA WG2, and IRTF.

3.1.1. Standardization Achievements at the ITU-T SG 13

In the third year period, Waseda participated in ITU-T SG13/Q.22 activity as the editor. Waseda looked for the suitable timing to submit contributions. The main topic of this group during the third period, however, was the ICN function chaining and its naming structure. This is one of the very important aspects of ICN but not yet brought into the 5G!Pagoda project. Therefore, the contribution based on this project was not submitted during the third year period. Since Waseda keeps contributing to this topic, we have a future plan to seek for the opportunity to submit contributions to Q.22 or possibly Q.20 based on the results obtained in this project.

3.1.2. ITU-T Study Group 20

Given that the technical standardization contributions were mostly focused on 3GPP, and that only a few members of the consortium can contribute to that SDO, other standardization paths have been explored, including at the ITU. In the third year of the project, another contribution has been prepared and submitted to the ITU-T SG20 to summarize the achievements of 5G!Pagoda by MI and DG.

3.2. Standardization Achievements at 3GPP

3GPP is an influential standardization body and has been actively working on 5G. KDDI mainly participates and contributes in the following work items.

- TS 23.501: “System architecture for the 5G System (5GS); Stage 2”
- TS 23.502: “Procedures for the 5G System (5GS); Stage 2”
- TS 23.503: “Policy and charging control framework for the 5G System (5GS); Stage 2”
- TR 23.725: “Study on enhancement of Ultra-Reliable Low-Latency Communication (URLLC) support in the 5G Core network (5GC)”
- TR 23.726: “Study on Enhancing Topology of SMF and UPF in 5G Networks”
- TR 23.731: “Study on enhancement to the 5GC LoCation Services (LCS)”
- TR 23.734: “Study on supporting Flexible Local Area Data Network”
- TR 23.738: “Study on Enhanced support of Vertical and LAN Services”
- TR 23.742: “Study on Enhancements to the Service-Based Architecture”
- TR 23.743: “Study on optimizations on UE radio capability signaling”
- TR 23.754: “Study on supporting unmanned aerial systems connectivity, Identification and tracking”
- TR 23.791: “Study of enablers for Network Automation for 5G”

KDDI, Orange, Ericsson and NEC have submitted many contributions to these documents for three years. In the first year, KDDI proposed a framework enabling the user terminals/IoT devices to select slices to which they connect, and functional roles in this feature.

In the third year of the project, KDDI, Orange, Ericsson and NEC proposed the interwork procedures between 5GS and OTT systems: The policy negotiation, registrations and enforcement, sharing policy of network utility status, and setting traffic control policies from network utility analysis.

3.3. Major Specifications for 5G system architecture at 3GPP

The major specifications for 5GS are specified in three documents: TS 23.501, TS 23.502 and TS 23.503. All the study of technical reports (TR) described in Section 3.2 would be reflect to these three documents.

Originally, the 3GPP SA had planned to complete the specifications of release 16 by the end of June, 2019. However, there are various features have been tried to be included into the release 16 specifications, the end time had been extended by the end of September, 2019. KDDI and 5G!Pagoda partners will continue to contribute in order to extend the 5G system specifications by September.

The following sections summarize the documents: TS 23.501, TS 23.502 and TS 23.503

3.3.1. 3GPP TS 23.501 "System architecture for the 5G system"

TS 23.501 is a technical specification which describes the stage 2 system architecture for the 5GS, which provides data connectivity and services. the solutions for various system requirements specified in TR 23.799 are adopted in TS 23.501. TS 23.501 contains architecture concept and model, network functions description, roaming and non-roaming scenarios, interworking among EPS (evolved packet system: the 4th generation mobile core system) and 5GS, policy and charging, mobility, authentication and security aspects.

3.3.2. 3GPP TS 23.502 "Procedures for the 5G system"

TS23.502 describes detailed procedures for registration management, session management, user plane functions interactions, security and authentication. Regarding TS 23.502, KDDI proposed detailed procedures of negotiation for background data transfer for 5GS. 5G allows mobile network operator to configure mobile edge computing environments. This document includes procedures such as handling of protocol data unit (PDU) session corresponding to Local Area Data Network.

