Co-funded by
the Horizon 2020
Framework Programme
of the European Union

A Holistic, Innovative Framework for the Design, Development and Orchestration of 5G-ready Applications and Network Services over Sliced Programmable Infrastructure

DELIVERABLE D7.6

5G-PPP INTERACTION, DISSEMINATION, CLUSTERING & STANDARDISATION ACTIVITIES REPORT - FINAL

Due Date of Delivery:	M38 *Mx* (31/07/2020 *dd/mm/yyyy*)
Actual Date of Delivery:	11/08/2020 *dd/mm/yyyy*
Workpackage:	**WP7 – Dissemination, Communication, Exploitation and Business Planning**
Type of the Deliverable:	R
Dissemination level:	PU
Editors:	AALTO
Version:	1.0

Call:
H2020-ICT-2016-2

Type of Action:
IA

Project Acronym:
MATILDA

Project ID:
761898

Duration:
38 months

Start Date:
01/06/2017

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Table of Acronyms

Acronym	Definition
5G-PPP	5G Infrastructure Public Private Partnership
3GPP	3rd Generation Partnership Project
EC	European Commission
ETP	European Technology Platform
ETSI	European Telecommunications Standards Institute
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IoT	Internet of Things
ISO	International Organization for Standardization
ITU	International Telecommunication Union
KPI	Key Performance Indicator
NFV	Network Function Virtualization
RFC	Request For Comments
SDO	Standards Developing Organization
SME	Small Medium Enterprise
S&T	Scientific and Technical
SG	Study Group
TC	Technical Committee
TS	Technical Specification
WG	Working Group
WI	Work Item

1 Executive Summary

This deliverable presents a concise and comprehensive report on the scientific and technical dissemination, clustering, standardization and 5GPPP programme interaction activities which are the direct outcomes of Tasks 7.1, **Dissemination, Clustering and Standardization Activities** and 7.2, **5G PPP Programme Interaction** of the MATILDA project. This deliverable, which is indeed the final report on the activities carried out within the purview of the above-mentioned tasks shall focus on reporting comprehensively and concisely the activities carried out since the release of the dissemination halfway report [1] until the very end of the project. The reported dissemination activities are those specific to the scientific and technical results generated within the scope of the project and tailored to a range of potential users which include both academic and non-academic researchers, such as the industrial research and development bodies. The reported dissemination results are not only limited to the successful outcomes of the project, but also possible challenges encountered during the implementation and advancement of the different aspects of the project. While many of the activities are interactive (i.e., they involve giving presentations, panel discussions and participation in forums), others are non-interactive (i.e., involve submission of the generated results to the scientific community in the form of conference, journal and magazine papers).

In addition, clustering activities and workshops organized by the MATILDA partners alone or in collaboration with partners from other 5G PPP peer projects, which are used as avenues to further facilitate the dissemination of MATILDA results to the targeted audience in the form of interaction activities such as scientific and technical workshops for the academic and industrial communities, are also reported in this deliverable. Moreover, targeted standardization bodies and standardization activities achieved throughout the advancement of the research and the outcomes of the different aspects of the MATILDA project are also detailed and reported until the very end of the project.

2 Introduction

A major goal of the MATILDA project is to design and implement a radically new framework consisting of both networking and computing segments and prototypes bridging the gap for the telecommunication layer platforms that is able to support functional and performance requirements for deploying and running communication services, as well as for the effective management of the lifecycle of 5G-ready applications over a programmable slice-based network infrastructure. Achieving this goal is hugely important to the MATILDA project consortium members, and within the last few years, the MATILDA consortium has been working tremendously hard towards delivering on all of the set objectives of the project including the one mentioned above.

5G-ready applications provisioned and powered by computing shared virtual resources and operated over orchestrated network slices that are deployed and managed over infrastructure running within multiple administrative domains are of enormous importance in telling the story of the MATILDA project. This story is what has informed the decision of the MATILDA consortium members in making the success of the project an utmost priority. Achieving this prioritized goal is paramount for the collaborative efforts of the partners and in overcoming the different obstacles, foreseen and unforeseen along the journey embarked upon towards the project's successful outcome. This important story has to be told and would be told in a way that will benefit both the consortium members from within the MATILDA project and other stakeholders from without in a way to reach far and wide.

In order to properly share the nitty gritty of the MATILDA project's story and how the consortium members are actively and closely collaborating to achieve the important objectives and other minor goals set from the beginning of the project, the consortium members have come up with a clear dissemination activity plan. The dissemination activities and plans have been designed based on the journey embarked upon more than 30 months ago by the project partners, where project results and challenges have been continuously and proactively shared and reported to the larger community of stakeholders through technical, scientific and in all other respects – within the open source communities, both in academia and industry. These project results are intended to serve beneficial and relevant purpose for use by the different communities of stakeholders in enabling them with important decisions in the future. As a consequence, to make the achieved results available for use by the industrial and academic stakeholders, a significant number of activities are presently going on for their dissemination through different communication channels. In addition, within the context of this deliverable, the consortium members have been addressing already ongoing standardization efforts and contributing to them through the different activities of the project undertaken by its members.

In line with the above information, the main aim of this deliverable is to provide an extensive report on the outcomes of the activities of the interaction of the MATILDA project within the 5G-PPP framework, report on the dissemination efforts of the project from the halfway report up until the very moment of compiling this one, as well as the standardization activities achievements with other standardization bodies. In addition, this report will provide details of the clustering activities between MATILDA and other EU Horizon 2020 projects, and on scientific and technical dissemination for the benefit of the wider MATILDA stakeholders and the international community at large. Based on the organization of WP7, which is responsible for the dissemination, communication, exploitation and business planning within the MATILDA

project development activities, this deliverable, in particular, provides a comprehensive report of the activities of the following WP7 tasks:

Task 7.1 Dissemination, Clustering and Standardization Activities

The primary objective of this task is to report and **disseminate the scientific and technical knowledge** generated within the scope of the MATILDA project. This S&T knowledge shall be effectively diffused among and used to address the need of the wide range of potential users of the outcomes of the project, including the academics, the research and development bodies in the industries, as well as other open source communities and other relevant stakeholders. The dissemination activities within the project are carried out both in an iterative and non-iterative manner.

The **iterative dissemination activities** are carried out in the form of project meetings (plenary, review, virtual bi-weekly) which involve human interactions aimed at fostering and strengthening the relationship and building more trust among the consortium members. This will bring about a better collaboration amongst the project partners and ultimately yield better project results.

The **non-iterative dissemination activities** are targeted towards local, regional and international scientific conferences, as well as topic-specific journals such as Magazines and Transactions, and carried out in the form of submission of published manuscripts revealing the results gathered from the activities and tasks within the MATILDA project. In addition, to further widen the reach of these activities and broadcast the project results, **clustering activities** have been carried out in the form of scientific and technical workshops, either alone or in collaboration with other relevant projects where the scientific and technical outputs from MATILDA have been presented to the scientific community and discussed. In order to realize these objectives, partners from within the MATILDA project committed to organize at least one scientific and technical workshop where results from MATILDA will be presented to the scientific community and two industrial workshops targeted at the vertical industries.

Also within the scope of this task, MATILDA aims to identify important **standardization activities,** closely monitor their progress and participate actively in standardization meetings. Moreover, whenever appropriate, the results stemming from the activities within MATILDA will be discussed for feedback with relevant standardization organizations.

Task 7.2 5G PPP Programme Interaction

The primary responsibility of this task is to closely coordinate, collaborate and execute notable interactions with the peer projects of the 5G Infrastructure Public Private Partnership programme and the 5G Infrastructure Association, in order to build global consensus on important approaches and ultimately achieve the global programme's KPIs.

This deliverable is organized as follow: Firstly, the dissemination organization and plan are described in Section 3, identifying the target scientific and industrial groups, as well as the definition of different dissemination activities and steps envisioned during the MATILDA project. The main communication channels are also described with a detailed workplan schedule of envisioned dissemination activities. Secondly, Section 4 depicts the scientific and industrial dissemination, and clustering activities carried out since the release of deliverable D7.2 [1]. Thirdly, the 5G PPP interaction, relevant standardization activities and potential contributions are described in Section 5. Finally, the deliverable is concluded in Section 6.

3 Dissemination organization and scope of the work

In this section, we shall present the organization and scope of the MATILDA project's dissemination activities. Similar to the very first version of this document [1], i.e., deliverable D7.2 "5G-PPP interaction, dissemination, clustering & standardization activities – Halfway Report", this document presents a comprehensive picture of the coverage of the dissemination activities as undertaken by the consortium members of the MATILDA project since the release of the dissemination halfway report.

3.1 Dissemination, clustering and standardization activities

The ultimate goal of the dissemination activities of any project or research studies is to make available the research outcomes to as many audiences for which they are useful as possible, in the effort of enabling them to make appropriate decisions regarding both their ongoing and future project development and execution. The dissemination goals of the MATILDA project are no different from this. In fact, the MATILDA project hopes to achieve even more by using the results not only to help others in making informed decisions but also to inspire others in creating additional values for their businesses, especially the small and medium enterprises. Results of the 5GPPP project clustering and standardization activities are being communicated to the stakeholders through the use of different available communication channels that allow both interactive as well as non-interactive means of information dissemination. All of these means are utilized in order to maximize the reach of the impact of the project.

Table 1 shows the results achieved so far within the dissemination activities with respect to the key performance indicators. The target values for the KPIs as shown in the table are the same as presented in the proposal, while the presented achieved values are the total values achieved until the end of the project, which also include those reported in deliverable D7.2. The table presents an aggregation of both the interactive and non-interactive activities...

Table 1 – KPIs for dissemination and standardization activities achieved in the scope of the project.

KPIs	Overall Target value	Achieved Value
Participation in MWC 2019	Yes	The consortium participated
Contribution to EU booth at MWC 2019 with demo/testbed showcasing MATILDA's results	Yes	Done
White papers and contribution to roadmaps	≥5	3
Journals	≥10	13
Conferences	≥20	32
Posters	≥3	3
Scientific and technical workshops	3	3
Book chapters	0	3

The clustering as well as the standardization activities have equally progressed as planned. The clustering activities, which focus on how different 5GPPP projects could leverage the relevant outcomes of one another and create a better collaboration understanding moving forward through the use of technical workshops, are also discussed in detail in subsequent sections. Similarly, standardization activities are not left out of the bigger picture. The different standardization activities that the consortium members of the MATILDA project are contributing to are also explained.

4 MATILDA dissemination works

The MATILDA dissemination activities have been fashioned around the target areas of business, scientific, technical, legislative and social community of people, with important emphasis on the business community as expertly defined in Table 2. Using the different communication tools at the disposal of the MATILDA project consortium members, we have been able to drive the interest of this targeted group of people towards having the awareness of the results generated within the project that could be leveraged and beneficial to them in a variation of ways.

Table 2 – Identified target groups and their definitions.

