



Programmable edge-to-cloud virtualization fabric for the 5G Media industry

D1.3 - Project Periodic Report (intermediate)

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02	IBM ISRAEL - SCIENCE AND TECHNOLOGY LTD	IBM	Israel
03	SINGULARLOGIC ANONYMI ETAIREIA PLIROFORIAKON SYSTIMATON KAI EFARMOGON PLIROFORIKIS	SiLO	Greece
04	HELLENIC TELECOMMUNICATIONS ORGANIZATION S.A. - OTE AE (ORGANISMOS TILEPIKOINONION TIS ELLADOS OTE AE)	OTE	Greece
05	CORPORACION DE RADIO Y TELEVISION ESPANOLA SA	RTVE	Spain
06	UNIVERSITY COLLEGE LONDON	UCL	United Kingdom
07	TELEFONICA INVESTIGACION Y DESARROLLO SA	TID	Spain
08	UNIVERSIDAD POLITECNICA DE MADRID	UPM	Spain
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Definitions and acronyms

5G-PPP	5G Infrastructure Public Private Partnership
CI	Continuous Integration
CD	Continuous Delivery
CNO	Cognitive Network Optimizer
DoA	Description of Action
EC	European Commission
FaaS	Function as a Service
KPI	Key Performance Indicator
MANO	Management and Orchestration
MAPE	Monitoring, Analysis, Planning and Execution
MS	Milestone
NFV	Network Function Virtualization
NFVI	Network Function Virtualization Infrastructure
NS	Network Service
NSD	Network Service Descriptor
OSM	Open Source MANO
QoS	Quality of Service
SDK	Service Development Toolkit
SVP	Service Virtualization Platform
UC	Use Case
WG	Working Group

Executive summary

This deliverable represents an intermediate periodic report (with Public dissemination level) whose aim is to outline the progress and outcomes achieved in the first period of the 5G-MEDIA workplan (M1-M13 / June 2017-June 2018). It has to be noted that a more extended version of the content with confidential details (e.g. including Explanation of the work carried out per Work Package, use of resources, updated exploitation plans, etc.) is presented in the Periodic Technical Report – Part B, following the EC template.

Main achievements of such first period can be summarized by the following facts:

- 9 deliverables have been submitted (D1.1, D1.2, D1.3, D2.1, D2.2, D3.1, D7.1, D7.2, D7.3);
- 6 milestones have been achieved (MS1, MS2, MS3, MS4, MS5, MS6);
- Beyond the Steering and Technology Boards, an active participation in 5G PPP activities is in place in 8 Working Groups (i.e. Architecture WG, Software Network WG, COMMS WG, Vision WG, Network Management & QoS WG, Trials WG, Security WG, SME WG). The collaboration with Phase 2 projects is also remarkable;
- 12 technical publications have been produced by the consortium partners;
- 28 events have been attended and, in most of them, one or more presentations of the project results has been given. Among the most relevant ones: EuCNC 2017, NEM Summit 2017, Mobile World Congress 2018, IEEE Broadband Multimedia Systems and Broadcasting (BMSB) 2018 and EuCNC 2018;
- Significant presence in social media: 480+ followers in Twitter, 290+ followers in LinkedIn and 2500+ unique visitors in our website
- 6 videos have been produced with the objective to make more accessible the activities and demos of the project; at the time of writing it has been registered more than 450 views.

Finally, it is important to mention that 8 new deliverables (D2.3, D3.2, D3.3, D4.1, D5.1, D6.1, D7.4, D7.5) are planned to be released in M15 (August 2018). This is going to be a first major outcome in terms of progress of the technical work packages as well as in terms of the business model definition.

1. Introduction

This deliverable represents an intermediate periodic report (with Public dissemination level) whose aim is to report the progress in the first period of the 5G-MEDIA workplan. The first period started in M1 (June 2017) and has ended in M13 (June 2018). This document is organised as follows:

- Section 2 explains the work carried out in this period with respect to the project objectives
- Section 3 reports about the deliverables produced in this period and the milestones achieved
- Section 4 reports about the 5G PPP related activities, including meeting and events as a mean of collaboration at program level
- Section 5 lists those Public Events attended by the consortium partners
- Section 6 lists the publications produced by the 5G-MEDIA consortium partners.

2. Overview of the progress with respect to 5G-MEDIA objectives

2.1. Objectives

In this section 5G-MEDIA project objectives are presented divided into three different categories (technical, business innovation and impact creation), as per DoA [5G-MEDIA_DOA], and progress achieved in this period is described.

2.1.1. *Technical: Objective 1, Objective 2, Objective 3*

Table 1 - Objective 1 (technical)

OBJ 1: Support the full application lifecycle management (ALM) of development, testing, deployment and operation, hiding the complexity of the network management and orchestration from developers

In order to increase the agility and productivity of skilled developers and operators and also reduce the entry barriers for new developers (especially SMEs) aiming to build new media applications and services, 5G-MEDIA platform will:

- *Define a suitable programming model and provide a set of well-integrated open source networking-related and media-specific tools in an SDK toolbox, assisting the function, application and service development, emulation, testing and validation process, prior to the deployment phase.*
- *Support the 5G-MEDIA Service Virtualization Platform owner and the NFVI providers via a Development & Operations (DevOps) toolbox enabling efficient network function and service deployment, edge-to-cloud resource orchestration and management as well as media-related policies establishment (e.g. caching strategy). Being in the centre of interest of 5G-MEDIA partners, the serverless computing approach will be also followed, extending available DevOps tools that have been developed within 5G-PPP phase 1 projects.*

KPIs	<ul style="list-style-type: none"> • 5G-MEDIA SDK will support microservice-based application development for both hypervisor-based and containerized approaches, specifically supporting at least Docker, unikernel, and LXC. • 5G-MEDIA platform will integrate innovative and open source tools related to serverless computing (e.g. OpenWhisk), to reduce development time in the order of 5 minutes. • Re-use and/or extend at least 4 major components or platforms from at least 3 5G-PPP phase 1 projects (e.g. SDK toolbox, Repository, MANO framework, monitoring system, etc.). • Integrate at least 3 different NFVIs/VIMs to 5G-MEDIA platform, according to partners' business interests (e.g. OpenStack, VMware, Kubernetes, etc.).
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Table 2 - Objective 2 (technical)