3.3.3. 3GPP TS 23.503 "Policy for the charging control for the 5G system"

This specification describes the policy and charging control framework for the 5GS and the interaction between network functions. The policy and charging controls are extended to deal with mobile slices in 5G specifications, interactions between 5GS and OTT systems.

3.4. Standardization Achievements at IRTF

In the third year of the research, the following standardization achievements at IETF can be noted. Waseda kept watching of ICN related activities in IRTF. However, no significant discussion closely related to 5G!Pagoda activities was found.

3.5. Main Contributions to Standardization Bodies

The following Tables below give an overview of the main contributions submitted by the partners to the standardization bodies. The 5G!Pagoda project has focused on 3GPP to accelerate reflecting the research result to commodity products.

Table 8 - Summary of contributions to 3GPP and ITU-T in the third year (part 1)

Document Title	Document Type	Publication Date	Conference / Journal	5G!Pagoda related %	Consortium Contributors
S2-187168: An addition of a new Key Issue on Network Status”、”Study of enablers for Network Automation for 5G	contribution	2018/7/6	3GPP SA WG2	20%	KDDI
S2-187560: Update of parameter in call flow and service operation for NSI ID	contribution	2018/7/6	3GPP SA WG2	20%	KDDI
S2-187815: Update of NEF service table (7.2.8) for Chargeable party and AFsessionWithQoS	contribution	2018/8/24	3GPP SA WG2	20%	KDDI, Orange
S2-188377: Update of Key issue #5 (support interworking between Ether-type 5GLAN communication and Ethernet network)	contribution	2018/8/24	3GPP SA WG2	20%	KDDI
S2-188587: BDT: clarification on network area information and ASP identifier	contribution	2018/8/24	3GPP SA WG2	20%	KDDI
S2-189050: Solution for Key Issue 7: NWDAF assisting Future Background Data Transfer	contribution	2018/8/24	3GPP SA WG2	20%	KDDI, Ericsson
S2-1811117: Solution to UC and KI on how to determine the QoS profile”、”Study of enablers for Network Automation for 5G	contribution	2018/8/24	3GPP SA WG2	20%	KDDI, Orange, NEC, Ericsson
S2-1811353: Deferred 5GC-MT-LR Procedure for Solution 14	contribution	2018/10/19	3GPP SA WG2	20%	KDDI, Ericsson
S2-1811394: Update of Solution 18: Further AMF modularization	contribution	2018/10/19	3GPP SA WG2	20%	KDDI
S2-1811420: Clarification on URSP rule and UE local configuration association	contribution	2018/10/19	3GPP SA WG2	20%	KDDI
S2-1811569: Clarification on user preference and URSP	contribution	2018/10/19	3GPP SA WG2	20%	KDDI
S2-1811587: NWDAF assisting Determination of Background Data Transfer Policy	contribution	2018/10/19	3GPP SA WG2	20%	KDDI, NEC
S2-1811588: New solution: Data exposure to AF for Background Data Transfer	contribution	2018/10/19	3GPP SA WG2	20%	KDDI, NEC
S2-1811593: New solution to support communication between Ethernet type 5GLAN and Ethernet network in data network	contribution	2018/10/19	3GPP SA WG2	20%	KDDI
S2-1811597: Conclusions for key issue 4 - Stateless NF Services	contribution	2018/10/19	3GPP SA WG2	20%	KDDI, Ericsson
16885-C92-R2: Scalable Service Management and Orchestration Framework in IMT-2020	Contribution	2018/10/22	ITU-T Q21/13	60%	HITACHI, UT, Orange
ML5G-I-105-R1:Application-Specific Network Slicing through In-Network Deep Learning	Contribution	2018/11/27	ITU-T FG-ML5G	60%	UT
S2-1812488: Revised WID for xBDT	contribution	2018/11/30	3GPP SA WG2	20%	KDDI
S2-1812551: Proposed New WID on Enhancing Topology of SMF and UPF in 5G Networks	contribution	2018/11/30	3GPP SA WG2	20%	KDDI, NEC, Ericsson
S2-1812605: New solution X: RAN mapping of 'pointer' to Full capability with Backward Compatibility	contribution	2018/11/30	3GPP SA WG2	20%	KDDI
S2-1812704: KI#1: Updates of Solution #1	contribution	2018/11/30	3GPP SA WG2	20%	KDDI, Ericsson
S2-1812705: KI#1: Updates of Solution #9	contribution	2018/11/30	3GPP SA WG2	20%	KDDI, Orange
S2-1812799: Evaluation for Solution#28 (Exposure to AF for BDT)	contribution	2018/11/30	3GPP SA WG2	20%	KDDI
S2-1813035: 5GS Enhanced support of Vertical and LAN Services	contribution	2018/11/30	3GPP SA WG2	20%	KDDI, Ericsson
S2-1813202: Conclusions on key issue: NWDAF assisting BDT negotiation	contribution	2018/11/30	3GPP SA WG2	20%	KDDI, Ericsson
S2-1813337: Unified 5GLAN architecture	contribution	2018/11/30	3GPP SA WG2	20%	KDDI
S2-1813341: Study on supporting unmanned aerial systems connectivity, Identification and tracking	contribution	2018/11/30	3GPP SA WG2	20%	KDDI, Orange, Ericsson

