Small cEllS coordinAtion for Multi-tenancy and Edge services

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Plans for Dissemination, Communication, Standardization and Exploitation, Interaction with 5G-PPP

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Abstract

This deliverable provides the strategies for communication, dissemination, standardization, exploitation and collaboration with 5G-PPP, which are envisaged by the SESAME Consortium, in the context of the corresponding Grant Agreement No.671596. In this framework, the present document provides detailed plans for the above mentioned activities, in order to generally define the strategies undertaken by the consortium such as to cover the whole project's duration and to achieve, to the extent possible, all related project aims and/or explicit targets. Specific actions -already identified- have also been presented, further focusing on the first year of SESAME project and which are envisaged at M06 of the SESAME evolution. Considering the time scale of the SESAME activities and the availability of tangible results, this document will provide valuable contents to refine the identified strategies as the project further progresses. In this way, strategies and actions can be timely updated following the broader evolution of SESAME, also reflecting the feedback received from the relevant stakeholders.

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Glossary

Acronym	Explanation
3GPP	3rd Generation Partnership Project 3rd Generation Partnership Project
4G	4th Generation (of mobile communications)4th Generation (of mobile communications)
5G	5th Generation (of mobile communications)5th Generation (of mobile communications)
5GMF	5G Mobile Communications Promotion Forum
5G-PPP	5th Generation-Public Private Partnership5th Generation-Public Private Partnership
AI	Artificial Intelligence
APC	Article Processing Charges
API	Application Programming Interface
ARM	Acorn RISC Machine
BBF	Broadband Forum
BGP	Border Gateway Protocol
BS	Base Station
BSS	Business Support System
CA	Consortium Agreement
CAPEX	Capital Expenditure
CC	Cloud Computing
CDMI	Cloud Data Management Interface
CDN	Content Delivery Network
CESC	Cloud-Enabled Small Cell
CESCM	Cloud-Enabled Small Cell Manager
CMOS	Complementary Metal Oxide Semiconductor
COIT	Official College of Telecommunications Engineers
CPE	Customer Premises Equipment
CPU	Central Processing Unit
C-RAN	Cloud Radio Access Network
CSA	Coordination and Support Action
D2D	Device-to-Device
DAS	Distributed Antenna System
DC	Data Centre
DMIPS	Drhystone MIPS
DMTF	Distributed Management Task Force
DNS	Domain Name System
DoW	Description of Work
DP	Data Plane
DPDK	DataPlane Development Kit
DPI	Deep Packet Inspection
DSML	Directory Services Mark-up Language
DWDM	Dense Wavelength Division Multiplexing
EC	European Commission
ECC	Electronic Communications Committee
EIT	European Institute of Innovation
EMEA	Europe, Middle-East and Africa
EMS	Element Management System
eNB	E-UTRAN NodeB
EPC	Evolved Packet Core

EPO	European Patent Office
ETP	Executive Training Program
ETS NFV	European Telecommunication Standards Institute Network Functions Virtualization
ETSI	European Telecommunication Standards Institute
ETSI MEC	European Telecommunication Standards Institute Mobile Edge Computing
EU	European Union
EUCNC	European Conference on Networks and Communications
E-UTRAN	Evolved UTRAN
FD-SOI	Fully Depleted Silicon-on-Insulator
FI	Future Internet
FE	Forwarding Element
FP	Framework Programme
FP7	7th Framework Programme
FPGA	Field Programmable Gate Array
FSO	Free-Space Optics
GA	General Assembly
GA	Grant Agreement
GPU	General Processor Unit
GS	Group Specification
GSM	Global System for Mobile Communications
GSMA	GSM Association
H2020	Horizon 2020
HD	High Definition
HetNet	Heterogeneous Network
HTTP	Hypertext Transfer Protocol
HW	Hardware
IaaS	Infrastructure as a Service
IC	Innovation Centre
ICN	Information Centric Networking
ICT	Information and Communication technology
IEEE	Institute of Electrical and Electronic Engineers
IETF/RTF	Internet Engineering Task Force/Research Task Force
IMS	IP Multimedia Subsystem
IO	Input/Output
IoT	Internet of Things
IP	Internet Protocol
IPv6	Internet protocol version 6
IPR	Intellectual Property Rights
ISG	Industry Specification Group
ISP	Internet Service Provider
IT	Information Technology
ITU	International Telecommunication Union
ITU-R	International Telecommunication Union - Radiocommunication Sector
ITU-T	International Telecommunication Union - Standardization Sector
JCR	Journal Citation Report
JVM	Java Virtual Machine
KPI	Key Performance Indicator
KTP	Knowledge Transfer Partnership
KVM	Kernel-based Virtual Machine
LightDC	Light Data Centre
LSA	Light Spot Aircraft
LTE	Long Term Evolution
LXC	Linux Container
M2M	Machine-to-Machine

MANO	Management & Orchestration
MCTC	Multimedia Communications Technical Committee
MEC	Mobile Edge Computing
MDC	Mobile Distributed Caching
MIPS	Microprocessor without Interlocked Pipeline Stages
MNO	Mobile Network Operator
MOCN	Multiple Operator Core Network
MORAN	Multiple Operator Radio Access Network
MoU	Memorandum of Understanding
NAT	Network Access Translation
NFV	Network Functions Virtualisation
NFVRG	Network Functions Virtualisation Research Group
NFVI	Network Functions Virtualisation Infrastructure
NGA	Next Generation Access
NGIN	Next Generation Intelligent Network
NGMN	Next Generation Mobile Network
NM	Network Management
NMS	Network Management System
NPU	Network Processing Unit
NSP	Network Service Platform
NSP	Network Service Provider
OA	Open Access
OAM	Operations, Administration and Management
OCCI	Open Cloud Computing Interface
ODL	OpenDayLight
ODP	Open DataPlane
OFP	Open Fast Path
OFDM	Orthogonal Frequency Division Multiplexing
OGF	Open Grid Forum
OMi	Open Models Laboratory
ONF	Open Network Foundation
ONOS	Open Network Operating System
OPEX	Operational Expenditure
OPNFV	Open Network Function Virtualisation
OS	Operating System
OSGi	Open Service Gateway Initiative
OSS	Operational Support System
OVF	Open Virtualisation Format
OVS	Open vSwitch
OVDSB	Open vSwitch DataBase Protocol
PB	Project Board
PC	Personal Computer
PLS	Physical Layer Security
PM	Project Manager
PoC	Proof of Concept
PON	Passive Optical Network
PPP	Public Private Partnership
PT	Project Team
QEMU	Quick Emulator
QoE	Quality of Experience
QoS	Quality of Service
R/D/I	Research/Development/Innovation
RAN	Radio Access Network
RAT	Radio Access Technology