<p>OBJ 2: Develop new VNFs and media-related functions and extend existing ones to support media-oriented use case scenarios</p>	
<p>The amount of time to develop a media and entertainment application is critical and its drastic reduction is a clear target of the 5G-PPP initiative. Therefore, 5G-MEDIA aims for the provisioning of media applications related building blocks and virtualized network functions, packaged as "network apps" to be easily utilized and extended according to developers' needs.</p> <p>During the project lifetime, a large set of network services and functions will be developed, and existing ones (especially those developed in the 5G PPP phase 1 projects) will be enhanced to fulfil the requirements of 5G-MEDIA use case scenarios (Immersive Media and Virtual Reality, smart production integrating user-generated content, and UHD content distribution over enhanced CDN). Most importantly, following a clear open source strategy, the consortium will provide network functions as open source to the developers' community.</p> <p>One of the strategic decisions of the consortium is to open the platform to EU projects and programs, external to 5G-PPP, and in particular the Celtic-Plus Eureka projects and EIT-ICT-Labs for liaison and further uptake of the project impact.</p>	
KPIs	<ul style="list-style-type: none"> • Reuse and/or extend at least 3 virtual network functions already available as open source. • Develop at least 5 open source VNF implementations. • Develop or extend at least 6 media components related to 5G-MEDIA use case requirements.

Table 3 - Objective 3 (technical)

<p>OBJ 3: Support and move beyond edge computing paradigm via dynamically defined and orchestrated VNF Forwarding Graphs</p>	
<p>5G-MEDIA will automatically discover the nodes that are in close network proximity, create dynamic VNFFGs and select the most appropriate ones (based on beyond state-of-the-art path computation algorithms) that take into consideration various parameters, such as required and available resources, processing and networking load and delay.</p> <p>In this way, 5G-MEDIA will enable critical, time-sensitive data and real-time multimedia interactions to be processed on virtualized network edges, while less time-sensitive data and less intensive processing tasks may be transferred to the "central cloud" for further processing and/or long-term storage.</p>	
KPIs	<ul style="list-style-type: none"> • Path prolongation between automatic VNFFG and optimal forwarding path will not exceed 15%. • The platform will take into consideration at least 5 supported networking parameters and performance metrics for VNFFG selection.

Progress towards the Objective during Period M1-M13

As reported in *D1.1 - Quality Plan* [5G-MEDIA_D1.1], the objective 1 is related to WP2, WP3 and WP5. In this period, an early version of the 5G-MEDIA Architecture and the functional specifications of its components have been defined and documented through a draft internal version of *D2.3 - 5G-MEDIA Platform Architecture* and *Milestone 3 - Initial 5G-MEDIA Architecture* achieved in M5. This internal document has been used as a basis for the preparation of implementation activities in the project and since then it has been iteratively updated following the progress of technical work. In the context of WP3, the initial architecture design has been officially reported in *D3.1 - Initial design of the 5GMEDIA Operations and Configuration Platform* at M9 [5G-MEDIA_D3.1]. The deliverable *D3.1* also contained initial specification of the Service Virtualization Platform, which is the core element of the 5G-MEDIA platform. Also, in the context of WP2, *D2.1 - APIs and Tools for Operation Support* [5G-MEDIA_D2.1] has been released in M6 with the purpose to define the DevOps toolchain to support Continuous Integration (CI) and Continuous Delivery (CD) to be used both during the 5G-MEDIA platform development and the use case realisation. A DevOps approach and toolchain are also defined in the context of WP5 with respect to the 5G-MEDIA Service Development Toolkit (SDK) through *Milestone 6 - 5G-MEDIA Programming Tools defined* and that will be officially released with *D5.1 - 5G-MEDIA Programming Tools* in M15.

With respect to identified KPIs:

- The 5G-MEDIA SDK will support the development of new media applications and services assisting the function, application and service development, emulation, testing and validation process, prior to the deployment phase and it will allow the use of lightweight virtualization through Docker and unikernels. More specifically it will provide an all-in-one environment to validate Network Service Descriptors, emulate network services through the integration of the Sonata Emulator (son-emu)¹ recently embraced by the Open Source MANO (vim-emu)², to onboard NS in the NFV catalogue and finally instantiate it on a specific NFVI/VIM through the Service Virtualization Platform (SVP).
- In the context of WP3, the 5G-MEDIA platform is integrating OpenWhisk [OpenWhisk] to enable the innovative paradigm of serverless computing, also known as Function-as-a-Service (Faas); the reduction of the service development time will be evaluated in the second period of the project
- The result integrated and/or extended coming from 5G-PPP phase 1 projects:
 - (WP3) the design of the Monitoring, Analysis, Planning and Execution (MAPE) loop and Cognitive Network Optimizer (CNO) from the CogNet [CogNet] 5G-PPP phase 1 project
 - (WP4) the design and core development of the Service Catalogue as a result of the SELFNET [SELFNET] 5G-PPP phase 1 project

¹ Sonata Emulator (son-emu): <https://github.com/sonata-nfv/son-emu>

² Open Source MANO (vim-emu): https://osm.etsi.org/wikipub/index.php/VIM_emulator

- (WP5) the integration of Sonata Emulator (son-emu) recently embraced into Open Source MANO (vim-emu) into the 5G-MEDIA SDK coming from the SONATA [SONATA] 5G-PPP phase 1 project
- The 5G-MEDIA platform, based on the Open Source MANO (OSM) [OSM] framework, has been integrated with 3 different NFVIs/VIMs which are specifically: OpenStack (both deployed in Engineering and OTE cloud), OpenNebula (deployed in TID as part of the OnLife [OnLife] initiative), Kubernetes/OpenWhisk to support the new serverless/Function-as-a-Service (Faas) NFVI/VIM.