Table 9 - Summary of contributions to 3GPP and ITU-T in the third year (part 2)

Document Title	Document Type	Publication Date	Conference / Journal	5G!Pagoda related %	Consortium Contributors
SG13-C624-R1: Proposed updated draft Recommendation ITU-T Y.NetSoft-SSMO: Scalable service management and orchestration framework in IMT-2020	Contribution	2019/3/4	ITU-T Q21/13	60%	HITACHI, Univ. Tokyo
ML5G-I-118-R9:Machine learning in 5G and future networks: use cases and basic requirements	Contribution	2019/3/5	ITU-T FG-ML5G	60%	Univ. Tokyo
S2-1903868: Removal of Annex for BDT	contribution	2019/4/12	3GPP SA WG2	20%	KDDI
S2-1904005: Correction for background data transfer in TS 23.502	contribution	2019/4/12	3GPP SA WG2	20%	KDDI
S2-1904006: Removal of Editor's note for BDT warning notification	contribution	2019/4/12	3GPP SA WG2	20%	KDDI
S2-1904009: Conclusion for Key Issue 14	contribution	2019/4/12	3GPP SA WG2	20%	KDDI, Ericsson
S2-1904376: Adding Support for Delivering Background Data Transfer Polices to the UE	contribution	2019/4/12	3GPP SA WG2	20%	KDDI
S2-1904610: Removal of Editor's note related to N6 routing	contribution	2019/4/12	3GPP SA WG2	20%	KDDI
S2-1904786: Clarification of Inserting and Removing VLAN tags for 5GLAN	contribution	2019/4/12	3GPP SA WG2	20%	KDDI
S2-1904805: NF Service Context Transfer Procedures	contribution	2019/4/12	3GPP SA WG2	20%	KDDI
S2-1904806: AMF utilizesNRF to discover NSSF	contribution	2019/4/12	3GPP SA WG2	20%	KDDI, Ericsson
S2-1906683: 23.501 CR1083R4: Clarification of Inserting and Removing VLAN tags for 5GLAN	contribution	2019/5/17	3GPP SA WG2	20%	KDDI
S2-1906726: New SID: Study on enhanced support of Non-Public Networks	contribution	2019/5/17	3GPP SA WG2	20%	KDDI, Ericsson
S2-1906745: 23.501 CR1391: Service Context Transfer Support in UDSF	contribution	2019/5/17	3GPP SA WG2	20%	KDDI
S2-1906746: 23.502 CR1393: Service Context Transfer Support in UDSF	contribution	2019/5/17	3GPP SA WG2	20%	KDDI
S2-1906775: 23.501 CR1331: Support of Service Context Transfer in TS23.501	contribution	2019/5/17	3GPP SA WG2	20%	KDDI
S2-1906751: 23.502 CR1305R6: NF Service Context Transfer Procedures	contribution	2019/5/17	3GPP SA WG2	20%	KDDI
S2-1906722: Enablers for Network Automation for 5G - phase 2	contribution	2019/5/17	3GPP SA WG2	20%	KDDI, Ericsson, Orange
S2-1906390: 23.501 CR1333: Alignment of IMS Voice Service via EPS Fallback with RAN specifications	contribution	2019/5/17	3GPP SA WG2	20%	KDDI
S2-1905848: 23.502 CR1134R3: UE Policy association procedures correction	contribution	2019/5/17	3GPP SA WG2	20%	KDDI, Ericsson
S2-1905849: 23.502 CR1135R3: UE Policy association procedures correction	contribution	2019/5/17	3GPP SA WG2	20%	KDDI, Ericsson
S2-1905949: 23.501 CR1366: Subscriptions Segmentation in PCF and UDR	contribution	2019/5/17	3GPP SA WG2	20%	KDDI, Ericsson
S2-1905893: 23.503 CR0242R4: Adding Support for Delivering Background Data Transfer Polices to the UE	contribution	2019/5/17	3GPP SA WG2	20%	KDDI
S2-1906785: 23.501 CR1445: Update of TS23.501 for xBDT feature	contribution	2019/5/17	3GPP SA WG2	20%	KDDI
S2-1906083: 23.502 CR1140R5: Removal of Editor's note for BDT warning notification	contribution	2019/5/17	3GPP SA WG2	20%	KDDI
S2-1906087: 23.502 CR1329: Adding new event in Namf_EventExposure for Network Performance Analysis	contribution	2019/5/17	3GPP SA WG2	20%	KDDI
ML5G-I-153-R1:Machine learning in IMT-2020 and future networks: use cases and basic requirements (previous version were posted as ML5G-I-118)	Contribution	2019/5/18	ITU-T FG-ML5G	60%	Univ. Tokyo