REST	Representational State Transfer
RF	Radio-Frequency
ROAR	Registry of Open Access Repositories
RPH	Radio and Physical Layer Working Group
RRH	Remote Radio head
RTC	Real-Time Clock
RTD	Research & Technical Development
SA	System Architecture
SC	Small Cell
SCF	Small Cell Forum
SDK	Software Development Kit
SDN	Software Defined Network
SDO	Standards Development Organisation
SG	Study Group
SME	Small & Medium Enterprise
SOC, SoC	System on Chip
SPV	Special Purpose Vehicle
SW	Software
TCP	Transport Control Protocol
TL	Technical Leader
TR	Technical Report
TST	Technical Steering Team
UE	User Equipment
UTRAN	Universal Terrestrial Radio Access Network
VE	Virtualization Extension
vDPI	Virtual DPI
VIM	Virtualised Infrastructure Manager
VM	Virtual Machine
VNF	Virtual Network Function
VNFaaS	Virtual Network Function as a Service
VNFFG	Virtual Network Functions Forwarding Graph
VNFM	Virtual Network Functions Manager
VNPaaS	Virtual Network Platform as a Service
VoIP	Voice over IP
VT	Virtualization Technology
WG	Working Group
WP	Work Package
WPL	Work Package Leader
WRC	World Radiocommunication Conference
XCP	Universal Measurement and Calibration Protocol

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1. Introduction

This deliverable provides detailed communication and dissemination strategies, the roadmap for standardization, exploitation and the interaction with other 5G-PPP European projects to promote a unified view of the 5G technology development. Regarding these activities, *in this document*, we provide the strategies envisioned by the SESAME Consortium to cover the whole project duration, as explicitly described within the respective *Grant Agreement (GA) No.671596*. This is in line with SESAME's specific ***Objective#9:*** *Communication/dissemination of project results raising awareness and impact on stakeholders and the wider community, as well as assessment of received feedback - Creation and exploitation of synergies with the rest 5G-PPP projects and the Association towards building a consistent 5G view* [1].

SESAME [2] is one of the nineteen 5G-PPP projects funded by the European Commission (EC) and has the ambitious goal to generate new concepts which shall become an "integral part of the roadway leading to the design and implementation of 5G technology". Consequently, the SESAME Consortium will set in place the necessary actions to provide information on SESAME generally, and on its expected results. The consortium will also set in place the necessary actions and will develop the methodology to promote SESAME concepts and visions, as well as to disseminate SESAME-*based* results to an audience "as wide as possible". The audiences that are targeted by the SESAME project are both technical and non-technical and include industries, standard bodies, research and academic institutions, open source initiatives, as well as the general public. The SESAME Consortium will develop adequate communication and dissemination strategies in order to "raise general awareness around SESAME and consensus about the technology developed", and will make sure to "maximise the impact of the scientific outcomes generated by the project".

As explicitly clarified by this document, the SESAME Consortium has developed appropriate strategy for standardization in order to contribute and "bring the project to the attention of different standard bodies and industry forums which are currently involved in the development of different aspects of the 5G technology". SESAME will achieve this ambitious objective whereby its partners, who are highly committed in different international arena(s). In the same way, SESAME will also make sure to maximise its contribution to the development of 5G participating and contributing to relevant open source initiatives on Software-Defined Network (SDN) and Network Functions Virtualization (NFV).

SESAME has also developed a detailed set of actions which target to exploit the results and the innovative concepts developed -or are to be developed- within the project. In this regard, all the partners of SESAME Consortium have provided suitable exploitation plans, which are provided later in this document. This is aligned with ***Objective#8:*** *Conduct of Market Analysis, Road-mapping, as well as establishment of new Business Models - Detailed Techno-economic Analysis towards exploitation and commercialisation by industrial partners, is also a priority*. The SESAME Consortium has also identified strategies and actions for the project to cooperate with other H2020 5G projects, as well as with the 5G-PPP Coordination and Support Action (CSA) Working Groups. The strategies envisaged by the consortium are provided by this document.

As a general remark, the planned actions provided hereinafter may be subject to modifications as the project evolves since the above mentioned activities will be continuously monitored and updated, and further refinements will be presented in the next deliverables of the corresponding WP8.

In particular, updated activities and actions will be made available in subsequent deliverables, D8.2 and D8.3, *respectively*.

The structure of the deliverable is as provided in the following:

- Section 2 provides detailed communication and dissemination plans covering the whole project duration with specific focus on the first year (Y1) of the project.

- Section 3 provides detailed strategy identified by the consortium for tracking and contributing to standard bodies, industry forums and open sources initiatives.

- Section 4 will detail the exploitation plans envisioned by all partners of the project.

- Section 5 will instead detail the strategy identified by SESAME to contribute to and be an integral part of the 5G-PPP work programme.

- Finally, Section 6 provides general conclusions of this deliverable.

2. Communication and Dissemination

This section, part of the outcomes of Task 8.1, describes the dissemination and communication strategy and planned actions envisaged by the SESAME Consortium. This includes the processes of communicating, raising awareness, promoting and disseminating project results and achievements, as well as the necessary instruments to fulfil them. Task 8.1, *"Dissemination and Communication"*, runs for the whole duration of the SESAME project (i.e.: M01-M30). Thus, it is responsible for disseminating and creating awareness of SESAME vision, concepts, objectives, innovations and results to different targeted audiences, including the scientific community and relevant stakeholders to which the project will represent an added value. National, European, and global reach are all considered. Task 8.1 takes care of disseminating and communicating the project's scientific evolution and advances, value propositions, tangible results and or prototype definition, including benefits for target audiences to foster possible uptake, potential exploitation and sustainability of project developments.

To this end, this section lays out the general guidelines for communication and dissemination which have been identified by SESAME partners and shall be used for the project's full lifecycle. Specific attention is dedicated on planned activities for the first year both for dissemination and communication as envisaged at M06 of the project. Clearly, as the project evolves and concrete project outcomes are made available, the plan presented in this section will be updated accordingly. In this way, the communication and dissemination plan will adapt to the project evolution to timely meet any opportunity to leverage SESAME results, as well as to exploit any opportunity opened up by the ecosystem of H2020 projects, as a whole.

2.1 Objectives and Methodology

Dissemination and communication are two primary activities that all partners of the SESAME Consortium will carry on, during the project's lifetime. Given the experience of the SESAME partners, specific actions in terms of dissemination and communication shall keep up with the pace of the project's evolution. In general, they will follow the roadmap identified by the EC in order to unveil 5G technology by 2020. Time-wise this implies to maximise the visibility of SESAME value propositions during *Phase I* of the H2020 5G projects.

In this context, dissemination is the collection of all the actions that SESAME partners will set in place during the project's lifetime to disseminate, foster and circulate project-*based* concepts, and to stimulate the proper uptake of project's scientific and prototype results by the relevant stakeholders. Targets of these actions include the related scientific community, industry stakeholders, standards bodies, international forums, and other projects and/or arena in which 5G technology is being developed. The constant feedback received by the targeted communities will be an important additional input that will help to properly steer the design, development and evaluation of SESAME-*based* results.