Target areas	Potential audience	Technical level	Main focus
Business	Industry, Investors, SMEs	Extent of revealing business opportunities and potentials of the technology for societal benefits	Identification of business opportunities, Identification of potential derivable societal benefits, Extraction of business-related projects, Identification of resultant scientific and technical innovations.
Legislative	Public administrators, Policy-makers	Extent of revealing legislative and possible social implications	Implementation of the new EC law on privacy and security legislation.
Scientific	Research community, International forums	Extent of revealing the main scientific and technical innovation and discoveries of the project	Exposure of the community to the generated technical and scientific knowledge through the submitted journal articles, as well as conference papers focusing on novel scientific innovations and ideas.

Target areas	Potential audience	Technical level	Main focus
Social	General public, Public administrators	Extent of being easily understandable by the vast majority of non-specialist public	Focus on the economic impacts and societal implications and derivable benefits, General project presentation and Personal data protection and human privacy assurance.
Technical	System developers	Extent of revealing deep systems knowledge understandable by system developers and managers	Specific project presentations, Software development paradigms and user requirements.

4.1 Dissemination work description

The MATILDA project's dissemination activities have been designed around a clear project identity, which has created a conspicuous visibility and recognition for the project leading to a clear differentiating factor from amongst other 5G-PPP projects. This identity has enabled MATILDA to develop varieties of materials suitable for promoting different activities undertaken within the project, their results and other potential impacts in the form of pamphlets, newsletters, posters, PowerPoint slides, technical workshop proceedings and so on and so forth. These sets of materials are developed bearing in mind certain categories of people who are defined as the target group on which the MATILDA project hopes to have meaning impact. This target group cuts across people from the industry as well as the research institutions. In the dissemination of the defined set of activities and their respective research and development outcome within the MATILDA project, the consortium members have been exploring different mixes of the dissemination avenues listed in Table 3 below. Particularly, the use of interactive means of information dissemination such as participation in international workshops as well as conferences, participation in exhibitions and panel discussions and also through the organization of technical workshops. Other dissemination means in which the MATILDA project has been fundamentally active are the non-interactive ones, such as the social media platforms and primary project website.

Table 3 – Information dissemination avenues.

Dissemination avenues
Organization of conferences
Organization of technical workshops
Press releases
Exhibitions
Trainings
Social media presence
Website
Mainstream media campaigns e.g., on TV and Radio stations
International conference participation
International workshop participation
Pitch event
Trade fairs
Participation in expositions organized by other H2020 peer projects
Brokerage events
Flyer
Others

4.2 Dissemination, clustering and standardisation activities performed

4.2.1 Dissemination activities

The set of dissemination activities aggregated and presented in Table 4 represents the dissemination efforts put forward by the different consortium members of the MATILDA project. These activities span from the participation in workshops, to conferences, exhibitions, brokerage events, training, brochure presentation, symposia as well as media talks in order to promote the ethos and image of the MATILDA project. The presented dissemination activities are those carried out within the project from the moment after the compilation of the halfway report in deliverable D7.2, but not included therein, up until the very moment of compiling this report.

Table 4 – Final set of dissemination activities after the dissemination halfway report.

#	Dissemination activity and contribution	Date	Location
1	Organisation of a Workshop **MATILDA – Autonomic Deployment and Lifecycle Management of 5G & Beyond Services** Organisation of online Workshop and Webinar *Organizers*: Franco Davoli, CNIT; Tarik Taleb, Aalto University *Technical Support*: Ibrahim Afolabi, Aalto University *MATILDA Speakers*: Miloud Bagaa, Aalto University; Kay Burow, BIBA; Luka Koršič, ININ; Panagiotis Gouvas, Ubitech *External Speakers*: Rui Aguiar, University of Aveiro, Portugal; Jaafar Elmirghani, University of Leeds, UK; Artur Hecker, Huawei Technologies, Germany; Sławomir Kukliński, Orange, Poland; Antonio Manzalini, Telecom Italia Mobile, Italy; Ingrid Moerman, IMEC and Ghent University, Belgium	30/6/2020	Online
2	Participation in an Event other than a Conference or a Workshop **ETSI MEC ISG Meeting #22** Presentation *Deploying and orchestrating modern cloud-native applications in the programmable 5G infrastructure* A. Zafeiropoulos, P. Gouvas, R. Bruschi, F. Davoli, R. Bolla - presented by A. Zafeiropoulos	4/6/2020	Online

#	Dissemination activity and contribution	Date	Location
3	Participation in activities organized jointly with other H2020 projects **Contribution to the 2020 Edition of the European 5G Annual Journal** Short account of MATILDA activities F. Davoli, C. Lombardo on behalf of the Consortium	03/2020	
4	Participation in a Workshop **Italian Networking Workshop 2020** Paper presentation *A Model-based Approach Towards Real-time Analytics in NFV Infrastructures* R. Bolla, R. Bruschi, F. Davoli, J. F. Pajo - presented by Jane F. Pajo	27-29/1/2020	Cavalese, Italy
5	Participation in a Conference **Scientific Sessions at "5G Italy 2019"** Invited Talk *Separation of concerns in application, networking and security orchestration platforms in virtualized 5G environments* R. Bolla, R. Bruschi, F. Davoli, J. F. Pajo, M. Repetto – presented by R. Bolla and F. Davoli	4/12/2019	Rome, Italy

#	Dissemination activity and contribution	Date	Location
6	Participation in a Conference **International Telecommunication Networks and Applications Conference (ITNAC 2019)** Invited Keynote *Mobile Edge Computing in the 5G Era – Bridging Applications and Networking Environments* F. Davoli (CNIT)	27-29/11/2019	Auckland, New Zealand
7	Participation in an Event other than a Conference or a Workshop **PhD Thesis IEEE/ABB Award** Women in Engineering - IEEE Italy Section ABB Award *PhD Thesis "Enabling Scalable and Sustainable Softwarized 5G Environments", University of Genoa, Feb. 2019* Jane Frances Pajo (CNIT)	11/9/2019	Florence, Italy
8	Participation in a Conference **Computing Conference 2019** Paper presentation *Towards the identification of context in 5G infrastructures* Chrysostomos Symvoulidis	16-17/7/2019	London, UK

#	Dissemination activity and contribution	Date	Location
9	Brokerage Event **H2020 ICTurkey 2019** Presentation at 5G session and pitches to customers *ININ activities in H2020* Janez Sterle (ININ)	5/7/2019	Istanbul, Turkey
10	Exhibition **EuCNC 2019 and the 7th Global 5G Event** Booth support *5G PPP SME* ININ, UBITECH	17-21/6/2019	Valencia, Spain
11	Exhibition **EuCNC 2019 and the 7th Global 5G Event** Booth support *MATILDA – Enabling vertical industries to take advantage of 5G technologies* ININ, UBITECH, ITALTEL	17-21/6/2019	Valencia, Spain

#	Dissemination activity and contribution	Date	Location
12	Participation in a Conference with a peer-reviewed paper **EuCNC 2019** Paper presentation Deploying Smart City Components for 5G Network Slicing Cristian Patachia (Orange Romania)	17-21/6/2019	Valencia, Spain
13	Non-scientific and non-peer-reviewed publication (popularised publication) **EuCNC 2019** Paper in special session *Definition and Evaluation of Latency in 5G with Heterogeneous Use Cases and Architectures* ININ, CNIT	20/6/2019	Valencia, Spain
14	Non-scientific and non-peer-reviewed publication (popularised publication) **European SME Expertise in 5G and Beyond** Brochure *ININ Collaboration in 5G-PPP and H2020* ININ	18/6/2019	Valencia, Spain

#	Dissemination activity and contribution	Date	Location
15	Exhibition **Digital Assembly 2019** Booth and Demo *MATILDA and SLICENET and 5G-EVE – 5G Smart Lighting City* ORO	13-14/6/2019	Bucharest, Romania
16	Participation in a Conference **35. delavnica o telekomunikacijah VITEL 2019** Presentation *5G Security Architecture for IoT | Varnostna arhitektura 5G za internet stvari* Janez Sterle (ININ)	20-21/5/2019	Brdo pri Kranju, Slovenia
17	Participation in a Workshop **SINOG 6.0** Presentation *How to build your own mobile network* Janez Sterle (ININ)	14/5/2019	Ljubljana, Slovenia

#	Dissemination activity and contribution	Date	Location
18	Participation in a Conference with a peer-reviewed paper **IFIP/IEEE International Symposium on Integrated Network Management** Paper presentation *5G Smart City Vertical Slice* Horia Stefanescu (Orange Romania)	8-12/4/2019	Washington, D.C, USA
19	Participation in a Conference **e-Society 2019** Paper presentation *INTRA: Introducing adaptation in 5G monitoring frameworks* Marios Touloupou	11/4/2019	Utrecht, Netherlands
20	Participation in activities organized jointly with other H2020 projects **Contribution to the 5G Annual Journal 2019** Section with Project Overview *MATILDA Overview and Current Status* F. Davoli on behalf of the MATILDA Consortium	3/2019	Internet

#	Dissemination activity and contribution	Date	Location
21	Participation in a Conference **The Optical Networking and Communication Conference & Exhibition 2019 (OFC 2019)** Panel *Network Infrastructure Virtualization and Network Slicing - Network Awareness in Network Function Virtualization* A. Bravalheri (UNIVBRIS)	7/3/2019	San Diego, CA, USA
22	Participation in an Exhibition **MOBILE WORLD CONGRESS 2019, Spain** Booth and demo Orange, Romania	25-28/2/2019	Barcelona, Spain
23	Participation in an Exhibition **MOBILE WORLD CONGRESS 2019, Spain** Live presentation *MATILDA 5G-ready Applications' Orchestration Ecosystem* UBITECH, ININ	25-28/2/2019	Barcelona, Spain

#	Dissemination activity and contribution	Date	Location
24	Participation in an Exhibition **MOBILE WORLD CONGRESS 2019, Spain** Booth and demo *MATILDA – Orchestrating 5G Ready Emergency Services (5G PPDR)* ATOS, UBITECH, ININ	25-28/2/2019	Barcelona, Spain
25	Training **PhD School lectures at the University of Trento** *"Network Softwarization, Virtualization and Slicing Foundations of the 5th Generation Mobile Radio Networks"* R. Bruschi	3-8/2/2019	Trento, Italy
26	Participation in an Event other than a Conference or a Workshop **Lecture at Faculty of Computer Science - Iași, Romania** Poster presentation Marius Iordache	12/1/2019	Iași, Romania

#	Dissemination activity and contribution	Date	Location
27	Social Media **MATILDA @ ININ LinkedIn** Project activities presentation ININ	2019	Internet
28	Social Media **MATILDA @ ININ Twitter** Project activities presentation *qMON VNF RELEASE* ININ	2019	Internet
29	Exhibition **PSCE 2018** Booth and demo *5G PublicSafety - INTERNET INSTITUTE* ININ	12-13/12/2018	Bled, Slovenia