3.6. Limits and Opportunities in Standardization

Looking back at standardization activities throughout 3 years of the 5G!Pagoda project, several opportunities, and limits can be noted, which may be insightful for similar research projects in the future:

3.6.1. Limits:

- Partners with strong experts in developing technologies have not always been active in standardization and vice versa.
- A number of partners did not have the authority to participate in the SDOs, which limited their potential to participate in standardization activities. However, there were multilateral discussions within the 5G!Pagoda Consortium to facilitate standardization and ease joint contributions.
- The convenient and easy utilization of ICT allows global communication service systems to be implemented without system interworking to the competitive players, and this implies that the influences of conventional standards developed for communication services to be newly created decrease.

3.6.2. Opportunities:

- It may be interesting to explore the possibility of creating a working group between Japan and EU to facilitate the standardization between both regions.
- Discussion on research results with delegates participating to the standardization bodies can more accurately clarify use cases to which the research results are to be applied
- The project can promptly verify the solutions as standard specifications through implementing prototypes due to helps of the multilateral partners in the project.
- The strong experts in software programing communities (e.g., development of M-CORD [Mobile Central Office Re-architected as a Datacenter]) can also be active, and their achievements are, in a sense, leading standards through processes of creating software, because the various types of standards and their bodies are derived recently.

4. Partnerships, Liaisons and Cooperation

The development of partnerships, liaisons and cooperation is part of task T6.3.

4.1. Strategy and Objectives

A key objective of the task T6.3 is to leverage on the wide contact list of the participating partners. It intends to establish partnerships with the different relevant stakeholders, particularly IoT service providers outside the consortium, so that, with the definition of appropriate interfaces to their services, they could be included in the testbed of the 5G!Pagoda testbed (WP5).