The objective 2 is related mainly to WP4 which is specifically responsible for providing Generic Network Apps and Functions (T4.2) and Media Network Apps and Tools (Task 4.3).

The list of VNFs will be provided into *D4.1 - 5G-MEDIA Catalogue APIs and Network Apps* [M15]. An initial list on VNFs has been reported in the *D2.2 - 5G-MEDIA Requirements and Use Case Refinement*. In this period, in the context of the initial pilot demonstration, the following VNFs are under development:

- UC1 - v3DTranscoder (developed from scratch);
- UC2 - vCompression Engine (based on open source tool FFmpeg³); Speech-to-Text Engine (based on open source tool Mozilla DeepSpeech⁴); MPE (Media Process Engine) based on voctomix⁵ open source project;
- UC3 – vCache (based on Apache Traffic Server⁶ open source project).

With respect to Objective 3, an initial specification of the MAPE loop has been documented in *D3.1 - Initial design of the 5GMEDIA Operations and Configuration Platform* [5G-MEDIA_D3.1] at M9. The detailed specification referring to the initial prototype of the MAPE component will be reported to *D3.3 - Specification of the 5G-MEDIA QoS Control and Management Tools* in M15. In the initial prototype, the machine learning tools will be based on network metrics including network load and packet loss, taking as a reference example use case 3. However, over the next reporting period, more performance metrics will be supported by MAPE and a range of machine learning techniques and optimisation algorithms will be deployed to extend the role of MAPE in use cases 1 and 2.

³ FFmpeg - <https://www.ffmpeg.org/>

⁴ Mozilla DeepSpeech - <https://github.com/mozilla/DeepSpeech>

⁵ Voctomix - <https://github.com/voc/voctomix>

⁶ Apache Traffic Server - <http://trafficserver.apache.org/>

2.1.2. Business Innovation: Objective 4, Objective 5

Table 4 - Objective 4 (business innovation)

<p>OBJ 4: Enable a directly exploitable solution through the orchestration and placement of media services over heterogeneous nodes belonging to different administrative domains or infrastructure owners/operators</p>	
<p>5G-MEDIA aims to step from innovation to a truly exploitable solution. 5G-MEDIA platform will not only enable efficient microservice development, management and orchestration, but it will pioneer innovative Streaming as a Service (StraaS) business models, over nodes that belong to different administrative domains. 5G-MEDIA network applications will enable fully transparent, seamless and scalable traceability of each individual microservice instantiation throughout its lifetime and monitor the execution time and resources consumed at each node. Another novel feature of the services is the ability to modify, at any time, the permissions granted or the SLA negotiated during initial deployment, with a new set of permissions or new SLAs, or revoke service or VNF execution permission.</p>	
<p>KPIs</p>	<ul style="list-style-type: none"> • Full traceability of the microservice components throughout their lifecycle even when placed/migrated to nodes administered by different actors. • Automatic negotiation and monitoring of specific SLA between different actors. • New business models, based on StraaS innovative concept in the edge-to-cloud fabric.

Table 5 - Objective 5 (business innovation)

<p>OBJ 5: Evaluate and demonstrate the 5G-MEDIA platform through extensive test-bed experimentation and large-scale trials conducted by the 5G-MEDIA consortium, and developer communities</p>	
<p>5G-MEDIA will evaluate its solutions for building an open, integrated and service-enabling networking media ecosystem through extensive test-bed experimentation and large-scale trials, consisting of heterogeneous nodes and covering a gamut of different media-related applications.</p> <p>Furthermore, the 5G-MEDIA consortium, following an open innovation approach will offer the platform as well as the developed VNFs and network services to selected SMEs and developers’ community for validation, testing and experimentation, attracting interested stakeholders of the media and entertainment application domain.</p> <p>The validation of StraaS concept on real conditions and infrastructures will offer the opportunity to attract stakeholders from the 5G community and open new revenue streams and business models that 5G-MEDIA partners and the broader ecosystem can take advantage of.</p>	
<p>KPIs</p>	<ul style="list-style-type: none"> • The 5G-MEDIA platform will be demonstrated to at least 3 large events such as international workshops, conferences and industry fairs. • At least 3 open source communities, 3 Celtic-Plus Eureka projects to participate on the 5G-MEDIA platform validation.

Progress towards the Objective during Period M1-M13

The 5G-MEDIA platform is going to be instantiated and validated through the use cases defined first in D2.2 - 5G-MEDIA Requirements and Use Case Refinement [5G-MEDIA_D2.2] and further refined in D6.1 - 5G-MEDIA Use Case Scenarios and Testbed to be released in M15 which are specifically:

- Use case 1 - Immersive Media

- Use case 2 - Mobile Contribution, Remote and Smart Production in Broadcasting
- Use case 3 - Ultra-High Definition (UHD) over Content Distribution Networks (CDN)

Since the beginning of the project the physical infrastructure layer needed to demonstrate the three use cases has been designed to include three different administrative domains: the cloud infrastructure provided by OTE and TID as Edge Cloud (NFVI), and the ENG Cloud as Core Cloud for the Service Virtualization Platform components, specifically hosting the components related to the ETSI MANO framework, the 5G-MEDIA Catalogue designed to be NFV MANO platform-agnostic, the Media Service MAPE and the corresponding Virtualized Infrastructure Manager (VIM) and WAN Infrastructure Manager (WIM) plugins enabling the integration to different NFVI platforms at the edge.

Although the Multi-PoP (inter-NFVI) deployment, orchestration and administration of a network service has been taken into consideration for the design of the 5G-MEDIA platform in the definition of the architecture and more specifically in *D3.1- Initial design of the 5G-MEDIA Operations and Configuration Platform* [5G-MEDIA_D3.1], inter-NFVI has not been implemented in the first period and each of the use cases is currently demonstrated on a single administrative domain. However, in the first demonstration of UC3, the project aims to validate the MAPE component in a single administrative domain environment and proof-of-concept validate the monitoring and accountability tools that could be later on extended to inter-NFVI scenarios.