#	Dissemination activity and contribution	Date	Location
30	Exhibition **ICT 2018** Demo and exhibition *MATILDA @ 5G PPP Demo and Exhibition Stands at ICT2018* UBITECH, ININ	4-6/12/2018	Vienna, Austria
31	Participation in a Workshop **MATILDA Presentation at the MOBISLICE/5GNETApp Workshop** Invited Talk *MATILDA* Overview F. Davoli (speaker), R. Bruschi, P. Gouvas, A. Zafeiropoulos	27/11/2018	Verona, Italy
32	Organisation of a Workshop **MOBISLICE/5GNETApp Workshop 5G-ready Network Applications Development and Orchestration over Network Slices with Mobility Support** in conjunction with **IEEE Conference on Network Function Virtualization and Software Defined Networks** Workshop organization A. Zafeiropoulos	27/11/2018	Verona, Italy

#	Dissemination activity and contribution	Date	Location
33	Participation in an Event other than a Conference or a Workshop **ITU Forum "Towards 5G Enabled Gigabit Society"** Project Presentation *MATILDA Overview* A. Zafeiropoulos (UBITECH)	11/10/2018	Athens, Greece
34	Participation in an Event other than a Conference or a Workshop **Sat Italia 5G** Presentation *Interaction of Satellite Networks in the 5G Ecosystem* M. Marchese (speaker), L. Boero, R. Bruschi, F. Davoli, F. Patrone	8/10/2018	Rome, Italy
35	Participation in a Conference **The Digital Media Industry and Academic Forum (DMIAF) 2018** Invited Talk at the Panel on Digital Delivery of Media Services *Digital Media Application Services in 5G: Orchestration, QoS/QoE and Energy Efficiency* F. Davoli (CNIT)	7/10/2018	Athens, Greece

#	Dissemination activity and contribution	Date	Location
36	Training **Ph.D. class at University of Rome "La Sapienza"** *"Network Softwarization, Virtualization and Slicing Foundations of the 5th Generation Mobile Radio Networks"* R. Bruschi (CNIT)	1/10/2018	Rome, Italy
37	Participation in a Conference **INFOCOM WORLD CONFERENCE 2018 Greece** *MATILDA's Value proposition to Telecom Service Operators for the Deployment of 5G-ready Applications and Network Services* E. Theodoropoulou (COSM)	21/11/2018	Athens, Greece
38	Participation in an Innovation Day **Innovation Forum 2019, Workshop IT–Telecommunications, OTE Group Research Activities on 5G** Presentation *MATILDA: A Holistic, Innovative Framework for the Design, Development and Orchestration of 5G-ready Applications and Network Services over Sliced Programmable Infrastructure* I. Mesogiti (COSM)	18/11/2018	Athens, Greece

#	Dissemination activity and contribution	Date	Location
39	Participation in a Symposium **Digital Technology Symposium: "20 Years GRNET (National Infrastructures for Research and Technology- Center)"** Invited Presentation *OTE Group Research Projects and Collaboration Perspectives* G. Lyberopoulos (COSM)	5-6/11/2018	Athens, Greece
40	Participation in an Industrial Day **Industrial Dissemination Day of the 5Gwireless H2020-ITN and 5G_AuRA H2020.ITN**. Presentation *MATILDA: A Holistic, Innovative Framework for the Design, Development and Orchestration of 5G-ready Applications and Network Services over Sliced Programmable Infrastructure* I. Mesogiti (COSM)	22/6/2018	Athens, Greece
41	Exhibition **EuCNC 2018** Demo *5G PPP SMEs – SMEs Expertise and Innovation in the 5G Domain* ININ	18-21/6/2018	Ljubljana, Slovenia

#	Dissemination activity and contribution	Date	Location
42	Exhibition **EuCNC 2018** Demo *MATILDA – Orchestrating 5G Ready Emergency Services (5G PPDR)* UBITECH, ININ	18-21/6/2018	Ljubljana, Slovenia

4.2.2 Journals

Table 5 presents the list of relevant journals which the consortium members have selected for the submission of their research and development results within the scope the MATILDA project. As it would be revealed in detail further on, some of the listed publications actually reflect the names of some of these identified journals as the publication platform.

Table 5 – List of relevant journals.

Event name	Event type
IEEE JSAC Series on Network Softwarization & Enablers	Journal
IEEE Transactions on Mobile Computing	Journal
IEEE Transactions on Cloud Computing	Journal
IEEE Access	Journal
IEEE Network	Journal
IEEE Communications Magazine	Journal
Computer Networks	Journal
IEEE/ACM Transactions on Networking	Journal
IEEE Transactions on Network and Service Management	Journal

4.2.3 Conferences

The list of conferences presented in Table 6 are indeed relevant for the conveyance and demonstration of the results of the MATILDA project. While a number of them might have already been considered, depending on the current situation of the Coronavirus pandemic, it might not be very feasible for any such conferences that allows for physical interaction to happen to take place any time soon. Nonetheless, a number of them as still viable options for the submission of the final sets of results derived from the MATILDA project.

Table 6 – List of relevant conferences.

Event name	Event type	Submission date	Publication date
IEEE NFV-SDN	Conference	May 2020	November 2020
IEEE CSCN	Conference	April 2020	September 2020
IEEE Globecom	Conference	April 2020	December 2020
IEEE Infocom	Conference	July 2020	May 2021
IEEE ICC	Conference	October 2020	June 2021

4.2.4 Publications

In addition to the number of publications mentioned in deliverable D7.2, the conferences as well as journals presented in Table 7 are the new set of publications detailing the important project results published till the moment of the compilation of this deliverable. Until the moment of compiling this report, the consortium members of the MATILDA project have collectively published a total of 48 scientific publications, the final list of which is presented in this report. The list presented in Table 7 consists of 21 conferences, 11 journal papers, 3 book chapters and 2 white papers.

Table 7 – Final list of publications after the dissemination halfway report.

#	Authors	Publication
1	R. Bruschi, F. Davoli, P. Lago, C. Lombardo, J. F. Pajo	Publication in Conference proceedings / Workshop "Personal Services Placement and Low-Latency Migration in Edge Computing Environments" **2018 5GNetApp WS., co-located with the 2018 IEEE NFV-SDN Conf.**, IEEE, 2018, Verona, Italy
2	F. Davoli, E. Bruschi, M. Aicardi, J. F. Pajo, P. Lago	Publication in Conference proceedings / Workshop "Decentralized Scalable Dynamic Load Balancing among Virtual Network Slice Instantiations" **2018 IEEE Global Communications Conference, Workshops (IEEE GlobeCom WS)**, IEEE, 2018, Abu Dhabi, UAE
3	R. Bruschi, F. Davoli, C. Lombardo, O. R. Sanchez	Publication in Conference proceedings / Workshop "Evaluating the Impact of Micro-Data Center (µDC) Placement in an Urban Environment" **2018 IEEE Conf. on Network Function Virtualization and Software Defined Networks (IEEE NFV-SDN)**, IEEE, 2018, Verona, Italy
4	R. Addad, D. Dutra, M. Bagaa, T. Taleb	Publication in Conference proceedings / Workshop "Towards A Fast Service Migration in 5G" **IEEE CSCN**, IEEE, Oct. 2018, Paris, France

5	F. Fontes, I. Neokosmidis, R. Trivisonno, F. Davoli, L. N. Binh, S. Mikroulis, I. Tomkos, V. Frascolla	Chapter in a Book "Why 5G?" **in M. Ajmone Marsan, N. Blefari Melazzi, S. Buzzi (Eds.), "5G Italy White Book: from Research to Market"**, CNIT, 5G IA, 5G PPP, 3-16, 2018, Rome, Italy (White Book produced for the event "5G Italy - The Global Meeting in Rome", 4-6 Dec. 2018)
6	R. A. Addad, T. Taleb, M. Bagaa, D.L.C. Dutra, H. Flinck	Publication in Conference proceedings / Workshop "Towards Modeling Cross-Domain Network Slices for 5G" **GLOBECOM**, IEEE, 2018, Abu Dhabi, UAE
7	K. Burow, K. Hribernik, K.-D. Thoben	Publication in Conference proceedings / Workshop "First Steps for a 5G-Ready Service in Cloud Manufacturing" **2018 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC): Stuttgart, 17.06.-20.06.2018**, IEEE, 2018, Piscataway, NJ, USA.
8	R. Bruschi, F. Davoli, P. Lago, J. F. Pajo	Article in Journal "A Multi-Clustering Approach to Scale Distributed Tenant Networks for Mobile Edge Computing" **IEEE Journal on Selected Areas in Communications**, IEEE, 2019, Piscataway, NJ, USA
9	R. Bruschi, R. Bolla, F. Davoli, A. Zafeiropoulos, P. Gouvas	Article in Journal "Mobile Edge Vertical Computing over 5G Network Sliced Infrastructures: an Insight into Integration Approaches" **IEEE Communications Magazine**, IEEE, 2019, Piscataway, NJ, USA

10	R. Bolla, R. Bruschi, F. Davoli, J. F. Pajo	Chapter in a Book "Modeling performance and energy efficiency of virtualized flexible networks" **in M. Obaidat, T. Ören, F. De Rango, Eds., Simulation and Modeling Methodologies, Technologies and Applications**, Springer Nature Switzerland AG, 257-273, 2019, Cham, Switzerland
11	C. Symvoulidis, I. Tsoumas, and D. Kyriazis	Publication in Conference proceedings / Workshop "Towards the identification of context in 5G infrastructures" **Computing Conference 2019**, Springer, 2019, London, UK
12	M. Touloupou, E. Kapassa, A. Kiourtis, P. Stavrianos, D. Kyriazis	Publication in Conference proceedings / Workshop "INTRA: Introducing adaptation in 5G monitoring frameworks" **e-Society 2019**, IADIS, 2019, Utrecht, NL
13	R. Bruschi, C. Lombardo, F. Diáz, J. Melián, A. Ramos, O. Toscano, I. Mesogiti, H. Stefanescu, A. Zafeiropoulos, P. Gouvas, E. Fotopoulou, T. Xirofotos, N. Stasinopoulos, E. Trouva, M. Bagaa, I. Afolabi	Other "OSS for 5G-Ready Applications" **MATILDA Whitepaper**, MATILDA Consortium, 2019, European Union
14	D. Sabella, V. Sukhomlinov, L. Trang, S. Kekki, P. Paglierani, R. Rossbach, X. Li, Y. Fang, D. Druta, F. Giust, L. Cominardi, W. Featherstone, B. Pike, S. Hadad	Other "ETSI White Paper No. 20: Developing Software for Multi-Access Edge Computing" **ETSI Whitepaper**, ETSI, 2019, France
15	I. Mesogiti, E. Theodoropoulou, G. Lyberopoulos, F. Setaki, A. Ramos, P. Gouvas, A. Zafeiropoulos, R. Bruschi	Publication in Conference proceedings / Workshop "A Framework to Support the Role of Telecommunication Service Providers in Evolving 5G Business Models" **Artificial Intelligence Applications and Innovations. AIAI 2019. IFIP Advances in Information and Communication Technology**, Springer, 60-69, 2019, Crete, Greece