4.2. Partnerships

The consortium is continuing its efforts to improve the strategic partnerships identified in T2.2. For the third year of the project, the following partnerships can be noted. Following subsection describes existing partnerships and ongoing activities.

4.2.1. UDG Alliance

UDG Alliance is a non-for-profit organization gathering several research partners engaged in the development of the Universal Device Gateway (UDG) control and monitoring system, which is actively engaged in highly scalable IoT deployment in smart cities. UDGA is in charge of the heterogeneous integration of IoT in the European Large-Scale-Pilot on IoT for Smart Cities: Synchronicity. MI and DG are members of the UDG Alliance, and discussions are ongoing to include relevant 5G!Pagoda technologies that could be tested and demonstrated in European cities.

4.2.2. CEATEC

Mandat International and KDDI are exploring the opportunity of sharing an exhibition area at the upcoming CEATEC trade show in Japan, held between 15-18 October 2019. Although this activity would take place after the end of the project, both partners are interested in further collaboration and are examining the possibility of presenting the final outcomes of the 5G!Pagoda project during the event.

4.3. Liaison and Cooperation with Other Organizations

A number of partners have established cooperation and liaison with other organizations. The following part outlines their achievements.

4.3.1. IoT Forum

MI is hosting the Secretariat of the IoT Forum and serves as President of the Board since 2016. One of the major activities of the IoT Forum is to organize the yearly IoT Week conference. Through the different editions of the IoT Week and other activities, the IoT Forum allows its members to collaborate between them and to exchange ideas not only about IoT, but also about the emerging technologies like 5G. MI has organized the IoT Week held between June 17 and 21st 2019 in Aarhus, Denmark. It offered high visibility to 5G!Pagoda through a presentation on 5G network slicing for IoT. The event was intended for the IoT community and industry.

4.3.2. TM Forum

The TM forum is a non-profit industry association for service providers and telecommunication operators. In the third year, MI collaborated with the TM forum to organize the following four sessions on 5G convergence on June 18th and June 20th 2019, during the IoT Week 2019 in Aarhus, Denmark:

- IoT and the 5G City
- 5G, IoT and End-to-End Security
- Realizing IoT-5G Convergence
- 5G for Connected Vehicles

4.3.3. IoT Lab

The IoT Lab association has been established by the European research project IoT Lab. It gathers and federates several European testbeds together with crowdsourcing resources and tools. The IoT Lab platform is managed by MI and the resources (sensors and actuators typically) available through IoT Lab can be used in the frame of the research, test and validation of IoT related applications of dynamic slicing. The IoT Lab resources are also used in the context of the 5G!Pagoda demonstration.

4.3.4. Open Platform for NFV (OPNFV)

Fraunhofer FOKUS is involved in OPNFV with the project Orchestra that was concluded last year with high success. Orchestra enables the integration of the open source NFV MANO platform Open Baton with other OPNFV projects for specific scenarios and use cases. In particular, the Open Baton installation was integrated into different OPNFV installers in order to be part of the OPNFV installation process.

Furthermore, many testing scenarios were also executed as part of the Functest project, providing a comprehensive testing methodology, test suites and test cases to test and verify OPNFV Platform functionality.

4.3.5. Open Source MANO (OSM)

OSM is an ETSI-hosted project to develop an open source platform aligned to the ETSI NFV specifications. Fraunhofer FOKUS is an active OSM member committed to provide its expertise and consultancy in the area of Management and Orchestration. Specifically, a first integration between OpenBaton and OpenVIM components was successfully performed.

4.3.6. GSMA Slicing Alliance

Fraunhofer FOKUS is one of the founding members of the “5G Slicing Association” formed in early 2018. It addresses requirements from vertical industry and potential application scenarios of 5G network slicing on the way to defining new business models.

4.3.7. Telecommunication Technology Committee (TTC)

Professor Nakao from the UT has been contributing the discussion on mobile access network softwarization architecture for ITU-T SG13/Q21. Oki Electronics, Mitsubishi, NEC, and NTT have submitted several proposals after the TTC discussions which is consistent with 5G!Pagoda architecture.