Communication will also play a very important role in SESAME, dealing with all the actions which are necessary to raise awareness of project's existence, its main objectives, partners involved, general and specific contributions made toward the conceptual definition and design of the 5G technology. For all these reasons, project's partners will choose the most appropriate tools and channels able to provide tailored information to multiple target audiences, ranging from the Research & Technical Development (RTD) community to the general public and/or media. For an effective communication, it is crucial to select not only the audience to whom a specific message is delivered but also the timing for delivering the message and whereby the most appropriate means and tools. Therefore, different channels will be identified and the information carried over these channels will be constantly monitored and updated.

Overall, dissemination and communication activities of the SESAME project will be conducted according to the following specific objectives:

- To raise awareness of the project toward the relevant stakeholders;
- To foster inter-communication with other projects;
- To disseminate project innovations to the public;
- To disseminate project outcomes to the scientific community;

- To disseminate and raise awareness of the project to Standards Organization and industries.

Detailed strategies and actions pertaining to dissemination and communication activities are reported hereinafter. Dissemination and communication actions shall take into account of individual partner's planned activities which were provided in SESAME's Description of Work (DoW) and reported in the appendix at the end of this document.

2.2 Monitoring of planned dissemination and communication activities

The planned activities for dissemination and communication will be constantly monitored by the SESAME partners, in order to evaluate the success of the strategies, as well as to be able to take any corrective action, on time. Therefore, measurable Key Performance Indicators (KPIs) have been defined for each action undertaken by the Consortium which will be monitored during the project's lifetime. Furthermore, KPIs have been defined also for evaluating the impact and visibility of the project. A specific team will be appointed to monitor the achievements of such measurable performance indicators. In general, the KPIs that have been identified so far are the following (for a more detailed description, refer to Table 1 and Table 4):

- KPIs related to dissemination actions: Number of conference and journal papers submitted and most importantly accepted; number of whitepapers; number of workshops organized in international events, EU contexts, etc.; number of events organized by the EC (e.g. EuCNC) to which SESAME partners will attend and number of booths provided; number of keynote speeches or talks provided in international events; number of summer schools organized, including the number and the nationality of attendees.
- KPIs related to communication actions: Number of leaflets, posters and brochures produced; number of newsletters; number of press releases; number of interviews
- Impact and visibility:
    - Consultation and access to the project website.
    - Presence in social media: This can be achieved by measuring the number of posts and followers.
    - Number of references to SESAME project: This can be achieved by using search engines and analysing existing databases to identify the hits of keywords related to SESAME.
    - Number of citations: Besides search engines, an analysis will be conducted based on the information made available in different databases (e.g., IEEE Xplore1 Digital Library) particularly in relation to conference and journal publications.

2.3 Update of the plan

As mentioned before, SESAME partners have already identified a number of planned actions for dissemination and communication. Furthermore, measurable KPIs have been identified in the previous section in order to allow effective monitoring of project-*based* achievements during the SESAME's lifetime. Upon identification and definition of the related KPIs, for each distinct action several minimum values will be defined, which can be considered as satisfactory (based also on past experience of the SESAME partners). KPIs' monitoring will further be crucial to promote corrective actions, whenever required.

The Project Board (PB) is in charge of aggregating the feedback coming from the monitoring of the planned activities. Afterward, concrete corrective actions will be undertaken, if or when needed. This will include, *inter-alia*, enriching the dissemination and communication activities with new actions or promote higher efforts in the activities which can maximise the visibility of SESAME project and the impact of the SESAME value chain. In the process of keeping the plans for dissemination and communications activities up-to-date, the communication flow is both "bottom-up" (i.e.: from the PB to WP leaders and individual partners) and "top-down" (from individual partners to WP leaders up to the PB). Therefore, the PB upon

[1] http://ieeexplore.ieee.org

selecting specific targets for both dissemination and communication will appropriately inform the Work Package Leaders (WPLs) of the most relevant WP(s) of these target activities. Afterward, WP participants which can best take the lead specific actions, will be identified. On the other way round, partners can bring to the attention of the WPLs and the other WP participants of specific dissemination targets and communication opportunities. Specific actions will then be undertaken in agreement with the PB. In both cases a continuous flow of inputs and updates is expected.

2.4 Identified stakeholders

Different stakeholders have been identified as they constitute the target audiences which shall benefit from the advances brought to the field of mobile communications by the SESAME project as a whole and who shall be able to exploit the outcomes of SESAME. Broadly speaking, the categories addressed by SESAME partners are the following:

- Large and small mobile network operators.
- Small cell equipment manufacturers and vendors.
- Additional software networks related stakeholders in value chain, including system integrators, virtualisation platform providers, etc.
- Standardization groups.
- Industries, including large enterprises and SMEs such as equipment and core/service VNF vendors.
- Academia, including research centres and universities.
- General public.

More specific stakeholders will be identified from the actors involved in the SESAME use cases [3].

2.5 SESAME plan for communication

The SESAME project has developed specific actions which compose the communication strategy of the corresponding Consortium. The aim of any communication action is to promote the project to an audience as wide as possible, between specialized and more general audiences in order to reach technical and less technical profiles. In all cases, adapting the message depends on the target audience, and the core of communication activities is to promote SESAME concepts, activities, project innovations and concrete outcomes. All in all, the final objective of the communication strategy is to foster awareness of SESAME through the project value chains.

Planned communication activities that will be undertaken by the SESAME Consortium during the project's full lifecycle are shown concisely in **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**. Specific activities for communication are detailed hereinafter.

Type of activity	Target audience	Description	Partners involved
Project awareness and Scientific Knowledge Transfer	Wider scientific and ICT related research and development community and industries.	Participation or organization of scientific events, conferences and workshops as well as participation to industry interest groups, venues, associations and standards bodies events.	ALL

Type of activity	Target audience	Description	Partners involved
Marketing Material	Managers and researchers in the ICT and related industries.	Brochures, Leaflets, Posters, Press Releases, Videos.	OTE, CNET, and selected partners leading specific actions; ALL to provide support material
Project Website	Wider public, but also the research and development community. Publication pages for the scientific and industrial research communities.	To foster project activities, events and results to attract and raise awareness of SESAME among specialized users and the general public.	CNET, OTE for maintenance and update; ALL to provide support material
Social Media	ICT community	Twitter, LinkedIn, etc. Where to continuously release project related news (i.e. findings and updates) during the project's lifecycle.	ALL

Table 1: Summary of communication activities planned by SESAME partners during the project lifecycle