16	I. Mesogiti, E. Theodoropoulou, G. Lyberopoulos, Fotini Setaki, A. Ramos, P. Gouvas, A. Zafeiropoulos, R. Bruschi	Publication in Conference proceedings / Workshop "MATILDA: A Value Proposition for Telecommunication Service Providers for Vertical Applications' Integration in a 5G -Ecosystem" **Proceedings of the European Conference on networks and Communications (EuCNC) 2019**, IEEE, 2019, Valencia, Spain
17	I. Afolabi, J. Prados-Garzon, M. Bagaa, T. Taleb, P. Ameigeiras	Article in Journal "Dynamic Resource Provisioning of a Scalable E2E Network Slicing Orchestration System" **IEEE Transactions on Mobile Computing**, IEEE, 2019, USA
18	T. Taleb, D.E. Bensalem, A. Laghrissi	Publication in Conference proceedings / Workshop "Smart Service-Oriented Clustering for Dynamic Slice Configuration" **IEEE Globecom**, IEEE, 2019, USA
19	R. A. Addad, D.L.C. Dutra, M. Bagaa, T. Taleb, H. Flinck	Publication in Conference proceedings / Workshop "Towards studying Service Function Chain Migration Patterns in 5G Networks and beyond" **IEEE Globecom**, IEEE , 2019, USA
20	J. Prados-Garzon, T. Taleb, O. El Marai, M. Bagaa	Publication in Conference proceedings / Workshop "Closed-Form Expression For The Resources Dimensioning of Softwarized Network Services" **IEEE Globecom**, IEEE , 2019, USA
21	T. Taleb, P. A. Frangoudis, I. Benkacem, A. Ksentini	Article in Journal "CDN Slicing over a Multi-Domain Edge Cloud" **IEEE Transactions on Mobile Computing**, IEEE, 2019, USA

22	M. Maiouak, T. Taleb	Publication in Conference proceedings / Workshop "A Dynamic Map-based Framework for Real-Time Mapping of Vehicles and their Surroundings" **in Proc. IEEE WCNC**, IEEE, 2019, Morocco
23	T. Taleb, I. Afolabi, M. Bagaa	Article in Journal "Orchestrating 5G Network Slices to Support Industrial Internet and to Shape Next-Generation Smart Factories" **IEEE Network Magazine**, IEEE, 146 - 154, 2019, USA
24	A. Laghrissi, T. Taleb, M. Bagaa, J. Prados-Garzon	Publication in Conference proceedings / Workshop "A Fuzzy Logic-based Mechanism for An Efficient Cloud Resource Planning" **in Proc. IEEE WCNC**, IEEE, 2019, Morocco
25	T. Taleb, I. Afolabi, K. Samdanis, F. Z. Yousaf	Article in Journal "On Multi-domain Network Slicing Orchestration Architecture & Federated Resource Control" **IEEE Network Magazine**, IEEE, 2019, USA
26	R. A. Addad, T. Taleb, H. Flinck, M. Bagaa, D.L.C. Dutra	Article in Journal "Network Slice Mobility in Next Generation Mobile Systems: Challenges and Potential Solutions" **IEEE Network Magazine**, IEEE, 2019, USA
27	R. A. Addad, M. Bagaa, T. Taleb, D.L.C. Dutra, H. Flinck	Article in Journal "Optimization model for Cross-Domain Network Slices in 5G Networks" **IEEE Transactions on Mobile Computing**, IEEE, 2019, USA
28	I. Afolabi, T. Taleb, P. A. Frangoudis, M. Bagaa, A. Ksentini	Article in Journal "Network Slicing-Based Customization of 5G Mobile Services" **IEEE Network Magazine**, IEEE, 2019, USA

29	K. Burow, M. Franke, K.-D. Thoben	Publication in Conference proceedings / Workshop "5G-Ready in the Industrial IoT-Environment: Requirements and Needs for IoT Applications from an Industrial Perspective" **Advances in Production Management Systems. Production Management for the Factory of the Future**, Springer International Publishing, 408-413, 2019
30	F. Davoli, M. Marchese, F. Patrone	Publication in Conference proceedings / Workshop "Flow assignment in multi-core network processors" **Internat. Conf. on Optimization and Decision Science (ODS 2019), XLIX Annual Meeting of AIRO – Italian Operations Research Society, Genoa, Italy, Sept. 2019; AIRO Springer Series "Advances in Optimization and Decision Science for Society, Services and Enterprises" (to appear)**, Springer, 2019, New York, NY, USA
31	R. Bruschi, F. Davoli, J. F. Pajo	Chapter in a Book "5G Management and Orchestration – From Cloud-Native to 5G-Ready Applications" **in M. Ajmone Marsan, N. Blefari Melazzi, S. Buzzi, S. Palazzo, Eds., The 5G Italy Book 2019: A Multiperspective View of 5G**, CNIT, 323-337, 2019, Parma, Italy (Invited contribution)
32	R. Bolla, R. Bruschi, F. Davoli, J. F. Pajo	Article in Journal "A Model-based Approach Towards Real-time Analytics in NFV Infrastructures" **IEEE Transactions on Green Communications and Networking**, IEEE, 2019, Piscataway, NJ, USA

33	Bogdan Rusti, Horia Stefanescu, Marius Iordache, Cristian Patachia, Jean Ghenta, Panagiotis Gouvas, Anastasios Zafeiropoulos, Eleni Fotopolou, Qi Wang, Jose Alcaraz Caler *on behalf of the MATILDA and SLICENET consortiums*	Publication in Conference proceedings / Workshop "5G Smart City Vertical Slice", **2019 IFIP/IEEE Symposium on Integrated Network and Service Management (IM)**, IEEE, 2019, Arlington, VA, USA, 2019, pp. 13-19
34	B. Rusti, H. Stefanescu, M. Iordache, J. Ghenta, C. Brezeanu and C. Patachia	Publication in Conference proceedings / Workshop "Deploying Smart City components for 5G network slicing" **2019 European Conference on Networks and Communications (EuCNC)**, IEEE, 2019, Valencia, Spain, pp. 149-154, doi: 10.1109/EuCNC.2019.8802054
35	K.X. Du, G. Carrozzo, M.S. Siddiqui, O. Carrasco, B. Sayadi, F. Lazarakis, A. Kourtis, J. Sterle, R. Bruschi	Publication in Conference proceedings / Workshop "Definition and Evaluation of Latency in 5G: A Framework Approach" **2019 IEEE 2nd 5G World Forum (5GWF)**, IEEE, 2019, Dresden, Germany
36	I. Afolabi, M. Bagaa, W. Boumezer, T. Taleb	Article in Journal "Towards a Real Deployment of Network Services Orchestration and Configuration Convergence Framework for 5G Network Slices" **IEEE Network Magazine**, IEEE, 2020, USA
37	R. Bruschi, F. Davoli, F. Diaz Bravo, C. Lombardo, S. Mangialardi, J. F. Pajo	Publication in Conference proceedings / Workshop "Validation of IaaS-based technologies for 5G-ready applications deployment" **2020 European Conference on Networks and Communications (EuCNC)**, IEEE, 2020, Dubrovnik, Croatia
38	R. Bolla, R. Bruschi, F. Davoli, C. Lombardo, J. F. Pajo	Publication in Conference proceedings / Workshop " Debunking the "Green" NFV myth: An assessment of the virtualization sustainability in radio access networks" **6th IEEE International Conference on Network Softwarization (NetSoft)**, IEEE, 2020, Ghent, Belgium

39	R. Bruschi, F. Davoli, G. Lamanna, C. Lombardo, S. Mangialardi, J. F. Pajo	Publication in Conference proceedings / Workshop "Enabling edge computing deployment in 4G and beyond" **6th IEEE International Conference on Network Softwarization (NetSoft)**, IEEE, 2020, Ghent, Belgium
40	A. Zafeiropoulos, E. Fotopoulou, M. Peuster, S. Schneider, P. Gouvas, D. Behnke, M. Muller, P.B. Bok, P. Trakadas, P. Karkazis, H. Karl	Publication in Conference proceedings / Workshop "Benchmarking and Profiling 5G Verticals' Applications: an Industrial IoT Use Case" **6th IEEE International Conference on Network Softwarization (NetSoft)**, IEEE, 2020, Ghent, Belgium
41	R. Bruschi, C. Lombardo, F. Diáz, J. Melián, E. Garrido, A. Ramos, O. Toscano, I. Mesogiti, H. Stefanescu, A. Zafeiropoulos, P. Gouvas, E. Fotopoulou, T. Xirofotos, A. Rodopi, A. Kourtis, T. Anagnostopoulos, M. Bagaa, I. Afolabi	Other "5G-Ready Vertical Applications Orchestration" **MATILDA Whitepaper**, MATILDA Consortium, 2020, European Union

4.3 MATILDA clustering activities

In this section, we will report the clustering activities that the MATILDA project consortium partners have engaged in since the release of the dissemination, clustering and standardization activities halfway report in deliverable D7.2 [1]. Since the release of that report, the consortium members have been involved in a number of different clustering activities, which will be reported in this deliverable. The activities are mainly clustering workshops in which the MATILDA project members have participated and/or co-organized with other 5G-PPP projects.

The first clustering workshop in this regard is the MOBISLICE/5GNETApp [3] clustering workshop which was organized in collaboration with the MATILDA project partners UBITECH and CNIT, respectively. The clustering workshop which is titled "5G-ready Network Applications Development and Orchestration over Network Slices with Mobility Support" was held in conjunction with the fourth IEEE Conference on Network Function Virtualization and Software Defined Networks, in Verona, Italy on the 27th of November 2018. During the workshop, a special focus was on the integration of the Mobility Support in Slice-based Network Control for Heterogeneous Environment and 5G-ready Network Applications Development and Orchestration. The project coordinator of MATILDA, Prof. Franco Davoli from CNIT gave an invited talk on the overview of the MATILDA project, titled, "MATILDA Overview", which provided details and discussion on the progress achieved so far within the project.

Similarly, the MATILDA consortium partner from UBITECH also participated in a 5G forum discussion which was organized by the ITU in October 2018, in Athens, Greece. The 5G forum discussion which is titled "Towards 5G Enabled Gigabit Society" [2] was graced by a MATILDA project presentation also titled MATILDA Overview, which was presented by a representative of the project consortium from UBITECH.

Another notable workshop in which the members from the MATILDA project participated was the Slovenian Network Operators Group workshop meeting encoded SINOG 6.0, which took place on the 14th of May 2019. During the workshop which over 140 people attended, a MATILDA consortium partner from ININ represented MATILDA and gave a presentation entitled "How to build your own mobile network".