4.4. Liaison and Cooperation with Other Research Projects

The members of 5G!Pagoda actively cooperate with other research projects. Indeed, a number of these projects, including METIS II, 5G Ensure and Coherent fall under the scope of the 5G-PPP (5G Infrastructure Public Private Partnership). The members also cooperate with other European projects.

4.4.1. 5G-PPP

5G!Pagoda project has had a number of linkages towards 5G-PPP most notably through the Global5G.org project. The latter project is a 5G-PPP Phase 2 Coordination and Support Action (CSA) that among other things monitors vertical use cases and standards impacts from 5G-PPP and international corporation projects. Furthermore, Global5G.org collaborates with these projects to co-organise vertical or standards oriented dissemination events. To that end, the IEEE 5G Summit of September 2017 which was co-organised by the 5G!Pagoda was leveraged by the Global5G.org project to organize a themed session on "The Road to 5G and Standardisation for new Health and Care Services" http://global5g.org/news/5g-health-session-road-5g-and-standardisation-health-care-services-ieee-5g-summit-18-september

4.4.2. Coherent

Conjointly, with the Coherent project, the 5G!Pagoda project has developed a novel RAN API, namely FlexRAN, which allows programming the RAN in order to enforce the resources sharing decisions made by the Slice Orchestrator. The FlexRAN protocol is composed by a controller, and agents run at the OAI eNodeB. The FlexRAN controller receives resources sharing information, i.e. number of resources blocks to assign to each slice, and the latter communicates this information to the OAI eNodeB. This technology has been demonstrated in many venues, including EuCNC 2017 and 2018 as well as project meetings (Helsinki 2018).

5. Exploitation

The detail exploitation (market analysis, implementation of strategy, and analysis of potential exploitations) are reported in Deliverable D6.5 "Report on innovation achieved and forthcoming industrial exploitation". Therefore, this report summarizes the D6.5 and the-third-year exploitation activities of individual partners.

5.1. Summary of forthcoming industrial exploitation

D6.5 outlines and analyses the innovation achievements in the scope of 5G!Pagoda in terms of six key technological assets resulting from the project: 1) Implementation of the 5G core network to support small messages and data plane diversity led by FOKUS; 2) Network Slice Planner led by Aalto; 3) Programmable RAN open source Open Air Interface led by EURECOM; 4) Deep data plane programmability system (granular fine grain traffic control) led by NESIC and UT; 5) Resource Pool for Scalable Orchestration led by HITACHI; 6) CDN/ICN Slicing as a Service led by Aalto and Waseda Universities. D6.5 also develops on the individual exploitations and business plans, on the developed partnerships and discusses the prospects of a future EU-Japan collaboration.

5.2. Individual Exploitation Achievements and Plans

The following subsections represent the exploitation achievements of the third year in 5G!Pagoda project from the individual partners.

5.2.1. Aalto University

AU will use the findings of 5G!Pagoda in its teaching material, and will use the prototypes developed to attract more funding from within the European Commission as well as from other sources. AU team has largely contributed to the community of Network Softwarization researchers and that is in the form of many scientific publications, tutorials and through the organization of IEEE WCNC 2019 which was a successful edition. AU has developed the NSP tool which is intended to be an important asset for the research community, and made it free access for the public.

5.2.2. Device Gateway SA

In continuation to DG's exploitation plan in the first and second year of the project, DG, as an IoT service provider, has been focusing on development of IoT use case using 5G!Pagoda technologies in the third year as well. DG, naturally, plays the core role on developing the scenario and advanced development of the testbed and the demo of 5G!Pagoda IoT use case, of which the technical details are in the deliverables of WP5. Benefiting from the accumulated knowledge from the first and the second year, the IoT use case is evolving close to the real-market needs for IoT service providers. The result is demonstrated in the public exhibition in the IoT Week 2019 in Aarhus, where a large number of IoT, Smart City and 5G stakeholders participate in. The first demo has been already presented in the IoT Week 2017 in Geneva, which received a large audience and raised the awareness about the advantages of network slicing in the IoT community. The advance demo in this year show Geneva-Berlin-Aarhus connection demonstrating inter-national level of IoT service using state-of-the-art 5G technologies. It is well in line with EU policy of digital single market by enabling inter-national services in Europe. The project result will be directly used to develop DG's further business models on IoT service provision benefitting from the 5G slice technology.