In terms of exploitation activities performed in this period, the exploitation approach in 5G-MEDIA has taken into account, through *D7.3 - 5G-MEDIA Impact and Exploitation Plan* [5G-MEDIA_D7.3], a market analysis, the individual exploitation plan of each partner, the identification and the analysing of the context in which stakeholders operate and, finally, a preliminary value chain and potential new stakeholders.

The final 5G-MEDIA exploitation plan and the relative Business Model will be refined during the second period of the project timeline when a definitive description of the expected results and the definition of the ecosystem will be completed. Foreseen deliverable including this work are *D7.5 - 5G-MEDIA Report on Impact and Exploitation (version 1)* [M15] and *D7.7 - 5G-MEDIA Report on Impact and Exploitation (version 2)* [M30].

A preliminary result that is going to be included into D7.5 is the identification of three main Value Propositions built by making use of the Canvas Business Model methodology; the three identified value propositions are:

- Network Functions, Applications and Tools for Improving the 5G Value
- Solutions for Media and Media Provider (e.g. Broadcaster, Media Companies, Gaming, AR and VR)
- Media Solutions for Media Customers.

The Objective 5 is mainly related to WP6 - 5G-MEDIA Use Cases, Scenarios and Validation and WP7 - Impact, Dissemination and Exploitation. In this period a preliminary setup of the use cases has been performed in the context of WP6 (officially started in M10) on top of the infrastructures provided by the telco operators (TID, OTE) providing edge cloud facilities and IT service providers (ENG) providing the core cloud. Extended validation, testing and experimentation of the 5G-MEDIA platform by a developer community will be done in the

second period of the project. One of the main industry fairs that the consortium is going to target will be the Mobile World Congress (MWC), Madrid (Spain), February 2019.

2.1.3. *Impact creation: Objective 6, Objective 7*

Table 6 - Objective 6 (impact creation)

OBJ 6: Actively promote widespread adoption, impact creation & standardization	
<p><i>The 5G-MEDIA results will be widely disseminated through major national and international activities, such as EuCNC, Global 5G Event, Mobile World Congress, etc. In order to further facilitate the widespread adoption, we will provide an open, experimentation infrastructure that can be used by developers, while the 5G-MEDIA platform will become publicly available. Moreover, a set of proof-of-concept applications will be implemented to demonstrate the 5G-MEDIA platform under real-operational conditions. Moreover, impact creation is foreseen by collaborating with the rest of the EU-funded projects under the 5G-PPP initiative through the existing Working Groups.</i></p> <p><i>Finally, we will also monitor and aim at linking and synchronizing the 5G-MEDIA activities with the OPNFV Pharos testbed and the OpenStack Magnum and Tacker projects to create worldwide impact. In parallel, contribution to ETSI NVF, MANO and MEC, to IETF ANIMA, IRTF SDNRG and NFVRG, and to ISO/IEC MPEG via established partners' activities and links will be addressed.</i></p>	
KPIs	<ul style="list-style-type: none"> • Contribution of at least 3 new drafts in IETF/IRTF • Participation in at least 3 ETSI and ISO/IEC working groups. • Contribution to at least 2 open source projects and initiatives. • Active participation in at least 5 different 5G-PPP existing Working Groups. • Contribute to at least 2 position and white papers issued by the 5G-PPP.

Table 7 - Objective 7 (impact creation)

Promote the commercial exploitation of the results	
<p><i>A complete 5G-MEDIA platform will be available as open source. Yet, the companies involved in the project will form the critical mass to establish the 5G-MEDIA concept in the SDN/NFV and media & content markets while the RTD partners will also be involved in the market activities through future commercial collaborations with the companies. By the end of the project, SILO, NETAS, OTE, RTVE, NXW and ENG are targeting to provide 5G-MEDIA-based services, which will be the first commercial exploitation of the results, while IBM, IRT and BIT plan to experimentally utilize the platform in several settings, ranging from crowded events (IRT, BIT), to Internet of Things networks.</i></p>	
KPIs	<ul style="list-style-type: none"> • Commercial exploitation through participation and demonstration to at least 5 major European or International events. • Promote 5G-MEDIA offerings to at least 50 B2B customers of the consortium partners.

Progress towards the Objective during Period M1-M13

Throughout the first period of the project, 5G-MEDIA has achieved some relevant milestones towards the wide outreach and technology transfer of the activities and outcomes from this Innovation Action. In the particular case of 5G-MEDIA, there are two domains that require a specific focus: the 5G technology field and its impact in the media vertical industry.

The project has gained traction in Europe as one of the frontrunners in the use of 5G capabilities to boost a vertical market such as the media. Some key results that underline such position of 5G-MEDIA are:

- Participation in 28 events, which 19 conferences, 8 workshops and 1 brokerage event, including some of international relevance:
 - EuCNC 2017, Oulu (Finland), June 2017
 - NEM Summit 2017, Madrid (Spain), November 2017
 - Mobile World Congress 2018, Barcelona (Spain), February 2018
 - IEEE International Symposium on Broadband Multimedia Systems and Broadcasting 2018, Valencia (Spain), June 2018, where the project organized the technical workshop "Media delivery innovations using flexible network models in 5G"
 - EuCNC 2018, Ljubljana (Slovenia), June 2018
- An audience of 480+ followers in Twitter, 290+ followers in LinkedIn and 2500+ unique visitors in our website
- A total number of 12 technical publications

The first demonstration of a 5G-MEDIA use case was made at EuCNC 2018: scenario ‘Dynamic and Flexible UHD Content Distribution over 5G CDNs’ from UC3.

The full list of events where 5G-MEDIA has been presented is available in section 5.

Within the ecosystem of the 5G PPP in Europe, 5G-MEDIA has adopted a quite active position, both in terms of contribution to the existing Working Groups and collaboration with Phase 2 projects.