Type of activity	Description
Project awareness and Scientific Knowledge Transfer	Presence of the project in at least **4** major events (EUCNC, GLOBECOM, MWC, etc.) Organization of at least **2** workshops during the project, to be planned by month 12
Marketing Material	Preparation and distribution of **4** different brochures during the project lifecycle Publish at least **5** posters during the project lifecycle Publish at least **4** press releases during the project lifecycle Publish at least **3** videos during the project lifecycle
Project Website	Number of visits and any other relevant statistics
Social Media	**1** account on LinkedIn **1** account on Twitter

Table 2: Measurable KPIs for communication activities during the project lifecycle

2.5.1 Planned Strategy for Communication activities

As mentioned before, communication activities refer to all the necessary actions that SESAME partners will set in place during the period of the respective grant to raise awareness of project existence and uptakes, project objectives, participants and results achieved by individual partners and/or by work packages during the lifecycle of SESAME, which is the period of 30 calendar months starting with the Kick-Off on the 1st of July 2015 until project's completion by the 31st of December 2017. The key proposition of all communication activities is to coordinate and address the above mentioned actions to various audiences, in a timely manner, keeping up with the project evolution and adapting the message in order to maximise the impact of the SESAME-*based* results within scientific and stakeholders communities

(including industry and standards bodies), and the visibility of SESAME to other related H2020 projects, within the EC, international forums and the general public.

The planned activities for communication pass through a number of identified actions which are detailed in the following subsections.

2.5.2 SESAME Project logo

At the beginning of the project, the logo was redesigned starting from that used during the project's preparation and submission for assessment -and finally for approval- by the EC. Several attempts were made and each partner could propose different options for the respective logo. Finally, the project partners voted to select the new SESAME logo out of a limited number of remaining options. The current logo was voted by all the partners expressing their opinion. Accordingly to the style of the new project logo that has been selected by the project partners, SESAME website, presentation slides and deliverable templates were re-designed, as well as the templates for leaflets and posters. SESAME project logo is shown in Figure 1, below.

Figure 1: SESAME project logo

2.5.3 Project website

SESAME's website (http://www.sesame-h2020-5g-ppp.eu/) was created at the beginning of the project by the project coordinator OTE (Figure 2). The project website will be constantly updated with latest news and project events and information. The project website is the first and probably the most important mean which the SESAME Consortium can use to bring SESAME to the attention of the general public, as well as to different specialized audiences. Indeed, SESAME website shall be organized in a way that general consortium information and contents are easy to retrieve and presented in an easy to understand, meaningful language which should stimulate visitors to spend time on the SESAME website and return for future contents.

Figure 2: SESAME project website

- Action leader: OTE/CNET (set-up, maintenance, update)
- Action participants: ALL (content provision)
- Action timing: M1 (set-up), M2-M30 (exploitation and update).

2.5.4 Leaflets, posters and brochures

Typical channels which will be used by the SESAME Consortium consist in the production of leaflet, poster materials and brochures. These means are used to communicate to different audiences, while selecting the most appropriate depending on the specific occasion. Leaflets and posters shall be used to raise general awareness around the key values, propositions and results achieved by SESAME. Leaflets, posters and brochures are therefore meant to be distributed during conference events such as the European

EUCNC and during any other European and/or international venue which is relevant to SESAME, as well as with the purpose to promote SESAME organized and sponsored events.

Leaflets and Posters

- Action leader: i2CAT
- Action participants: OTE, ORION, UPC, ATOS, UNIS, ATN, INC
- Action timing: First leaflet and posters available by Month 12 (subsequent leaflets and posters to be released in coincidence of selected events until 2017).

Brochures

- Action leader: CNET to start the general structure
- Action participants: OTE, IPA, STM, ITL
- Action timing: First brochure available by Month 06 (further brochures will be released during 2016/2017).

2.5.5 Newsletter

Newsletters shall be used to raise awareness about project news and updates both internally to the project partners, and moreover to external audiences.

A tentative structure of the newsletter is reported hereinafter, with the content that will be adapted to "reflect" the evolution of the project during the whole period of the grant. Essentially, the newsletter will include: Short presentation of progresses and achievements in each work package; summary of past project meetings; planning of the next meeting with dates, location, and preliminary information if available; news from partners; short survey on technological developments and advances; brief report of past and upcoming events; report on demonstrations if any. For external audiences, a brief description of SESAME's main features and objectives will also be included.

Newsletters

- Action leader: NCSRD
- Action participants: VOSYS, ZHAW, EHU, UoB, FLE
- Action timing: First Newsletter to be released by Month 12.

2.5.6 Presence in social media

The SESAME Consortium aims to maximise the visibility of the project, concepts, vision and activities exploiting all the channels which are available nowadays and therefore including Web platforms such as LinkedIn, Twitter, etc. This has the effect of opening up the project to even a wider audience, raising awareness, consensus and generating opinions around the project, as well as that of promoting transparency on project activities. CNET, which leads dissemination and communication activities inside SESAME, and NCSRD, opened two accounts one LinkedIn (https://www.linkedin.com/groups/8399017/profile) and one on Twitter (https://twitter.com/sesame_h2020). CNET and NCSRD will take care of maintaining updated both accounts, and together with all other partners SESAME related news, information and topic discussions will be started and made available so as to reach specialized technical audiences and the general public.

LinkedIn account

- Action leader: CNET (set-up, maintenance, update)
- Action participants: ALL (content provision)
- Action timing: M1 (set-up), M2-M30 (exploitation and update)

Twitter account

- Action leader: NCSRD/CNET (set-up, maintenance, update)
- Action participants: ALL (content provision)
- Action timing: M1 (set-up), M2-M30 (exploitation and update)

2.5.7 Video, interviews on media and Press releases

Actions will be targeted to provide interviews on media (e.g. newspapers, online media and magazines) to widespread the vision and objectives, outcomes and benefits to diverse stakeholders. At this stage, no specific action is planned as it is felt that this component of the communication plan will be better exploited at a more advance stage of development.

- Action leader: OTE
- Action participants: ALL
- Action timing: Periodically released

2.5.8 Communication plan for year one

This section aims to detail the plan for communication undertaken during the first year of SESAME by the consortium. The terminology "Multiple target audiences" includes *Industrial parties, End users, Academics and researchers and General public*, unless differently specified.