Besides the technical development for the exploitation, DG has been continued to promote the project results to its stakeholders, as the concepts of 5G slicing is not yet concrete in IoT community. As a frontier on building IoT-5G integrated use case, DG is engaging in community discussion on business development.

5.2.3. EURECOM

During the last year of the project, EURECOM continued his activity related to dissemination by publishing a work, in IEEE Network magazine, on the RAN programmability and the management of uRLLC slices at the RAN.

5.2.4. Fraunhofer-FOKUS

The different implemented items within the WP3 were integrated as part of the Open5GCore and licensed to the customers requiring 5G testbeds. These include the lightweight core network and the specific 5G service-based implementation, the interaction with deep programmable data path functions and the edge-central split. Additional considerations on orchestration as coming from the WP4 are considered to be implemented by Fraunhofer FOKUS as part of the own research projects especially in the direction of multiple slice deployments as part of on premise networks.

Furthermore, the integrated Japan-Europe testbed from WP5 is used as a bridge to extend the collaboration of Fraunhofer FOKUS with Japanese partners outside of the 5G!Pagoda project representing a fundamental trust piece into the developed technologies.

5.2.5. Mandat International

The different parts developed in the context of the 5G!Pagoda project are currently used inside the IoT Lab testbeds based in Geneva, in Switzerland. Basically, MI is able to create, deploy and delete dynamically slices dedicated to use cases linked to the Internet of Things. This was made possible only by all the developments and technical work done notably for the demonstrations realized during the three years. This work allows a better dynamic configuration of the network which corresponds to the real needs of the end-users.

5.2.6. Orange

During the final year of the project, Orange exploited its own laboratory environment based on National Instruments USRP SDR modules and the OpenAirInterface software developed by the consortium led by EURECOM. The initial configuration was evaluated and decisions about its extensions have been made. The cooperation with EURECOM, which was established within the 5G!Pagoda project, resulted in common discussion on an extension of the OpenAirInterface with interfaces allowing for dynamic management of network functions. Further activities on this topic are planned within the framework of the mutual cooperation, will be continued. Additionally, Orange decided to implement the Mosaic5G software environment with FlexRAN by EURECOM. Future validations and evaluations of slicing concepts developed by Orange will use the OpenAirInterface and Mosaic5G software.

5.2.7. University of Tokyo

Together with the network slicing using network virtualization technology, UT continued to work on the deep data plane programmability to enable the application based fine grained slicing. Especially during the third year period of this project, the application specific RAN slicing was made possible leveraging such application-based slicing as well as RAN programmability. This technology was reported in IEEE conference of CloudNet2018. In addition, UT introduced ML technology to application-based traffic control utilizing the

application classification traffic data. The use of ML/AI technology is expected to be essential in future 5G mobile. UT submitted three documents related to such ML/AI technology to ITU-T FG-ML5G.

5.2.8. KDDI

In the third year of the project, KDDI has been working on the 3GPP standardization with Orange, Ericsson, NEC and 3GPP members who are dealing with or adopting the specified 5G mobile communication systems as the potential exploitation. We have succeeded to have agreements for 49 contributions and three technical specifications which have been published in September 2019. In these contributions, KDDI built an interwork feature for the mobile core system and 3rd party system according to the multi-stakeholders' interworks implemented by this project. This standardization should enable venders to produce commodity products in 2 years.

KDDI has also been actively involved in evaluating the ability of 5G prototype systems in multiple proofs of concept: high-definition video deliveries in the snow-removal operations, sensing object for an industrial robot in a factory automation use case, and unmanned aerial vehicles. Further, KDDI verifies the interwork feature of multiple systems which work together to organize service-dedicated mobile slices. This verification took a use case where the network resources were provided to different mobile slices depending on a resource assignment policy according with a service priority example.