- 5G-MEDIA is represented in both the 5G PPP Steering and Technology Boards
- Consortium members are involved in 8 different Working Groups, according to the relevance for the project: Architecture, Software Networks, Vision, Communications, Security, Network Management & QoS, Trials and SMEs
- 5G-MEDIA has contributed to several 5G PPP-wide outcomes:
 - 5G PPP's European 5G Annual Journal 2018⁷
 - 5G PPP Software Network WG White Paper “From Webscale to Telco, the Cloud Native Journey”⁸
 - 5G PPP Vertical Cartography and Golden Nuggets
- The project maintains active communication channels with the majority of Phase 2 projects and the 5G PPP’s CSA (To-Euro-5G project), collaborating in initiatives such as

⁷ 5G PPP's European 5G Annual Journal 2018: <https://5g-ppp.eu/annual-journal/>

⁸ “From Webscale to Telco, the Cloud Native Journey” white paper produced within the 5G PPP Software Network WG: <https://5g-ppp.eu/wp-content/uploads/2018/07/5GPPP-Software-Network-WG-White-Paper-23052018-V5.pdf>

the organization and participation of workshops at EuCNC 2018, or mutual promotion in social media

A comprehensive list of the 5G PPP phone calls and physical meetings attended in this period is presented in section 4.

With regard to open source communities, special mention goes to two contributions:

- In January 2018, a contribution about the integration of OpenNebula VIM into Open Source MANO project using the XML-RPC API⁹ was submitted and accepted by this open source community;
- A number of contributions in the form of pull requests about a lighter version of OpenWhisk - lean OpenWhisk¹⁰ - with reduced resources footprint suitable to be part of 5G-MEDIA SDK and deployment at the edge in a resource constrained environment.

Other contribution to standards and/or open source communities are in a very early stage or planned for the second period of the project, targeting for example:

- ETSI NFV¹¹, ETSI MEC¹², ETSI ZSM¹³ - to e.g. continue monitoring the NFV SOL specifications and work on their applicability to the NFV catalogue service developed in 5G-MEDIA; to continue monitoring the Multi-access Edge Computing (MEC) standard evolution and identify its applicability to 5G-MEDIA; to identify areas for Monitoring, Analysis, Planning and Execution (MAPE) loop automation into Zero touch network & Service Management (ZSM);
- OSM End User Advisory Group (EUAG) and OSM Hackfest – to continue monitoring the OSM releases and to propose the 5G-MEDIA NFV catalogue for integration in future OSM releases. ENG intends to continue monitoring the OSM releases and to contribute to the integration of standard authentication protocols such as OpenID Connect;
- IETF Network Function Virtualization (nfvrg)¹⁴ – to propose the concept of a flexible and generalized catalogue for SDN and NFV applications and functions.

According to 5G-MEDIA's Description of Action¹⁵, WP7 contributes to project objectives 6 and 7, with the status of KPIs at M15 depicted in Table 8.

⁹ OpenNebula vimconnector module for OpenSource MANO: <https://osm.etsi.org/gerrit/#/c/5805/1>

¹⁰ Lean OpenWhisk: <https://github.com/apache/incubator-openwhisk/pull/2984> ,
<https://github.com/apache/incubator-openwhisk/pull/3886>

¹¹ ETSI NFV: <https://www.etsi.org/technologies-clusters/technologies/nfv>

¹² ETSI MEC: <https://www.etsi.org/technologies-clusters/technologies/multi-access-edge-computing>

¹³ ETSI ZSM: <https://www.etsi.org/technologies-clusters/technologies/zero-touch-network-service-management>

¹⁴ IETF Network Function Virtualization (nfvrg): <https://datatracker.ietf.org/rg/nfvrg/about/>

¹⁵ Cf. 5G-MEDIA Description of Action. Grant Agreement number: 761699

The extended full list of planned contribution will be reported into *D7.4 - Report on dissemination, communication and community building activities and updated plan* [M15].

Table 8 - 5G-MEDIA's Impact Creation KPIs

5G-MEDIA Objective	KPIs	Status M15
Objective 6: Actively promote widespread adoption, impact creation & standardization	<i>Contribution of at least 3 new drafts in IETF/IRTF</i>	None at this stage
	<i>Participation in at least 3 ETSI and ISO/IEC working groups</i>	Collaboration with 2 ETSI groups: NFV and MEC
	<i>Contribution to at least 2 open source projects and initiatives</i>	Contribution to Open Source MANO (OSM), OpenNebula, OpenID and OpenWhisk
	<i>Active participation in at least 5 different 5G-PPP existing Working Groups</i>	Participation in 5G PPP's Steering and Technical Boards, Architecture WG, Software Networks WG, Vision WG, Security WG, SME WG, Trials WG, NetMgmt & QoS WG and contributing to the "COMMS Group"
	<i>Contribute to at least 2 position and white papers issued by the 5G-PPP</i>	Contribution to: <ul style="list-style-type: none"> • 5G PPP's European 5G Annual Journal 2018¹⁶; • 5G PPP Software Network WG White Paper "From Webscale to Telco, the Cloud Native Journey"¹⁷; • 5G PPP Vertical Cartography and Golden Nuggets; • 5G PPP Phase 2 Brochure
Objective 7: Promote the commercial exploitation of the results	<i>Commercial exploitation through participation and demonstration to at least 5 major European or International events</i>	Participation in 28 events, including: <ul style="list-style-type: none"> • EuCNC 2017 • NEM Summit 2017 • Mobile World Congress 2018 • IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB) 2018 • EuCNC 2018
	<i>Promote 5G-MEDIA offerings to at least 50 B2B customers of the consortium partners</i>	5G-MEDIA's Communication channels reach: <ul style="list-style-type: none"> • 2500+ unique visitors in the website • 480+ followers in Twitter • 290+ followers in LinkedIn

¹⁶ 5G PPP's European 5G Annual Journal 2018: <https://5g-ppp.eu/annual-journal/>

¹⁷ "From Webscale to Telco, the Cloud Native Journey" white paper produced within the 5G PPP Software Network WG: <https://5g-ppp.eu/wp-content/uploads/2018/07/5GPPP-Software-Network-WG-White-Paper-23052018-V5.pdf>

3. Deliverables and Milestones

Table 9 presents the list of deliverables submitted in this period.