Type of activity	Target audience	Description	Partners involved
Project Logo (graphics)	Functional to communicate/disseminate SESAME within multiple target audiences	Design of the SESAME logo which will be used during the whole project duration ensuring immediate identification and uniqueness of the SESAME consortium in all events and through all communication and dissemination channels	ALL
Project website	General public, Academics and Researchers, Industrial parties and SESAME partners	Create the unique SESAME web portal through which communicate facts relevant for the project, news, upcoming events and disseminate publications in general	CNET, OTE for maintenance and update; ALL to provide support material
Newsletters	Multiple target audiences	Release **1** newsletter	ALL

Type of activity	Target audience	Description	Partners involved
Leaflets and posters	Multiple target audiences	Create **1** SESAME leaflet and **1** poster to be distributed in at least **1** international event related to SESAME	i2CAT for coordination; action participants: OTE, ORION, UPC, ATOS, UNIS, ATN, INC
Presence in social media	Multiple target audiences	Start at least **1** account in LinkedIn and **1** account in Twitter	CNET, NCSRD; ALL for participation
Videos	Multiple target audiences	At least **1** video during the first year	OTE for coordination; content from ALL
Interviews, press releases and social media coverage in general	Multiple target audiences	At least **1** interview; At least **1** press release	OTE, NCSRD, CNET
Brochures	Multiple target audiences	At least **1** during the first year of the project	CNET to start the general structure; action participants: OTE, IPA, STM, ITL

Table 3: Summary of communication activities planned by SESAME partners during year one

2.6 SESAME plan for dissemination

The SESAME project has developed specific actions which compose the dissemination strategy of the consortium. Planned dissemination activities which will be undertaken by the SESAME Consortium during the project's lifecycle are shown concisely in **Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε.**. Specific activities for dissemination are detailed hereinafter.

Type of activity	Target audience	Description	Partners involved
Scientific articles	Academic and industrial research community	Conferences, Open Access Journals and Peer Reviewed Publications	ALL
Whitepapers	Industrial decision makers and RTD engineers	Technical documents detailing SESAME features, advances and achievements released at different stages of the project	ALL
Project showcases	RTD community, wider ICT and Communications Technology interested public	Demonstrations, and Project Booth of SESAME system components	Mainly WP7 with the participation of ALL partners
Events Organization	Graduate level engineers and researchers	Seminars, tutorials and participation of SESAME partners to summer schools	ALL

Type of activity	Target audience	Description	Partners involved
Collaboration with other projects	European ICT research community	Working groups within the 5G-PPP as well as direct liaisons with related projects	Individual liaison-contacts to be decided
Software Code Release	Developers and research community	Release mature software to the related communities	To be decided at a later stage of the project

Table 4: Summary of dissemination activities planned by SESAME partners during the project lifecycle

Type of activity	Description
Journal Articles	Release at least **4** open-access journals and other journal publications compliant with green open-access policy[2]
Conference Papers	**20** conference publications (of which at least 60% are joint-authored papers between SESAME partners)
Whitepapers	Release at least **3** whitepapers during the project's lifecycle; Measurable: Number of channels where to disseminate the whitepapers
Special Issue	Promotion of at least one special issue; Measurable: Number of submitted papers, number of accepted papers, impact factor of the journal where the special issue appears
Project showcases	At least **2** innovation booths at exhibitions and fairs relevant to the community of stakeholders; Measurable: Number of visits from stakeholders, targeting at least 100
Demonstration Stands	At least **2** demonstration stands at international events Measurable: Number of visits from stakeholders, targeting at least 100; Number of attendees at the hosting events
Summer Schools	Organize at least **1** summer school with lectures on key SESAME topics Measurable: Number of students, attendees participating
Seminars	Organize at least **1** seminar per year at international events or forums Measurable: Number of participants including students attending the seminars
Tutorials	Provide at least **2** tutorials at international events or summer schools presenting project achievements Measurable: Number of attendees, including students
Collaboration with other H2020 5G projects	Working groups within the 5G-PPP as well as direct liaisons with related projects. The project shall target to participate in most of the working groups related to SESAME and a minimum of **4** Measurable: Number of working groups attended by SESAME partners

[2] "Guidelines on Open Access to Scientific Publications and Research Data in Horizon 2020", European Commission, Directorate-General for Research & Innovation, 30 Oct. 2015.

Type of activity	Description
Software Code Release	**4** contributions to open source project activities (OpenDayLight, OPNFV, ONOS, etc.) Link the project website to at least **1** community-based software code sharing platform (e.g. GitHub[3])

Table 5: Measurable KPIs on dissemination activities during the project lifecycle

2.6.1 Dissemination activities

SESAME has developed a detailed plan for dissemination and "how this will be implemented". The plan is in line with the objectives set out in the description of work. To achieve the targeted results, a wide range of dissemination means and channels, targeting particular audiences (as outlined in the table above) will be pursued.

One part of the strategy pursued by the consortium consists in having a clear understanding and focus on the different audiences which are targeted by the different dissemination activities.

Besides dissemination to the scientific community, SESAME has planned a wide range of activities, and foresees a number of different dissemination channels, which target more to reach the wider RTD and innovation community, as well as industry. This should prepare the wider understanding and the ground for adoption of the SESAME results.

The planned dissemination activities include:

- The project website will act as an information and service portal, disseminating project-*based* results and providing access to whitepapers, scientific publications, demonstration information, and material explaining SESAME innovations.
- Organising tutorials both, within the consortium member organisations, with the aim of educating a wider range of engineers and decision-makers on the technology outcomes of the project, as well as providing public tutorials, on specific topics, or on the whole of the SESAME concepts at conferences.
- Publication of scientific results to the wider scientific and industrial communities, high profile conferences and journals.
- Participation in program committees and editorial boards: This is important for team members who can, play a role in setting the agenda (e.g. defining special conference sessions), and defining key areas of interest for the research community.
- Collaboration with other related projects, both within and outside the 5G-PPP associations remit. Participation n 5G-PPP Working Groups (WGs).
- Demonstration of project concepts and findings during events like EUCNC or other relevant conferences.

Organisation of a summer school either as standalone or together with other EU-funded projects, in topics relevant to SESAME focus, e.g. access virtualisation, etc. Publication of white papers, book chapters or editorship of books on topics related to SESAME research.

2.6.2 Scientific Publications

This section aims to detail the strategy of SESAME project to prepare scientific publications either in the form of journal or conference papers. There is no specific partner appointed to lead this activity since any partner, and in particular academics, can take the lead. The general idea is that with sufficient advance notification and by means of frequent interactions between the partners through phone conferences, physical meetings and project-wide repositories, SESAME will manage to generate scientific publications which are co-authored by multiple partners. The dissemination plan for scientific publications will meet both top-down and bottom-up perspectives, taking into account expertise, interests and ambitions of

[3] For more details about GitHub see, for example: *https://en.wikipedia.org/wiki/GitHub*

individual partners, as well as properly selecting targets for disseminating scientific content related to the project in venues which are the most appropriate. As the project evolves and the activities undertaken by the communities related to SESAME contribute to the rise of importance of specific journals and conferences, the dissemination plan for SESAME will be correspondingly updated.

- Action leader: ALL partners can take the leadership in preparing journal papers
- Action participants: ALL partners can contribute to publications in order to generate papers jointly authored by SESAME partners and published in reputed international journals
- Action timing: M01-M30

Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε. below shows the list of journals relevant to ESAME with the corresponding JCR (Journal Citation Report - Impact Factor) up-to-date at the time of delivering this report. This list will be revised periodically, updating if necessary the targeted journals and their impact factors (in decreasing order). The information conveyed by the table is made available to the partners to facilitate the planning of future actions. Furthermore, the information conveyed by this table will be periodically revisited to maintain it updated.