In a bid to further the outreach of the progress recorded within the MATILDA project, Orange Romania, a MATILDA project partner who is also a project partner in the EU horizon-2020 project SLICENET and a major demonstrator (smart lighting use case) owner organized a clustering workshop [6]. as shown in Figure 1 between 12-14th of November 2019. This workshop provided more visibility for the MATILDA project within the SLICENET project consortium and vice versa. Consortium members from both projects had an effective and beneficial after-event discussions in order to foster better the understanding and alignment of both projects and benefit of their mutual results, as well as for other 5G-PPP projects.

Figure 1 – Group picture of the MATILDA and SLICENET consortium members.

In addition to the above-mentioned clustering workshops, also in November of 2019, MATILDA was equally represented in another very important 5G-PPP clustering event, which was held in Lucca, Italy. This clustering workshop was organized by the EU horizon 2020 project 5G-City [4]. Partners from the MATILDA project were equally present at the clustering event shown in Figure 2, which was tagged 5G Day, in order to showcase the successes and progress achieved in the development of the project as well as some of the challenges encountered during the course of the project. The presentation delivered by the MATILDA representative was titled "5G-ready applications in MATILDA – Network and Computing Slice Deployment Platform" The significance of the presentation and demo was to reveal the important role that the MATILDA project is playing amongst other 5G-PPP project in designing and developing a radically new prototypic framework of the Telecom Layer Platform, which provides fundamental support for both functional and performance requirements and the management of the lifecycle of 5G-ready vertical applications and their configurations using OSM.

Figure 2 – Group picture of the attendees of the 5G Day clustering workshop.

The last clustering workshop but not the least one, which was also organized in collaboration with two of MATILDA projects partners, AALTO University and CNIT, as the final technical and industrial workshop for the MATILDA project, was the workshop which was supposed to be co-hosted and organized alongside with the 2nd 6G Wireless Summit 2020, in Levi, Lapland, Finland from the 17th – 20th of March 2020. The workshop [5] was titled: *MATILDA – Autonomic deployment and lifecycle management of 5G & beyond services*. Unfortunately, due to the outbreak of the Coronavirus and its consequential effect on most European nations, and other countries across the world, several measures were enforced in order to contain it from further spreading. As a result, many activities including the intended physical workshop were also affected and thereby cancelled from physically taking place. However, efforts were made to convert it into an online workshop, whereby the guests who have been invited to speak at the workshop would produce video clips from their intended presentations and make them available to the organisers of the workshop. These video clips were then uploaded to the MATILDA's website where they will be easily accessible for public viewership. Furthermore, in a bid to further enrich the online workshop and make it a complete package, the organisers in collaboration with the invited guests also took part in an online discussion where the content of their respective presentations and more were thoroughly discussed for the benefit of the audience. The online workshop webinar was indeed a success with over a hundred registered participants across many professional disciplines both technical and otherwise and countries around the world as depicted in Figures 3 and 4.

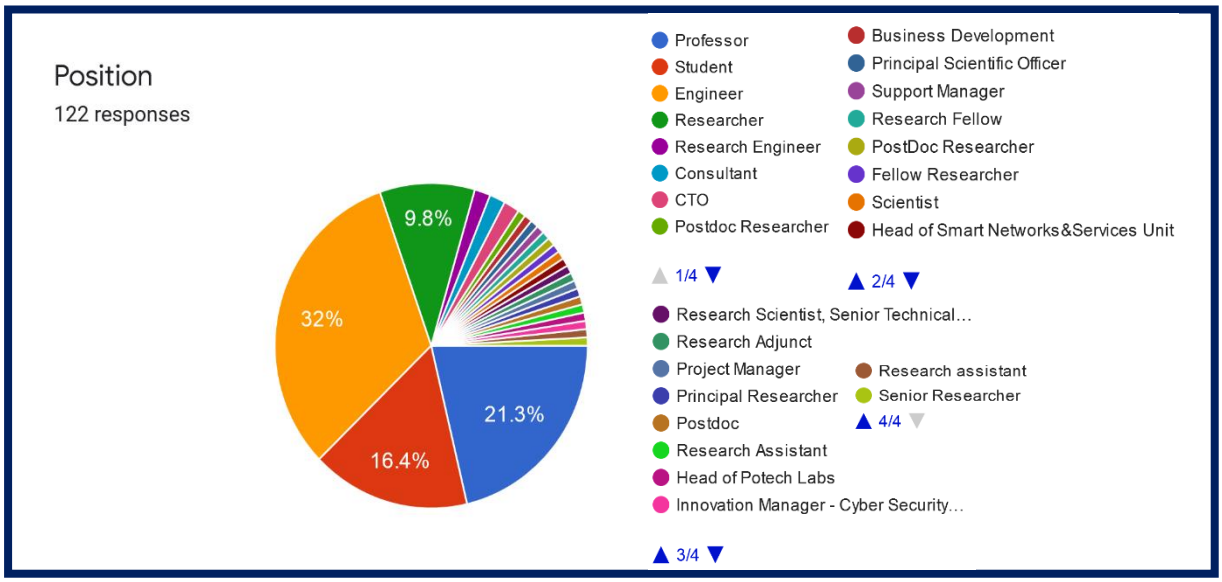

Figure 3 – Registered attendees to the MATILDA webinar by profession.

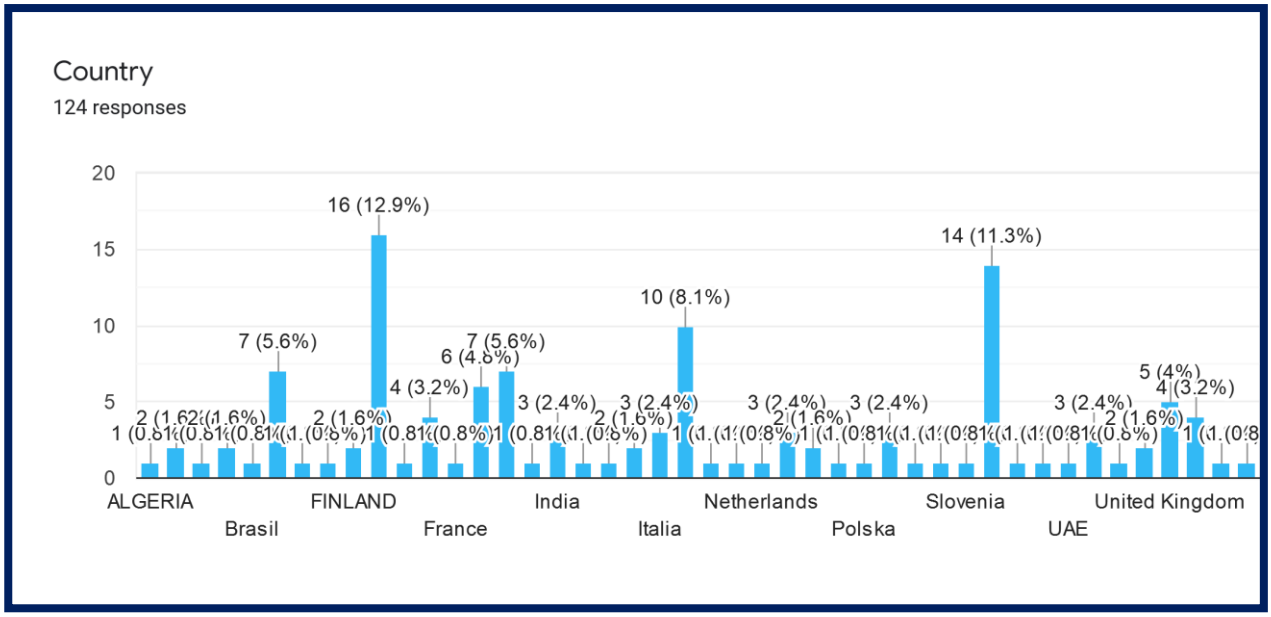

Figure 4 – Registered attendees to the MATILDA webinar by country.

4.4 MATILDA standardisation activities

This section reports the main standardization activities that the MATILDA project has been involved in. Based on the composition of the project consortium partners and the results derived from the project up until this moment, especially for the partners from industry, MATILDA has identified a number of standard development organizations (SDO) to which relevant results are contributed to and proposed for present and most importantly future exploitations.

4.5 Standardisation landscape

This section presents the standardization activities that the MATILDA project has identified and finds relevant to the research and project developments that have been undertaken within the scope of the project. Most importantly, based on the results derived from the progress of the project, MATILDA has been carrying out a number of standardization initiatives, which will be elaborated further in subsequent sections.

4.5.1 ETSI

The ETSI EE TC (Environmental Engineering Technical Committee) collects all the main activities of this European Standardisation entity addressing the measurement, test, and reduction of energy consumption in Telecommunications. In EE TC, the second version of the Green Abstraction Layer (GAL v2.0) has been approved and published (as well as in ITU-T, see below) at the beginning of 2020, with the name ETSI ES 203 682 (as an evolution of the previous ES 203 237). This interface is relevant to the vision of MATILDA as well, since the second

version has been extended explicitly for controlling the energy consumption in the NFV environment. During this first GAL evolution from v1.0 to 2.0, the NFV standard has been updated, and for this reason, at the end of 2019, a new Working Item (WI) named RES/EE-EEPS43 GAL v3.0 has been created with the support of CNIT. The aim of this WI is both to support the recent NFV updates and to evolve the GAL interface towards a more effective support of the new future networks (including 6G). CNIT with Prof. R. Bolla is one of the main contributors (and Prof. Bolla is the Editor of the corresponding ITU-T version, see below). The WI's current schedule fixes the final publication of the new standard for June 2021, but a more realistic forecast is the second half of 2022.

4.5.2 ITU

The ITU-T Study Group 5 "Environment and Climate Change"[1] – which has an active and important liaison with the ETSI EE TC and broader coverage of both themes (including sustainability in a general sense, e.g., e-waste) and territorial influence, sees a consistent presence of CNIT. The Editor role of Prof. Bolla (CNIT) in the ITU-T WI on GAL v3.0 is also tied with the MATILDA vision. The two WIs should operate in parallel and synchronized, with the same duration and objectives, but a partially different set of potential participants. The goal is to come up with a couple of at least compatible documents.

Though not at the core of MATILDA's activities, nevertheless these standardization actions have been constantly inspired by the project philosophy in the virtualization context and can broaden the vision of the slice intent mechanisms to include relevant energy-efficiency KPIs.

4.5.3 ETSI MEC

Another relevant contribution in ETSI has regarded the proposition of a new model for the integration of external network access to micro-services in a Mobile Edge Computing environment, as outlined in the MATILDA paper on the IEEE Communications Magazine [9]. The architectural solution proposed was presented upon invitation in MEC#22, the plenary meeting of the ETSI MEC WG held on June 2-5, 2020, and raised a good potential interest.