Table 9 - Deliverable submitted in this period (ordered by WP, date)

Deliverable number	Deliverable Title	WP number	Lead beneficiary	Type	Dissemination Level	Due Date (in months)	Actual date of release
D1.1	Quality Plan	WP1	ENG	Report	Public	M6	January 11 th 2018
D1.2	Data Management Plan	WP1	OTE	ORDP: Open Research Data Pilot	Public	M6	Dec 6 th 2017
D1.3	Project Periodic Report (intermediate)	WP1	ENG	Report	Public	M13	August 21 st 2018
D2.1	APIs and Tools for Operation Support	WP2	ENG	Other	Public	M6	Dec 1 st 2017
D2.2	5G-MEDIA Requirements and Use Case Refinement	WP2	UCL	Report	Public	M11	April 30, 2018
D3.1	Initial design of the 5G- MEDIA Operations and Configuration Platform	WP3	SiLO	Report	Public	M9	March 2 nd , 2018
D7.1	5G-MEDIA Website	WP7	ENG	Website	Public	M2	August, 3 rd 2017
D7.2	Dissemination, Communication and community building plan	WP7	IINV	Report	Public	M6	Dec 6 th 2017
D7.3	5G-MEDIA Impact and Exploitation Plan	WP7	ENG	Report	Public	M9	March 8 th , 2018

Table 10 presents the Milestone achieved in this period.

Table 10 - Milestone achieved in this period

Milestone number	Milestone title	Lead beneficiary	Due Date (in months)	Actual date of release	Explanation
MS1	Project kick-off	ENG	M1	June 19 th - 20 th 2017	Kick-off meeting has been held in Rome on June 19 th – 20 th 2017
MS2	APIs and Tools baseline for Operation Support	SiLO	M3	August 31 st 2017	Setup of the software development tools, provisioning to the partners and release of the first draft of the deliverable D2.1 with the description of the available tools.
MS3	Initial 5G-MEDIA Architecture	SiLO	M5	October 31 st 2017	Draft Architecture is in place through a draft version of D2.2.
MS4	Initial coordination in place with 5G-related projects and initiatives	IINV	M6	November 30 th 2017	Wide participation in 5G PPP Ecosystem in place: Steering Board, Technology Board, Working Groups and Phase 2 projects.
MS5	Specification of 5G-MEDIA Catalogue and Network Apps	UPM	M9	February 28 th , 2018	Specification of the Catalogue has been presented agreed and presented in Istanbul meeting.
MS6	5G-MEDIA Programming Tools defined	NET	M9	February 28 th , 2018	Definition of the programming tools has been finalized has been presented in Istanbul meeting.

4. 5G-PPP events, meeting, phone call attended

Table 11 - 5G-PPP events, meetings and phone calls attended

Name and description of the 5G-PPP event/meeting	When	Where	Attendees (name and organization) and role
Steering Board phone calls	Periodic (every month)	Phone call	Pasquale Andriani (ENG)
Steering Board Meeting	12/06/2017	Oulu, Finland	Pasquale Andriani (ENG)

Name and description of the 5G-PPP event/meeting	When	Where	Attendees (name and organization) and role
Steering Board Meeting	20/09/2017	Brussels, Belgium	Francesco Nucci (ENG)
Steering Board Meeting	10/01/2018	Brussels, Belgium	Pasquale Andriani (ENG)
Steering Board Meeting	25/05/2018	Heidelberg (Germany)	Pasquale Andriani (ENG)
5G PPP Technology Board calls (including participation in TB Cartography calls (4/12/17, 22/2/18), planning for contributions to TB (TB plans, Verticals cartography, golden nuggets)), planning contributions to EuCNC joint paper,)	Periodic (every 2-3 weeks)	Phones calls	Stamatia Rizou (SILO)
5G PPP Technology Board Meeting	13 October 2017	Brussels, Belgium	Stamatia Rizou (SILO), Pasquale Andriani (ENG) (remotely)
5G PPP Architecture WG	Periodic (each 2 week)	Phones calls	Stamatia Rizou (SILO), Ugur Acar (NET)
5G PPP Software Networks WG	Biweekly	Conference call	David Griffin (UCL), David Breitgand (IBM)
5G PPP COMMS WG	27 November 2017	Conference call	Jose Gonzalez and Giulia Pastor (IINNV)
5G PPP Net Mgmt & QoS WG Monthly calls with project presentations. Contributed to the brochure presented at the EuCNC 2018	Periodic (every month)	Conference calls	George Agapiou (OTE)
5G PPP Trials WG Conference calls every three weeks with project presentations. Contributed with the KPIs for 5G-Media project	Periodic (every 3 weeks)	Conference calls	George Agapiou (OTE)
5G PPP Vision WG	20 October 2017	Conference call	Jacques Magen (IINNV)
5G PPP Security WG Meeting	11 October 2017	F2F Meeting, Turin (IT)	Gino Carrozzo (NXW)
5G PPP Security WG. Monthly telcos with project presentations, physical meeting in Turin in Oct 2017, planning contributions to Security whitepaper version 2.0, planning contributions to Security whitepaper version 2.0	13/Dec/2017 2/Feb/2018	Conference Calls	Gino Carrozzo (NXW)

Name and description of the 5G-PPP event/meeting	When	Where	Attendees (name and organization) and role
5G PPP SME WG phone call	Periodic	Phone calls	Nicola Ciulli (NXW), Jacques Magen and Giulia Pastor (IINV)