Journal Name	Impact Factor
IEEE Wireless Communications	**5.417**
IEEE Communications Magazine	**4.007**
Communications of the ACM	**3.621**
IEEE Journal Selected Areas in Communications	**3.453**
Future Generation Computer Systems (Elsevier)	**2.786**
IEEE Transactions on Mobile Computing	**2.543**
IEEE Network	**2.54**
IEEE Transactions on Wireless Communications	**2.496**
IEEE/ACM Transactions on Networking	**1.811**
Computer Communications (Elsevier)	**1.695**
IEEE Communication Letters	**1.268**
Computer Networks (Elsevier)	**1.256**
Mobile Networks and Applications, MONET (Springer)	**1.045**
Wireless Networks (Springer)	**0.961**
IET Communications	**0.742**
IEEE Transactions on Network management	**NA**
IEEE Transactions on Cloud Computing	**NA**
IEEE Wireless Communication Letters	**NA**

Table 6: Journals targeted by SESAME

Σφάλμα! Το αρχείο προέλευσης της αναφοράς δεν βρέθηκε. shows the international conferences argeted by the SESAME Consortium during the entire duration of the project. The dates of the conferences are updated to 2015 and 2016, according to the information made available by each conference organization with sufficient advance notice. The list of conferences shown below can anyway be considered relevant targets during the whole project since many of them recur periodically. The list will

be updated as the project evolves and specific events might adhere more to the scope of SESAME than others.

- Action leader: ALL partners can take the leadership to prepare publications in international conferences
- Action participants: ALL can contribute to generate joint publications, which part of the scientific objectives of the project
- Action timing: M01-M30

Conference Name	Conference Date (subsequent editions)
European Conference on Networks and Communications (EUCNC)	Athens, Greece, 27-30 June 2016
IEEE International Conference on Communications (IEEE ICC)	France, 21-25 May 2017
International Conference on Telecommunications (ICT)	Thessaloniki, Greece, 16-18 May 2016
IEEE Global Communication Conference (IEEE GLOBECOM)	Washington, DC, USA, 4-8 December 2016
Mobile World Congress	2017
IEEE Conference on Computer Communications (IEEE INFOCOM)	Istanbul, Turkey, 23-27 April 2017
ACM Special Interest Group on Data Communication (ACM SIGCOM)	Salvador, Brazil, 22-26 August 2016
IEEE Personal Indoor and Mobile Radio Communications (IEEE PIMRC)	Valencia, Spain, 4-7 September 2016
IEEE Wireless Communications & Networking Conference (IEEE WCNC)	San Francisco, US, 19-22 Mar 2017
European Workshop on Software Defined Networks (EWSDN)	2016
IEEE Conference on Networks Softwarization (IEEE NetSoft)	Collocated Workshops in 2016 and the following event in 2017
IEEE/IFIP Network Operations and Management (IEEE NOMS)	2017
IEEE International Conference on Mobile Cloud Computing, Services, and Engineering (IEEE Mobile Cloud)	2017
IEEE International Conference on Cloud Networking (IEEE CloudNet)	2017
IEEE NFV-SDN	San Francisco, US, 18-21 November 2015
EAI International Conference on Mobile Networks and Management (MONAMI)	Santander, Spain, 16–18 September 2015
IEEE International Conference on Network Softwarization (NetSoft)	Seoul, Korea, 6-10 June 2016

Table 7: Conferences targeted by SESAME

2.6.3 Promotion of a Special Issue

This action delves into the promotion of a special issue in a reputed international journal on the topics promoted by SESAME: Cloud networking, Small Cells-as-a-Service, NFV and 5G system architectures.

- Action leader: UPC/i2CAT
- Action participants: ALL partners can support this action and in particular academics, participating to the editorial board, reviewing submitted papers, contributing to define the topic of the special issue, or taking any other relevant role.
- Action timing: Before M30

2.6.4 Sesame White Paper

SESAME whitepapers shall be used by the consortium to disseminate ideas, concepts achievements, and visions from the perspective of SESAME on 5G systems. Whitepapers shall be released during each year of SESAME as the project matures and concepts are consolidated.

Whitepaper 1

- Action leader: EHU
- Action participants: ALL partners are expected to contribute
- Action timing: Within M12

Whitepaper 2

- Action leader: INC/IPA
- Action participants: ALL partners are expected to contribute
- Action timing: Within M24

Whitepaper 3

- Action leader: ORION
- Action participants: ALL partners are expected to contribute
- Action timing: by M30

2.6.5 Summer schools and tutorials

This section has the aim to detail the dissemination activities undertaken by the consortium in the scientific domain, and which are carried out by the SESAME partners. Dissemination activities clearly also encompass the organization of summer schools and specialized events such as technical tutorials provided by the partners, which give the opportunity to disseminate the scientific knowledge in possess of the consortium, as well as to raise visibility of SESAME activities inside academia.

Summer School

The ICCLab at ZHAW organizes a summer school with students from this university and the Grand-Valley State University (Michigan - USA) since 2013. The summer school has a total duration of four weeks, and two of them are spent in Winterthur (Switzerland) and two in Allendale, Michigan (all the students from both universities attend courses throughout all the four weeks). The part of the summer school hosted in Switzerland is split in two parts: Cloud computing and computer systems. Teaching includes lectures on the respective parts and labs (to be carried out every day). SESAME concepts can be disseminated during the 2016 edition as part of the Networking lecture of the "Cloud Computing" section of the school. The lecture will include a section on 5G and SESAME can be introduced as a way to explain the challenges that need to be faced and the architectures that can be defined to achieve 5G requirements.

- Action leader: ZHAW
- Action participants: ALL partners can provide inputs and contributions.
- Action timing: July 2016

SESAME expects to make an impact in several ways, including technical and non-technical propositions. SESAME will indeed create an impact at societal, economic and technical levels. Small Cell-as-a-Service which leverages on cloud networking principles will create a number of new opportunities and it is one of the candidate architectural solutions for 5G. At the same time, the different components of the SESAME system, the cloud small cells, the Light Data Centre and the framework for flexible management and orchestration of resources developed within the project are the key components which give rise to develop new business models and deployment opportunities. The new business models are built on top of the separation of traditional roles such as infrastructure provider, physical/virtual small cell operators, venue owner, etc. Since SESAME Consortium has the ambition to be one key project in the scope of developing new 5G systems, the high level concepts and technical innovations produced within the project shall provide appropriate scientific ground to disseminate knowledge and contribute to form pre- and post-graduate students in the field of telecommunications. Therefore, two academic tutorials are in the SESAME roadmap at this early stage of the project, which can be potentially collocated with the summer school organized by ZHAW.