KDDI have started to build a plan to adopt the network slicing features in their commercial system and migrate a part of the mobile communication services to slicing-based 5G systems in a few years.

5.2.9. Waseda University

Through the working period of this project, Waseda has been striving towards the realization of ICN in a variety of ways, including through the means of standardization, publications, and the new project proposals. During the third year period, the following achievements have been done in each aspect. The future planes are also described.

As for the standardization, our focus has been on ITU-T SG13/Q.22, where Waseda proposed a new study item for this study period. The study item was accepted and Waseda was assigned as editor to promote the discussion. During the third year period, Waseda looked for the suitable opportunity to submit contributions. The main topic of this group during the third period, however, was the ICN function chaining and its naming structure. This is one of the very important aspects of ICN but not yet brought into the 5G!Pagoda project. Since Waseda keeps contribution to this topic, we have a future plan to submit contributions using the results obtained in this project.

The second type of activity worth mentioning involves written publications and presentations. In the third year of the project, Waseda published 2 journal papers, and made 2 presentations one for the international conference and one for the national conference. In addition, we coauthored one international conference paper with Aalto presented by Aalto. One of the journal papers was coauthored with Aalto, and one of the international conference papers was coauthored with Aalto, University of Tokyo, and Hitachi, showing the evidence of excellent international and national partnership established through the project. In the future, Waseda will continue the publication obtained by this project.

The third type of activity involves new project proposals using the technologies established by 5G!Pagoda. Waseda proposed some projects, and new one was accepted during the third year period. Waseda will enrich the ICN related 5G!Pagoda achievements by utilizing them in other projects, and has a good chance to do so in the coming years.

5.2.10. NESIC

NESIC and University of Tokyo demonstrated MVNO network using FLARE. Moreover, in another project sponsored the National Institute of Information and Communications Technology (NICT), NESIC demonstrated the adaptation of the technology of network slicing with FLARE to the CATV platform. The period is from November 2018 to May 2019. In this demonstration experiment, broadband services, agricultural ICT, municipal services using cameras for sightseeing and crime prevention, etc. provided by CATV were flowed, and it was demonstrated that a network slice could be realized by overlaying on a CATV network. NESIC will further promote function development and evaluation test and aim for commercial service.

5.2.11. Hitachi

In the final year of the project, Hitachi mainly worked with other project members to realize various use cases and to identify the orchestrator's issues. In addition, we worked on solving the issues and evolving the orchestrator and resource pool architecture that can handle the various network patterns. As a result, Hitachi submitted the document to ITU-T related to such resource pool architecture as Scalable Service Management and Orchestration Framework. Also, collaboration with other project members could be realized as a demonstration that orchestrating three slices that provide different services: ICN / CDN slice, mobile and connected car slice, and security slice.

6. Conclusion

The deliverable D6.4 has shown 5G!Pagoda's progress in the field of dissemination and standardization in the third year of the project.

The results on dissemination have been outlined in chapter 2. In the third year of the project, the partners have further disseminate and promote the 5G!Pagoda project continuing in the first and second years. The dissemination methods included the publication of articles in journals and magazines and presentations, the participation in global IoT events (particularly the FOKUS FUESCO Forum 2018, the Berlin 5G Week 2018, and the IoT Week 2019).

Chapter 3 outlined the efforts in the field of standardization in the third year of the project. The partner in 5G!Pagoda contributed to the ITU, 3GPP and IRTF. Their contributions have allowed to achieve broader recognition of the project's results by a wide industry community.

Chapter 4 on "Partnerships, Liaisons and Cooperation" has sought to provide an update on the status of the partnerships previously identified in D 6.2 and D6.3.

Finally, chapter 5 on exploitation has summarized the D6.5 submitted simultaneously, and the individual and collective exploitation achievements of all partners in the third year of the project.