5. Public events attended

Table 12 - Public events attended

Name of the conference/workshop	When	Where	Attendees (name and organization)
EuCNC 2017	14/06/2017	Oulu, Finland	Pasquale Andriani (ENG)
Opportunities in 5G Media : Las Jornadas de la RAI: Retos y oportunidades de la tecnología 5G en la producción de contenidos audiovisuales	28/06/2017	Madrid, Spain	Adolfo Muñoz (RTVE)
IEEE 5G-Summit	11/07/2017	Thessaloniki, Greece	George Agapiou (OTE)
Bit Experience	4/10/2017	Madrid (Spain)	Pere Vila (RTVE)
ICT Proposers' Day	08-10/11/2017	Budapest (Hungary)	Jose Gonzalez (IINV)
INFOCOM World Conference 2017	25/10/2017	Athens (Greece)	Maria Belesioti (OTE)
EBU Cloud Intelligence Seminar	20-21/11/2017	Geneva (Switzerland)	Madeleine Keltch (IRT)
NEM Summit 2017	29/11/2017	Madrid (Spain)	Pasquale Andriani (ENG)/Federico Alvarez (UPM)
II Conference on Innovation and Digital Transformation	14/12/2017	Madrid (Spain)	Gabriel Solsona (RTVE)
FITCE	15/12/2017	Thessaloniki (Greece)	George Agapiou (OTE)
OSM Tutorial @OSM-MR#4 Rome	5/02/2018	Rome (Italy)	Pasquale Andriani, Francesco Iadanza (ENG)
Mobile World Congress 2018	26/02-01/03/2018	Barcelona (Spain)	Jose Gonzalez (IINV)
IEEE INFOCOM 2018	15-19/04/2018	Hawaii (USA)	Truong Khoa Phan (UCL)
NFV & Zero Touch World Congress	24-26/04/2018	San Jose, CA (USA)	Patrick Lopez (TID)

Name of the conference/workshop	When	Where	Attendees (name and organization)
SELFNET Industry Workshop	24/05/2018	Heidelberg (Germany)	Pasquale Andriani (ENG)
5G Forum	25-26/04/2018	Malaga (Spain)	Pere Vila (RTVE), Adolfo Muñoz (RTVE), Jose Manuel Menendez (UPM)
25 th NEM General Assembly	30/05/2018	Brussels (Belgium)	David Jimenez (UPM)
QoMeX 2018	29/05-01/06/2018	Sardinia (Italy)	Dimitrios Zarpalas (CERTH)
ACM SYSTOR 2018	4-6/06/2018	Haifa (Israel)	David Breitgand (IBM)
IEEE Broadband Multimedia Systems and Broadcasting (BMSB) 2018	08/06/2018	Valencia (Spain)	Alexandros Doumanoglou (CERTH), Madeleine Keltsch (IRT), Gino Carrozzo (NXW), Juan Pedro Lopez (UPM)
BMSB Workshop “Media delivery innovations using flexible network models in 5G”	08/06/2018	Valencia (Spain)	Alexandros Doumanoglou (CERTH), Madeleine Keltsch (IRT), Gino Carrozzo (NXW), Juan Pedro Lopez (UPM)
Industrial Dissemination Day at OTE Academy	22/06/2018	Athens (Greece)	Antonis Gkortzis (SILO)
EUCNC 2018	18-21/06/2018	Ljubljana (Slovenia)	Stamatia Rizou (SiLO), Pasquale Andriani (ENG), David Breitgand (IBM), Gino Carrozzo (NXW)
EuCNC 2018 Workshop 1 “Vertical Industries & Services for 5G”	18/06/2018	Ljubljana (Slovenia)	Pasquale Andriani (ENG)
EuCNC 2018 Workshop 2 “From cloud ready to cloud native transformation: What it means and Why it matters”	18/06/2018	Ljubljana (Slovenia)	David Breitgand (IBM)
EuCNC 2018 Workshop 3 “2nd Multi-provider, multi-vendor, multi-player orchestration: from distributed cloud to edge and fog environments in 5G”	18/06/2018	Ljubljana (Slovenia)	Stamatia Rizou (SiLO)

Name of the conference/workshop	When	Where	Attendees (name and organization)
EuCNC 2018 Workshop 6 “5th International Workshop on programmable networks: Demystifying software networks for Vertical Industries”	18/06/2018	Ljubljana (Slovenia)	Gino Carrozzo (NXW)

6. List of publications

All of the following publications are available through OpenAIRE¹⁸ and linked in the 5G-MEDIA website¹⁹.

Table 13 - List of technical publications

Title	Authors	Journal / Book / Conference	DOI	Repository Link
Quality of Experience for 3-D Immersive Media Streaming	Doumanoglou, Alexandros; Griffin, David; Serrano, Javier; Zioulis, Nikolaos; Phan, Truong Khoa; Jiménez, David; Zarpalas, Dimitrios; Alvarez, Federico; Rio, Miguel; Daras, Petros	Transactions on Broadcasting 64(2) 379 - 391	10.1109/TBC.2018.2823909	https://zenodo.org/record/1290724
Media industry meets 5G: the 5G-MEDIA project in 5G-PPP phase 2	Andriani, Pasquale; Nucci, Francesco Saverio; Pantelopoulos, Stelios; Rizou, Stamatia; Griffin, David; Alvarez, Federico; Jimenez, David; Daras, Petros; Zarpalas, Dimitris; Fernandez, Estanislao; Neudel, Ralf; Gonzalez, Josè; Fritzsich, Igor; Carrozzo, Gino; Tsirakis, Christos; Prieto, Óscar; Acar, Ugur; Breitgand, David	NEM Summit 2017, Madrid, Spain, 29-30 November 2017 (Session Opening Plenary Session of the NEM Summit 2017)	10.5281/zenodo.1147623	https://zenodo.org/record/1147624
Utility-centric Networking: Balancing Transit Costs with Quality of Experience	Truong Khoa Phan; David Griffin; Elisa Maini; Miguel Rio	IEEE/ACM Transactions on Networking, vol. 26, no. 1, pp. 245-258, Feb. 2018	10.1109/TNET.2017.2780257	https://zenodo.org/record/1237800

¹⁸ OpenAIRE 5G-MEDIA page: https://www.openaire.eu/search/project?lang=en&projectId=corda_h2020::0cf2e209d7ace632ffd5653ea738df73