Tutorial 1

- Action leader: OTE
- Action participants: ALL partners can provide contributions
- Action timing: During 2016

Tutorial 2

- Action leader: CNET
- Action participants: ALL partners can provide contributions
- Action timing: During 2017

2.6.6 Dissemination in other events

The ambitious goal of the SESAME Consortium to disseminate the scientific and technical findings obtained within SESAME, is part of the dissemination strategy of the project and shall exploit all possible opportunities to maximise the impact of dissemination. This shall hence include seminars, booths and presentations provided by the SESAME partners in conferences, workshops, symposia and related international forums. The general idea is to address an audience as wide as possible, including industry, academia and identified interest groups.

SESAME partners plan to provide at least the following two seminars during the project.

Seminar 1

- Action leader: NCSRD
- Action participants: ALL partners can support this action providing inputs (slides, contribution material, etc.)
- Action timing: During 2016

Seminar 2

- Action leader: i2CAT/UPC
- Action participants: ALL partners can support this action providing inputs (slides, contribution material, etc.)
- Action timing: During 2017

In terms of booths, SESAME partners aim to provide at least two during the project as described below.

Booth 1

- Action leader: IPA/ITL

- Action participants: ALL partners and in particular those involved in prototypes development and system integration
- Action timing: EUCNC 2016

Booth 2

- Action leader: CNET
- Action participants: ALL partners and in particular those involved in prototypes development and system integration
- Action timing: EUCNC 2017

Additional two demonstration stands will be provided by SESAME partners during the project's lifetime in selected international events held during the period M01-M30 and identified by the SESAME Consortium. This should reflect the compromise between top-down and bottom-up approaches.

2.6.7 Contributions to Industry fora and Open Source Initiatives

As part of the dissemination plan, SESAME partners aim to contribute to industry forums, standard groups and open source initiatives which are related to SESAME technology development. SESAME will manage to make such contributions through specific partners, both industrial and academics involved in highly visible top activities. Next Generation Mobile Network (NGMN), 3GPP, Small Cell Forum (SCF), ETSI NFV and ETSI MEC are some of the standard bodies targeted by the SESAME Consortium.

SESAME will further do the effort to make contributions to open source initiatives in the area of SDN controllers such as OpenDaylight and ONOS, cloud management systems such as OpenStack, and NFV platforms and orchestrators such as OPNFV.

Finally, SESAME plans also to link the project website to at least one community-*based* software sharing platform, such as GitHub.

In Section 3, the efforts undertaken by SESAME partners in standard groups and forums, as well as an overview of the open source initiatives relevant to SESAME and the involvement of specific partners is provided to a much greater extent. In the same section, the relevance to SESAME of the activities carried out within these groups is appropriately addressed.

Activities in Standards Groups and Forums

- Action leader: Specific SESAME partners to lead this action, mainly industrial
- Action participants: ALL partners potentially involved to provide support
- Action timing: Continuously monitored but contributions are not expected before M12

Open Source Initiatives

- Action leader: Specific SESAME partners to lead this action, mainly academics
- Action participants: ALL partners potentially involved to provide support
- Action timing: Continuously monitored but contributions are not expected before M12

2.6.8 Collaboration activities

The consortium targets to build collaboration between SESAME and other ongoing FP7 funded projects to share findings and exchange experiences. The aim is to establish a link and find ground for cooperation. Cooperation could be materialized in the form of joint papers, co-sponsored workshops, whitepapers, etc. As SESAME will progress, the list provided below will be updated in the next deliverables of the communication and dissemination activities. Below a list of the projects which have been identified at the early stage of SESAME is provided below.

T-NOVA Project

- Action leader: NCSRD (set-up, maintenance, update)
- Action participants: ALL (content provision)
- Action timing: ad hoc interaction between the two projects and specific partners.

Section 5 will provide to a great extent both collaboration with other projects focusing on H2020 5G EU projects, as well as detailing the interaction with the 5G-PPP WGs and the actions undertaken by the SESAME Consortium in this respect. Also in this case, as SESAME approaches a more mature stage and the activities of each WG evolve, the efforts of SESAME partners may be subject to variations which will be detailed in the next deliverables of communication and dissemination activities.

2.6.9 Dissemination plan for year one

This section aims to detail the plan for communication undertaken during the first year of SESAME by the consortium.

Type of activity	Target audience	Description	Partners involved
Journal papers	Academics and researchers	At least **3** journal papers submitted	ALL
Conference papers	Academics and researchers	At least **10** conference papers submitted	ALL
Whitepapers	Academics and researchers, Industrial parties	**1** during the first year of the project	ALL
Cooperation with other 5G projects	Industrial parties, Academics and researchers	Co-organize at least **1** workshop during the first year	ALL
Invited Talks	Industrial parties, Academics and researchers	At least **1** invited talk during the first year	ALL
Seminars	Academics and researchers	**1** seminar during the first year	ALL
Presentations	Industrial parties, Academics and researchers	At least **5** presentations from SESAME partners in different international events on SESAME related topics	ALL
Tutorials	Academics and researchers	**1** tutorial is targeted during the first year	ALL
Booths	Industrial parties, Academics and researchers	**1** booth is targeted during the first year	WP7

Table 8: Summary of dissemination activities undertaken by SESAME partners during the first year

2.7 Open access policy

In SESAME, all publications will be published according to *Open Access (OA)* principles. The consortium will make use of both "green" (or self-archiving) and "gold" Open Access options to ensure Open Access to all publications produced.

Almost all the top publications in the fields related to the project are published via IEEE, Springer, Elsevier or ACM that provide authors with both "gold", with either hybrid publication or open access journals strategy, and "green" open access options.

Self-archiving or "green" open access peer-reviewed scientific research articles for dissemination will be published in scholarly journals that consent self-archiving options compatible with "green" open access, where the published article or the final peer-reviewed manuscript is archived (deposited) by the author - or a representative - in an online repository before, alongside or after its publication. SESAME will give preference to those journals that allow pre-print self-archiving in order to maximise the visibility of project outcomes.

Major achievements of the project will be considered to be published in a gold open access modality in order to increase the target audience. This implies the publication on Open Access Journals or on Hybrid Journals with OA agreement. The Article Processing Charges (APCs) that apply will be covered by the project budget.

Publication outputs will be placed either on arXiv or analogous archive (in accordance to the Registry of Open Access Repositories (ROAR)) and links from the project website to these Open Access publications will be published timely in order to maximise impact and visibility of SESAME results and its activities.

Any exception to this policy needs to be approved by the project coordinator and validated by the EU project officer.

Scientific content appearing in conference proceedings, peer reviewed books, monographs or any similar material suitable for publication will be made available through scientific literature digital libraries with flexible licensing for the scientific community. Open access archives, such as arXiv (www.arxiv.org), researchgate (www.researchgate.net), CiteSeerX (citeseerx.ist.psu.edu) can be used for this purpose.