4.5.4 ETSI NFV

ETSI NFV IFA group has proposed a use case (ETSI NFV IFA029 specification) related with the utilization of a service catalogue to enable the ability of managing the services that could be provided by a Platform as a Service (PaaS). This platform will be composed by one or several VNFs (dedicated VNFs) that may be used by other VNFs (consumer VNFs), meeting the requirements or dependencies expressed by the consumer VNFs. This approach is proposed to be done adding a PaaS service descriptor catalogue as a repository for PaaS service descriptors, so these services can be managed by the Service Management component in the IFA029 architecture, which is the component in charge of resolving the dependencies or requirements between consumer and dedicated VNFs, instantiating and configuring the PaaS.

The NFV convergence layer (NFVCL) makes MATILDA compliance with the aforementioned use case proposed by ETSI NFV IFA029 in the following way: the NFVCL includes a PaaS catalogue - MATILDA blueprints - to define the possible network services (NSs) onboarded in

[1] ITU-T Study Group 5, "Environment and Climate Change," Available Online: http://www.itu.int/en/ITU-T/about/groups/Pages/sg05.aspx.

MATILDA that can fulfil the requirements of a given consumer vertical application component (or link), and then sets up the mechanisms to extract the NS components from the catalogue/repository, deploying and attaching them to the vertical applications components. In this way it enables the automatic creation of an optimized slice that is customized for each 5G ready (vertical) application.

At the beginning of June 2020, once the MATILDA prototype was finished and several tests performed, a contribution to the ETSI NFV IFA029 group was prepared, concretely linked to MATILDA NFV Convergence Layer, with the objective of influencing activities around NFV release 4.

4.5.5 OSM

The aforementioned MATILDA specification compliance with ETSI IFA 029 use case can be implemented with OSM by means of integrating some components of the NFV convergence layer (NFVCL) inside OSM.

In MATILDA, the model of the PaaS catalogue is described by the MATILDA blueprints, which are defined by a set of network service descriptors and the way they are inter-connected, so the PaaS can satisfy the vertical applications requirements. The NFVCL will be responsible for taking decisions about which components of the PaaS/Blueprint should be instantiated so the 5G-Ready application is created.

The figure below shows the proposed interactions between OSM and MATILDA components. Before executing the instantiation of the consumer instance, if OSM lifecycle manager (LCM) detects a PaaS requirement, the VNFM requests the NFVCL to discover the required PaaS blueprint from the blueprints catalogue. Once retrieved, the NFVCL request to OSM catalogue the NSDs to be instantiated, composing the OSM slice template yaml file, that is instantiated by OSM. Once the slice is running the consumer can be also instantiated and able to interact with the PaaS instance.

This MATILDA potential addition to OSM was presented by Atos in its initial approach to OSM community in the OSM meeting that took place in February 2019 in Barcelona. After the MATILDA prototype was finished and several tests performed, these results were pushed again to OSM community for their consideration. Concretely, the demonstration provided during the 8th Hackfest held in Lucca, Italy, in November 2019, focused on showcasing the MATILDA Telco Layer Platform, and in particular how it exploits OSM to manage the lifecycle of network services to expose the 5G network infrastructure to vertical applications in terms of network and computing slices. After introducing the main building blocks composing the MATILDA framework and the slice intent metamodel, the demo showed the bootstrap of the main network services providing the system connectivity, followed by the materialization of a slice intent. The graphical interfaces of the involved software (OSM, VAO, etc.) were used to highlight the actual steps bringing to the deployment of a vertical application and related slice in MATILDA.

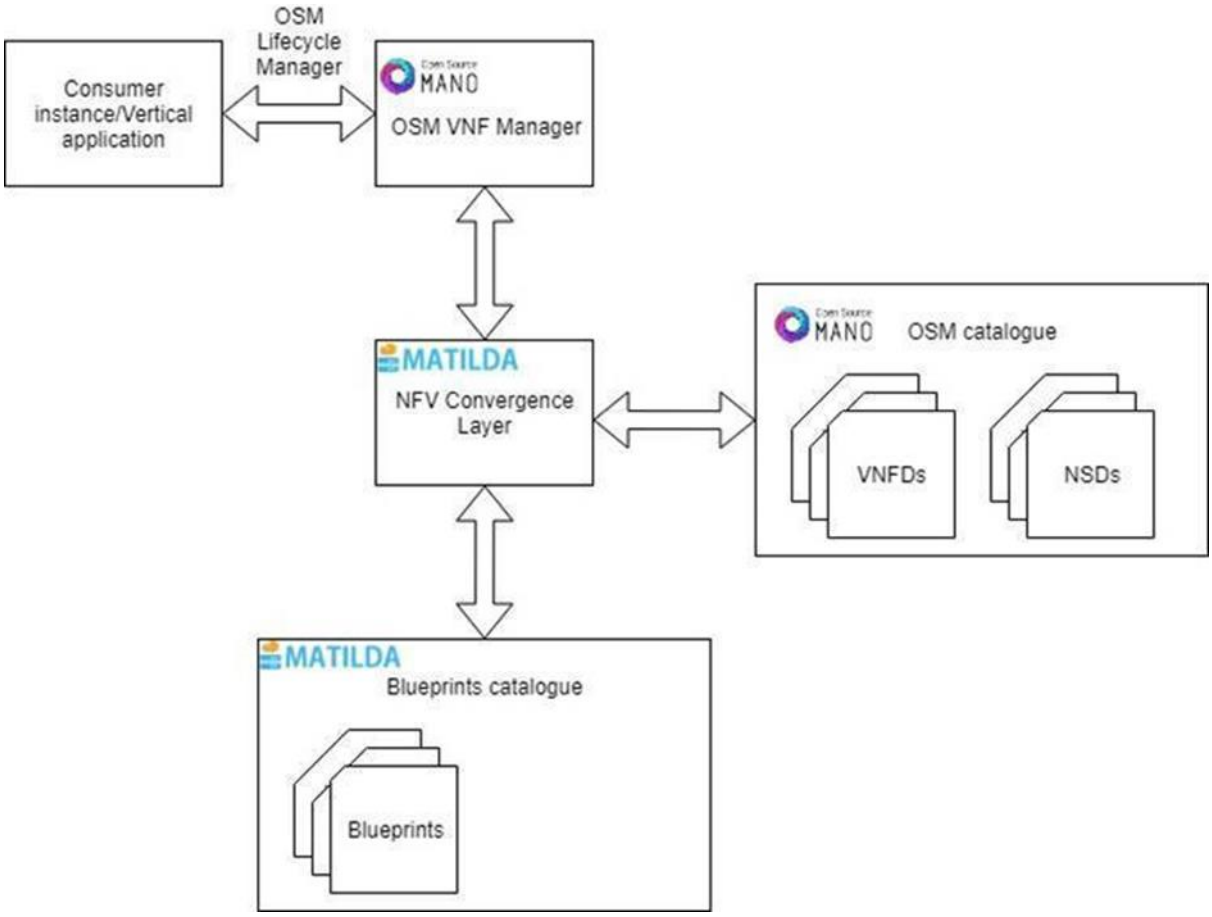

Figure 5 – OSM and NFVCL integration proposal.

5 5G PPP Interaction

In this section, we report the activities of the MATILDA project within the 5GPPP programme, focusing on the progress achieved since the release of the halfway report in deliverable D7.2. This covers the participation of MATILDA partners in multiple 5G PPP working groups, taking MATILDA results to the appropriate ones, as well as the MATILDA participation in the activities of the 5G PPP steering and technical boards in order to be coordinated with the overall 5GPPP activities guidelines, and which has facilitated the collaboration of the MATILDA project with other 5GPPP projects, work that is also reported here. Finally, the 5GPPP KPIs that MATILDA has contributed to are provided (details on technical KPIs by MATILDA are detailed in WP6 deliverables).

5.1 5G PPP Working Groups

MATILDA project coordinator (CNIT) and Technical Manager (UBITECH) have been continuously following and fulfilling all the required actions within the 5GPPP Steering Board and Technical Board, respectively. Several other MATILDA consortium members are also progressively participating and contributing to the 5G PPP working groups in order to report the outcome of the developmental and research work done within the MATILDA project to the related 5G PPP WGs. Besides, since last reporting period, two new Working Groups have been created and MATILDA is taking part on the discussions. Those are: the Business Validation, Models, and Ecosystems, a subgroup inside the Vision WG, and the Measurements WG.

The Table 8 below indicates the MATILDA partners that contribute to each WG.

Table 8 – Contributions to 5GPPP Working Groups.

5G PPP Working Group	MATILDA partners involved
Software Networks	ORO (co-organizer), INC
Network Management and QoS	ININ, UBITECH
SME	ININ, SUITE5, INC, UBI
Trials	ATOS
Architecture	ININ, UBI, CNIT
Communications	ATOS, ERICSSON
Pre-standardization	ATOS
Vision	ATOS, CNIT
Test, Measurement and KPI Validation	UBI, CNIT

Based on the different activities that are being undertaken by the MATILDA partners and the successes recorded, the activities of the consortium are showcased in the following subsections.

5.1.1 Software Networks

The purpose of the 5G-PPP Software Networks Working Group is to analyse and address unification and applicability of key research topics related to Software Networking including software defined concepts, infrastructures, systems and components for Wire and- Wireless Networks, including Networked Clouds, IoT and Services, i.e. Software Defined Networks (SDN) and Network Function Virtualization (NFV) as developed and promoted by the 5G PPP projects. Since beginning of 2018 Orange Romania is co-chairing this WG where the lead is on Nokia.

During the regular WG virtual phone conferences and projects sharing activities, MATILDA was represented by Orange Romania and Incelligent. The WG meeting minutes and deliverables are available on https://bscw.5g-ppp.eu. Periodic WG activity reports were submitted to the 5G-PPP Steering Board and Technology Board.

During the last 2 years, MATILDA had several interventions and contributions within the SoftNet WG, starting with project, use cases and developed tools introduction, proposing content for the 3 published white papers, co-organizing 2 workshops with other 5G-PPP projects and presenting MATILDA concepts and developments during the workshops.