¹⁹ 5G-MEDIA Publications: <http://www.5gmedia.eu/outcomes/publication/>

Title	Authors	Journal / Book / Conference	DOI	Repository Link
Subjective quality assessment of textured human full-body 3D-reconstructions	Zioulis, Nikolaos; Doumanoglou, Alexandros; Christakis, Emmanouil; Zarpalas, Dimitrios; Daras, Petros	International Conference on Quality of Multimedia Experience (QoMEX), Sardinia, Italy, 29 May - 01 June 2018 (Session OS5 – Video & 3D , Part 3)	10.5281/zenodo.1319964	https://zenodo.org/record/1319964
Remote production and mobile contribution over 5G networks: scenarios, requirements and approaches for broadcast quality media streaming	Keltsch, Madeleine; Prokesch, Sebastian; Oscar Prieto, Gordo; Serrano, Javier; Phan, Truong Khoa; Fritsch, Igor	IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), Valencia (Spain), 6-8 June 2018	10.29007/n4ll	https://zenodo.org/record/1299183
A service platform architecture enabling programmable edge-to-cloud virtualization for the 5G Media industry	Rizou, Stamatia; Athanasoulis, Panagiotis; Andriani, Pasquale; Iadanza, Francesco; Carrozzo, Gino; Breitgand, David; Weit, David; Griffin, David; Jimenez, David; Acar, Ugur; Gordo, Oscar Prieto	IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), Valencia (Spain), 6-8 June 2018	10.29007/bn68	https://zenodo.org/record/1299197
Virtual CDNs over 5G networks: scenarios and requirements for ultra-high definition media distribution	Carrozzo, Gino; Moscatelli, Francesca; Solsona, Gabriel; Gordo, Oscar Prieto; Keltsch, Madeleine; Schmalohr, Martin	IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), Valencia (Spain), 6-8 June 2018	10.29007/c5r4	https://zenodo.org/record/1299211
Utilitarian Placement of Composite Services	Phan, Truong Khoa; Rocha, Miguel; Griffin, David; Rio, Miguel	IEEE Transactions on Network and Service Management, vol. 15, no. 2, pp. 638-649, June 2018	10.1109/TNSM.2018.2798413	https://zenodo.org/record/1237802
A System Architecture for Live Immersive 3D-Media Transcoding over 5G Networks	Doumanoglou, Alexandros; Zioulis, Nikolaos; Griffin, David; Serrano, Javier; Phan, Truong Khoa; Jimenez, David; Zarpalas, Dimitrios; Alvarez, Federico; Rio, Miguel; Daras, Petros	IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), Valencia (Spain), 6-8 June 2018	10.29007/t9pb	https://zenodo.org/record/1304910
Virtualized Module for Distributed Quality Assessment Applied to Video Streaming in 5G Networks Environments	López, Juan Pedro; Jimenez, David; Rodrigo, Juan Antonio; Sanchez, Nuria; Menendez, Jose Manuel; Alvarez, Federico; Lalueza, José María	IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB), Valencia (Spain), 6-8 June 2018	10.29007/pntm	https://zenodo.org/record/1303988

Title	Authors	Journal / Book / Conference	DOI	Repository Link
DR-Cache: Distributed Resilient Caching with Latency Guarantees	Li, Jian; Phan, Truong Khoa; Chai, Wei Koong; Tuncer, Daphne; Pavlou, George; Griffin, David; Rio, Miguel	IEEE INFOCOM. (In press), Honolulu, HI, USA, 15 April 2018 - 19 April 2018	10.5281/zenodo.1237804	https://zenodo.org/record/1237804
Towards Serverless NFV for 5G Media Applications	Breitgand, David; Weit, Avi; Rizou, Stamatia; Griffin, David; Acar, Ugur; Carrozzo, Gino; Zioulis, Nikolaos; Andriani, Pasquale; Iadanza, Francesco	11th ACM International Systems and Storage Conference (SYSTOR), Haifa (Israel), 4-6 June 2018	10.1145/3211890.3211916	https://zenodo.org/record/1299116

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[5G-MEDIA_DOA] 5G-MEDIA Description of Action. Grant Agreement number: 761699

[5G-MEDIA_D1.1] 5G-MEDIA – D1.1 - Quality Plan. Available at:
http://www.5gmedia.eu/cms/wp-content/uploads/2018/01/5G-MEDIA-D1.1-Quality-Plan_v1.0.pdf

[5G-MEDIA_D2.1] 5G-MEDIA – D2.1 - APIs and Tools for Operation Support. Available at:
http://www.5gmedia.eu/cms/wp-content/uploads/2017/12/5G-MEDIA-D2.1-APIs-and-Tools-for-Operation-Support-_v1.0.pdf

[5G-MEDIA_D2.2] 5G-MEDIA – D2.2 - 5G-MEDIA Requirements and Use Case Refinement. Available at: <http://www.5gmedia.eu/cms/wp-content/uploads/2018/07/5G-MEDIA-D2.2-v1.0.pdf>

[5G-MEDIA_D3.1] 5G-MEDIA – D3.1 - Initial design of the 5G-MEDIA Operations and Configuration Platform. Available at: http://www.5gmedia.eu/cms/wp-content/uploads/2018/03/5G-MEDIA-D3.1-Initial-Design-of-the-5G-MEDIA-Operations-and-Configuration-Platform_v1.0.pdf

[5G-MEDIA_D7.3] 5G-MEDIA – D7.3 - 5G-MEDIA Impact and Exploitation Plan. Available at: http://www.5gmedia.eu/cms/wp-content/uploads/2018/03/5G-MEDIA-D7.3_5G-MEDIA-Impact-and-Exploitation-Plan_v1.0.pdf

[OpenWhisk] Apache OpenWhisk - <https://openwhisk.apache.org/>

[CogNet] CogNet project - <http://www.cognet.5g-ppp.eu/>

[SELFNET]Selfnet project - <https://selfnet-5g.eu/>

[SONATA] SONATA project - <http://www.sonata-nfv.eu/>

[OnLife] Telefonica OnLife Network - <https://inform.tmforum.org/news/2017/05/telefonica-gets-hands-dirty-new-platform-architecture/>

[OSM]ETSI Open Source MANO - <https://osm.etsi.org/>