The main interventions within SoftNet WG are:

- 3 white papers with specific MATILDA content, available on the 5G-PPP page (https://5g-ppp.eu/white-papers): July 2018, ''From Webscale to Telco, the Cloud Native Journey'', August 2019, ''Cloud-Native and Verticals' services - 5G-PPP projects analysis'' and February 2020, ''Cloud-Native and 5G Verticals' services";
- 34 phone conferences with clear agenda and follow-up minutes that are available on https://bscw.5g-ppp.eu/sec/bscw.cgi/52699;
- 3 virtual workshops with presentations from each of the SoftNet WG projects including MATILDA;
- 2 EuCNC workshops: 18th June 2018, ''From cloud ready to cloud native transformation: What it means and Why it matters'' and 18th June 2019, '' From Cloud-ready to Cloud-native transformation'';
- 1 MATILDA papers accepted and presented during EuCNC SoftNet 2018: ''Separation of concerns among application and network services orchestration in a 5G ecosystem'', Anastasios Zafeiropoulos, UBITECH;
- 2 MATILDA presentations during EuCNC: ''Separation of concerns among application and network services orchestration in a 5G ecosystem'' (2018, Anastasios Zafeiropoulos, https://www.eucnc.eu/2018/www.eucnc.eu/wp-content/uploads/2018/06/EUCNC_2018_program_web.pdf) and ''Cloud native applications design and deployment'' (2019, Anastasios Zafeiropoulos, https://www.eucnc.eu/workshops/workshop-2/);

5.1.2 Network Management and QoS

The MATILDA project had several contributions within the Network Management and QoS WG related to delivering outcomes of the project as targeted contributions for the release of "Network Management and QoS brochure and flyers" prepared for the for the ICT and EuCNC events. MATILDA also co-organized workshop titled "3rd Network Management and QoS for 5G Networks" during the 2018 EuCNC conference in Ljubljana, Slovenia.

The progress of the NMQ WG has slowed down in 2019 and reach a level which entailed the closure of the NMQ WG in October 2019.

5.1.3 SME

The MATILDA project had several contributions within the SME WG mainly targeting promotion of solutions developed by the SMEs. Main activities provided within MATILDA are:

- delivering targeted content for the prepared printed and online versions of the SME brochures (release 2018, release 2019 and release 2020),
- delivering targeted content for the 2020 NetWorld SME web page, such us SME success stories, SME technological expertise by domain and verticals, etc.
- supporting SME booth activities organized by the 5G PPP and 5G IA at the EuCNC 2018 even in Ljubljana, Slovenia and EuCNC 2019 and the 7th Global 5G Event in Valencia, Spain,
- supporting SME booth activities organized by the 5G PPP and 5G IA at the MWC 2018 event in Barcelona, Spain.

5.1.4 Trials

In the scope of the Trials WG, through the Technical Committee, a call was launched to decide the demonstrators of 5G PPP projects that could be part of the "5G PAN-EUROPEAN TRIALS ROADMAP VERSION 5.0". MATILDA demonstrator PPDR (Public Protection and Disaster Relief) demonstrator was selected.

This PPDR demonstrator has been also published in the New (September 2019) H2020 5G Infrastructure PPP – 10 Trials & Pilots Brochure as one of the 10 Phase 2 Projects Trials & Pilots selected. Additionally, MATILDA has committed to contribute to the T&Ps Brochure n°2 (to be released by the end of 2020) with the description of the Smart Lighting pilot from ORO.

Finally, MATILDA has also contributed to this WG to verticals cartography based on its demonstrators. At the moment of delivering this document, the verticals cartography is being updated and new pilot dates are indicated.

5.1.5 Architecture

Contribution to the editing of the white paper "View on 5G Architecture" of the 5G PPP Architecture Working Group that was released in February 2020. The main architectural aspects introduced in MATILDA, especially with regards to the separation of concerns among orchestration aspects for telcos and OTT players, have been highlighted. Also, MATILDA was co-organizing special session workshop event "5G Architecture towards Verticals" at the 2018 EuCNC event in Ljubljana, Slovenia.

5.1.6 Communications

In this subsection, the different activities contributed to the COMMS group is presented as follows:

- MWC'19 participation (Feb'19)
  - Dissemination material, leaflet and videos sent by MATILDA to be part of the 5GIA booth
  - MATILDA was one of the projects selected to settle a demo in the 5GBarcelona booth.
- ICT'18 participation (Dec'18): MATILDA Demo at the ICT2018 as part of 5GIA booth.

In October 2019, during the COMMS Group telco, it was discussed that the full5G CSA was launching a new survey amongst the running 5G PPP projects to revise and update the list of stakeholders of the 5G PPP. The latest version of that exercise was made with contribution from Phase 1 projects and some Phase 2 projects and was released in April 2016. In the last part of 2019, when Phase 2 projects were being completed and many Phase 3 projects had already been started, it was decided to look again into these stakeholders in the light of the more recent evolution of the 5G PPP. Atos collaborated in this activity proposing new actors in the 5G Industry, Open Source communities, SDOs and Business Vertical stakeholders' groups, along with their detailed definition.

Although the MWC 2020 didn't finally take place, the MATILDA consortium was organizing the shipping of MATILDA leaflets to the 5GIA stand for promotional purposes.

5.1.7 Pre-standardization

During the pre-standardization phase, the consortium prepared the following:

- Draft contribution about how MATILDA uses ETSI/OSM and what are the key outcomes from MATILDA that will be ahead of OSM.
- Information about the different vertical demonstrators in MATILDA and how they are related with different standardization initiatives.

5.1.8 Vision

5.1.8.1 Vision on Smart Networks and Services beyond 5G

The objective of this sub-group is to further develop a vision for Smart Networks beyond 2020, covering both advanced research and societal challenges. Three MATILDA partners (CNIT, BIBA and ATOS) have realized a drafting contribution to technical future vision whitepapers, regarding:

- Vision on future smart network services for Industry 4.0
  In this respect, with the supervision of CNIT, in April 2019 BIBA has produced a contribution for the joint AIOTI/5GIA document that describes common technical topics between the Smart Networks and Services community and the IoT community. The contribution regards specifically **Safe unfenced human-robot interaction (HRI) in assembly lines**, and highlights the characteristics that certifiable sensor systems in combination with real-time supervision and assessment tools for human safety should provide to offer a real-time projection of humans addressing safety-related concerns,

like presence, number, position and motion capturing of existing humans in a collaborative workplace (conformant with safety requirements for collaborative industrial robot systems according to ISO 10218-1, ISO 10218-2 and DIN ISO / TS 15066 – Robots and Robotics – Collaborative Robots – Technical Specifications, which still represent a significant challenge), particularly regarding the use of Mobile Edge Computing approaches for intensive data processing tasks, along with 5G Ultra-reliable and/or Low Latency Communications (URLLC) services.

- Vision of future smart network services for mobility.

5.1.8.2 Pre-structuring Model

MATILDA partners (ATOS) are involved in this group in which they are contributing to the creation and follow-up of pre-structuring models for 5G PPP calls and forthcoming Horizon Europe Partnership, analyze the mapping of the PPP calls projects portfolios with the proposed models.

5.1.8.3 Business Validation, Models, and Ecosystems

Late in 2019, the Working Group "Visions and Societal Challenges" took the initiative to establish the "Business Validation, Models, and Ecosystems" Sub-Group (BVME-SG). This group was formally constituted in February 2020 focussing on the applied research area of business models, their validation and translation in ecosystem thinking and policies. Several 5G PPP projects are working together to address common challenges with business validation for and together with verticals, being the first outcome of the group a white paper "Business Validation in 5G-PPP vertical use cases", released in June 2020.

MATILDA partner, ATOS has collaborated in the production of this document participating in the calls and sharing its perspective about business validation methods with a formal presentation to the group on the 26th of March 2020.

MATILDA has also participated in the internal BVME Digital Workshop, on the 26th June 2020, where several methods for using the different business validation phases were suggested and further assessed. The assessment was a collaborative exercise responding to a set of relevant criteria, such as: advantages and disadvantages of the method proposed; types of use cases, perspectives, contexts for which the method is suitable; challenges and how to mitigate them, etc. Jacques Magen, from the 5G IA Board, participated in the workshop presenting some ideas for the group, after reading and approving the above-mentioned white paper.

5.1.9 Test, Measurement and KPI Validation

MATILDA has contributed to the 5G PPP Test, Measurement and KPIs Validation Working Group White Paper, entitled "Validating 5G Technology Performance – Assessing 5G architecture and Application Scenarios" that was released in June 2019.

5.2 Collaboration with other 5G PPP projects

The main goal of this section is to report the different collaboration activities that are going on between the MATILDA project and other 5G PPP projects, by presenting as much details as possible. MATILDA has always emphasized the significance of beneficial collaborations with other projects, most especially other 5G PPP ones. The reported collaboration activities are those involving the sharing of important information/ideas regarding the development,

deployment, experimentation and testing using different technologies and applications for enabling different use cases or demonstrators within the project and between the MATILDA project and other 5G PPP projects.

The following collaborative activities have been done between MATILDA and the projects below:

- 5G-PICTURE: alignment on the metamodels.
- NGPaaS: elaboration of a joint paper (CNIT, ININ) about mechanisms in both projects to achieve low latency. This paper was sent to the IEEE open call on the 24th of May 2019. Besides, the organisation of a MATILDA-NGPaaS workshop in EuCnC'19 in the context of Software networks 5GPPP WG (ORO) and the elaboration of a white paper in the Software Networks 5G PPP WG (ORO, UBI), published in September 2019
- 5GVINNI project distributed a questionnaire to ask for collaboration in particular by vertical enterprises which has been distributed among MATILDA partners to provide their inputs are key for understanding the pain points that vertical industries face today, their propensity to experiment during product/service life-cycle and how the 5G ecosystem could help them innovate in a mutually beneficial way. And furthermore, to understand the strategic/business drivers for adopting 5G technologies, as well as to identify trends across different verticals, countries, organizations of different sizes, etc. for the aspects above.

With 5GTango and SLICENET there has been a closer collaboration that has materialized in concrete results described in the sections below.

5.2.1 MATILDA synergy with 5GTANGO

Researchers in MATILDA focusing on graph recommendations towards the application developers have been obtaining information regarding the use cases/applications of 5GTANGO as additional data/application graphs that can be utilized by the proposed recommendation engine (based on machine learning tools). Moreover, the way monitoring data are collected and aggregated in 5GTANGO (through Prometheus) has been analysed and compared with the MATILDA approach with an emphasis on how these can be analysed in runtime in order to trigger infrastructure adaptations. Furthermore, the CEP engine developed in MATILDA (focusing on the analysis of various datasets during runtime in order to identify the factors of importance for various policy rules implementations and triggering) has been evaluated with information obtained from the 5GTANGO testbed for different deployments (including concurrent ones) and how the monitoring data are analysed and their parameters/dimensions are weighted has important factors for runtime adaptations.

Furthermore, MATILDA and 5GTANGO colleagues have participated and exchanged views and aligned visions in joint workshops organized within EUCNC 2018 and EUCNC 2019, entitled "From Cloud-ready to Cloud-native transformation", related with the evolution and adoption of cloud-native principles within NFV Orchestration solutions.

5.2.2 MATILDA synergy with SLICENET

An excellent collaboration with periodic calls between two 5GPPP Phase 2 projects, MATILDA and SLICENET culminated with a technical and coordination meeting hosted by Orange Romania on 12-14th November 2019 in the CAMPUS Research Centre, Politehnica University of Bucharest, where the smart connected city - intelligent lighting application was

demonstrated. The joint collaboration and the clustering technical event brought together 33 partners from 13 countries that exchanged project status and technical details for the 8 use cases. As a result of the fruitful collaboration between both projects we can mention also a scientific paper described at Table 8 line 32 and the exhibitions described at Table 5 line 40 and line 20.

The liaison element between the two 5G-PPP projects was the smart city lighting 5G cloud native application implemented in Romania with Orange Romania leading the way in both projects. The two projects have used both testbed and demonstrator collaboratively to create the Smart City Intelligent Lighting use case showing how street lighting can be monitored and controlled by a central point, helping with lighting issues, saving costs and providing feedback on the system.

The successful collaboration between SLICENET and MATILDA is highlighted in the video created by Orange Romania and available on YouTube[8]

Figure 6 – Video on MATILDA - SLICENET technical workshop available on YouTube.

Amongst other things, MATILDA and SLICENET consortium members as shown depicted in Figure 6 had a very fruitful discussions on the positioning of both projects and their respective outcomes. In particular, the focus of the clustering workshop was on the practicalities of the application of the results generated from both projects and their alignment with respect to their set objectives. More specifically, the coordination teams of both projects identified areas of interests in some of the implementation results realized within their respective frameworks.

As depicted in Figure 7, while MATILDA is focusing more on the end to end framework and on the upper layers related to marketplace and application orchestration, SLICENET is more focused on virtualization/slicing concepts. Orange Romania demonstrator shows how the two frameworks could be integrated in order to automate the deployment and in life management and bringing key benefits in terms of cost and time to market.

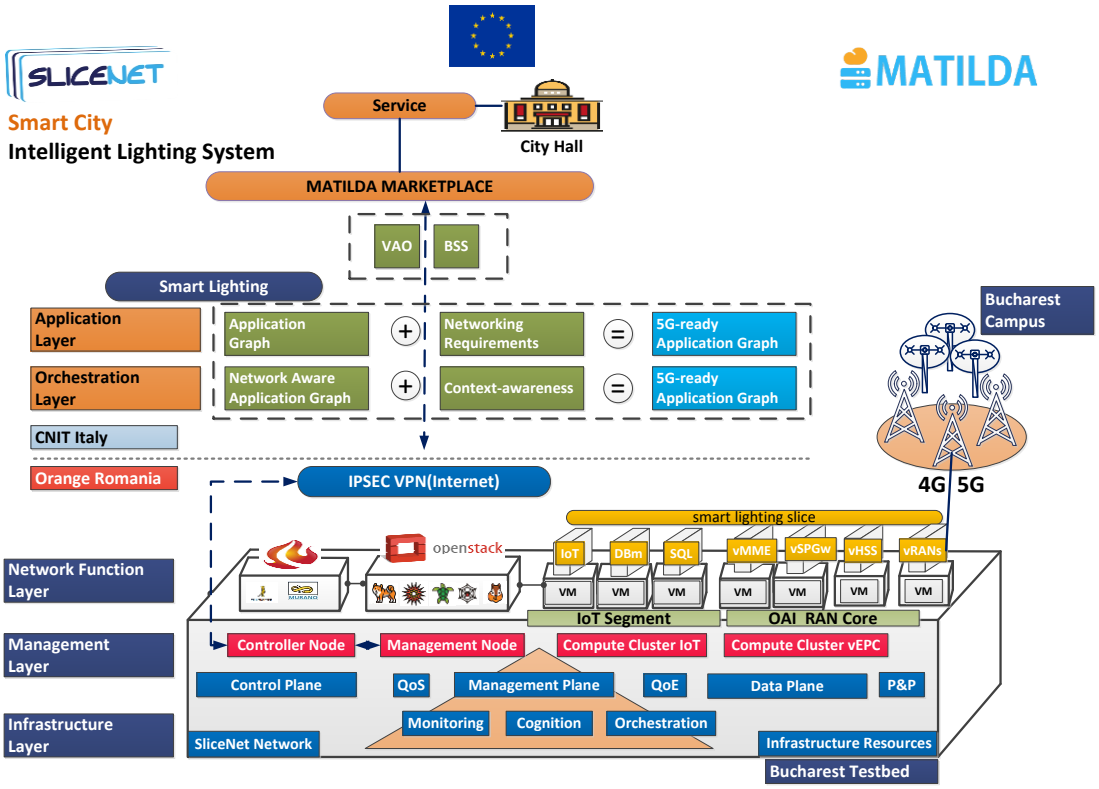

Figure 7 – MATILDA - SLICENET Smart City Intelligent Lighting System test bed architecture.

During the technical workshop, MATILDA presentation highlighted the 5G architectural concepts implemented on Orange Romania testbed, concepts related to the 5G infrastructure developed but also to the specific network components and applications integrated for the end-to-end use case development. Concrete MATILDA experts provided a detailed overview related to key aspects such: (1) integration between MATILDA Marketplace, VAO and OSS components deployed within CNIT infrastructure and ORO programmable infrastructure, (2) application components and graph creation, (3) use of the metamodels for application graph deployments and slice creation and (4) in life management.

Orange Romania experts insisted on the Smart City Intelligent Lighting use case that was deployed and demonstrated using this 5G framework developed within MATILDA taking also benefit of the SLICENET collaboration for the development of Orange Romania programmable infrastructure. The integration among the two project stands also as proof for the high grade of openness and interoperability of the developed 5G framework.

An observation during the workshop sessions was that MATILDA 5G framework can be easily used to orchestrate the end to end life cycle of 5G ready application over programmable infrastructure.

SLICENET participants were very interested to understand how the Smart City Intelligent Lighting application components are on boarded in the MATILDA Marketplace, how the application graph is built and orchestrated over the programmable infrastructure using the VAO and OSS. MATILDA participants were questioning more on the management of the end to end dedicated slice supporting the connectivity of the demonstrator, how is it instantiated and managed using the vEPC solution.

At the moment of the demonstration from November 2019, all the Smart City Intelligent Lighting application components were available, including the C1 component in its dockerized version. Therefore, a complete MATILDA developed application graph was available and all the functionalities of the platform were shown, including ticketing, alarming or billing. The slicing concepts developed within SLICENET were also demonstrated as the OAI RAN and Core components were available and integrated. The demonstration took place over a live environment of 56 lamps deployed in Politehnica University of Bucharest campus.

Thanks to the follow-up on the exchanges from the MATILDA – SLICENET technical workshop and particularly on the additional development performed within SLICENET, Orange Romania was able to perform a full demo of the use case with all functionalities in place during a remote review meeting (due to coronavirus pandemic) held in March 2020. This demonstration took place also in Bucharest in a remote manner and was able to prove on the live environment from Politehnica campus the end to end solution automating the deployment and in life management. The main difference versus the previous demos was achieving the full integration between the VAO, OSS and ORO programmable infrastructure enabling automated deployment of the application graph and slice instantiation. The VAO and OSS were hosted in CNIT infrastructure and fully integrated with the OpenStack and ETSI MANO OSM from ORO programmable infrastructure.

An interesting aspect to be considered is that following the integration of the technical components developed within the two projects, all the tests were performed in a real environment together with the use case beneficiary – Politehnica University of Bucharest. After the end of the two projects, Politehnica University of Bucharest will start using the solution with the support of Orange Romania and will be able to add new functional components that were designed in MATILDA and SLICENET. This is a relevant validation and an expected reference that will help Orange to move in the business monetization stage by going in the field with the solution targeting small cities and campuses with similar requests.

5.3 Contribution to 5G PPP KPIs

The 5G PPP programme has identified some prominent 5G KPIs, e.g. business, societal and performance KPIs. MATILDA project has closely monitored and contributed significantly to the work performed in the context of 5G-PPP TB regarding the 5G KPIs. This section builds on previous version of the deliverable, D7.2, highlighting the main 5G PPP KPIs that MATILDA is contributing.

Performance KPIs

P3: Reducing the average service creation time cycle from 90 hours to 90 minutes (high relevance).
How MATILDA contributes: the MATILDA development and profiling environment is an important catalyst in the service creation time.
P4: Creating a secure, reliable and dependable Internet with a “zero perceived” downtime for services provision (high relevance).
How MATILDA contributes: MATILDA intelligent orchestration mechanisms, including the runtime policies enforcement and the machine learning mechanisms adopted improve the downtime service perceived by the users, due to the increase of automation in the orchestration.

Although these 5G PPP KPIs are very relevant to MATILDA, the project has demonstrated to meet more ambitious technical indicators. For more detailed information, there is a complete analysis in D6.7. (Annex2) describing also network and operational KPIs for MATILDA demonstrators.

Societal KPIs

S3: European availability of a competitive industrial offer for 5G systems and technologies (high relevance).
How MATILDA contributes: MATILDA is releasing a 5G cost effective solution, most of its components as open source code, contributing in this way to increase availability of 5G systems and technologies in Europe.
S4: Stimulation of new economically viable services of high societal value like U-HDTV and M2M applications (medium relevance).
How MATILDA contributes: MATILDA is contributing to this KPI thanks to the 5GPACE demonstrator.

Business-related KPIs

B1: Leverage effect of EU research and innovation funding in terms of private investment in R&D for 5G systems in the order of 5 to 10 times (medium relevance).
How MATILDA contributes: As explained in D7.8, in the partners exploitation plans, MATILDA results are being capitalized in future R&D investments, as well as in the business lines of the commercial partners.
B2: Target SME participation under this initiative commensurate with an allocation of 20% of the total public funding (high relevance).
How MATILDA contributes: SMEs have been represented in MATILDA project by a high percentage of the partners.

5.4 Participation in the production of the first draft of the Strategic Research and Innovation Agenda 2021-27

The interaction with 5G PPP IA and the NetWorld 2020 Technology Platform has fostered the participation in the drafting work of the next Strategic Research and Innovation Agenda (SRIA) 2021-27 “Smart Networks in the context of NGI”, which was released for public consultation in June 2020. CNIT (F. Davoli) provided contributions in Sect. 4 (System Architecture) and Sect. 5 (Edge Computing and Meta-data) of the document, which stem from the MATILDA vision and philosophy.

6 Conclusions

In this document we have provided the details of the activities achieved within the context of the clustering & standardization, dissemination as well as the 5G PPP project interactions carried out within the scope of the MATILDA project. We have presented how well the different KPIs and set objectives have been achieved by showing the different statistics that correspond to the attained objectives with respect to the set KPIs which were enumerated in the proposal. Without a scintilla of doubt, we can safely conclude that these activities have been fruitfully executed and quite a reasonable landmark were achieved.

This document also presents an overview of the various achieved number of publications in different high impact journals and conferences through which we have been able to broadcast the progress and outcomes of the MATILDA project to the scientific community, be it in the industry or the academic side. Standardisation efforts that have been explored in different organisations through synergy with various standardisation working groups are also detailed in this document. In addition, the 5G PPP clustering activities that have been organised by members of the MATILDA consortium with members from other 5G PPP projects in order to align thoughts and share visions on the numerous gains that have been achieved through the introduction of different methods and exploration of new techniques for the realization of certain results, for general of specific challenges, are also discussed in the document.

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