SESAME will also produce specific outcomes in terms of implementation of individual software components which will be used in scientific publications together with the data collected during experiments done within the project lifetime. To make software and data used in publications available to the related community, such software and data will be made open source or subject to very flexible licensing and available whereby different channels. This includes the creation of repositories in open source code management tools such as GitHub, where to store the software developed which is in a mature stage and updated from time to time as new stable releases of the code are available. Furthermore, since the SESAME Consortium aims to maximise the impact inside the related SDN and NFV communities, the software will be also made available inside open source initiatives (OpenDayLight, OPNFV, etc.) whenever possible. With this policy, SESAME Consortium will disseminate project achievements to an audience as wide as possible and will allow other parties to replicate the results presented in scientific publications.

2.8 Publication procedure

A copy of any proposed publication, or at least a draft of such contribution that is sufficiently elaborated to allow the other partners for a substantive assessment whether objections should be raised as described below in connection with or relating to the project, shall be made available to the partners at least 25 calendar days before the publication. Any objection shall be made in accordance with the General Assembly (GA) writing to the Project Coordinator and to the parties involved in the dissemination within 15 calendar days after receipt of notice on any of the following grounds: (i) that they consider that the protection of the objecting party's foreground would be adversely affected by the proposed publication; (ii) that the proposed publication includes the confidential information of the objecting party, or; (iii) the publication of such information would be contrary to the commercial interests of the objecting party. In

the absence of any objection within the aforementioned period, it is deemed that the parties agree to the proposed publication. Following the end of the above-mentioned period, the Project Manager (PM) shall inform the parties whether or not any objection has been received[4].

In the event that an objection is raised on any of the above-defined grounds, the party proposing the publication and the party objecting shall seek in good faith to agree a solution on a timely basis whereby such objection is resolved. Parties cannot be quoted without prior agreement of the related parties in occasions different from technical-scientific ones and, in any case, with advertising aims.

2.9 Acknowledgement to the project

All SESAME publications will include the following acknowledgment:

This research received funding from the European Union's H2020 Research and Innovation Action under Grant Agreement No.671596 (SESAME project).

[4] In any case, the detailed description of the corresponding procedure is described in the context of the SESAME Consortium Agreement (CA) that complements the related Grant Agreement (GA).

3. Standardization

3.1 Objectives

SESAME will work in conjunction with the 5G-PPP initiatives to identify standardization and regulatory bodies to which the activities in the project will align. Due to the nature of the SESAME project, this is expected to extend from the traditional cellular network standardization groups such as 3GPP and IEEE, towards some of the distributed systems standardization activities.

This section outlines SESAME initial strategy and timelines along with the project's early views on the potential standardization targets. This will be enhanced as the project progresses and a roadmap will be developed.

3.2 SESAME Approach

Contributions to standardization bodies will ensure that SESAME results will be adopted by related industrial sectors and that interoperability in multi-vendor environments will be guaranteed. The SESAME project aims to evaluate and identify potential contributions to the standardization arena.

The standardization bodies are listed in Table 9 which shows also the agreed sharing of responsibility among consortium members, based on their current involvements in the different bodies.

Group	Leading partner	Involved partners	Notes
ETSI NFV	ITL	ITL, FLE, ORION, VOSYS	
ETSI MEC	FLE	FLE, ITL, ATN, CNET, ORION, VOSYS	
3GPP	IPA	IPA, FLE, OTE	3GPP have many working groups covering a range of cellular standards. We will need to target specific working groups
IETF/RTF			
Small Cell Forum	IPA	IPA, ATN	
IEEE SDN Initiative	CNET	CNET	
NGMN	FLE	FLE	FLE is only monitoring NGMN and not attending
ONF	FLE	FLE, CNET	Although Fujitsu is a member FLE is not actively involved in the ONF

Group	Leading partner	Involved partners	Notes
OCCI	ZHAW	ZHAW	Andy Edmonds from ICCLab (ZHAW) is chair of the (Open Grid Forum) OGF Open Cloud Computing Interface (OCCI) Working Group

Table 9: Groups and Standardization bodies relevant for the SESAME project

Consortium members have long experience in the groups listed in Table 9 and are active in the standardization processes within the different groups. This will bring knowledge on standardization to the project and will make the consortium aware of any standardization results that can be applied to the project.

Work Package Leaders, supported by Technical Leaders (TLs), will monitor the research and development activities and stimulate the standardization of their outcomes, in accordance with the guidelines of WP8.

In order to ensure the effectiveness of the standardization process, and provide adequate support to consortium members working on activities having potential impact on standardization, the following roles and responsibilities have been identified:

- A Standardization Manager, who is in charge of the overall coordination of standardization activities in the project.
- A Reference Person for each standardization group who has strong knowledge of status of work in the standardization group and can assist consortium members to finalize and focus their contributions.

The process agreed in the SESAME project to stimulate, prepare and submit standard contributions is described in the following:

1. Opportunities for standard contributions should be identified by Work Package Leaders and the technical experts in each technical Work Packages.
2. Identified opportunities for standard contributions should be notified at an early stage to the Standardization Manager and the Reference Person for the target standardization group, who will assist, if needed, the author(s) during the preparation of the submission and will guarantee that an effective coordination is achieved among project partners.
3. The author(s) is(are) requested to notify the Standardization Manager and the Reference Person(s) to share draft contributions on the SESAME mailing list before submission, to gather comments and possibly for co-signing contributions.
4. The author(s) of the submitted contribution(s) is(are) requested to announce over the SESAME mailing list the results of the submission (whether the contribution was accepted, revised and/or rejected) and also circulate useful information gathered during the discussion of the contribution(s), so that it can be used as guidance for future project work.

Whenever allowed by the drafting rules of a standardization body, submitted contributions relating to the SESAME project foreground must include the following statement acknowledging the financial support of the European Community:

“SESAME project is an EC funded Integrated Project under the HORIZON 2020 Framework Programme – H2020-ICT-2014-2 - grant agreement number 671596.”

3.2.1 SESAME Schedule

SESEAME project plan is structured around the well proven approach of requirements, architecture, design and implementation with a specific focus on multi-tenancy in future networks. The research and

timescales for the associated deliverables reflect this as the project progresses. Such an approach is consistent with the traditional 3 stages standardisation process adopted by many standardisation groups. This process is complemented by standardisation of associated management functionality. The SESAME Consortium have started evaluating the standardisation activity, identifying *where, when and how SESAME might contribute towards 5G standardisatio*n based on the SESAME project plan:

SESAME Workplan (Standardisation Impact)

Work Package	2015		2016				2017				Comments
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
WP2 Requirements, Specifications and Architecture			Use Cases /requirements	Initial Architecture			Detailed Architecture				Target Use Cases, Requirements and Architecture Standardisation
WP3 Small Cell Design & Implementation					Design				Implementation		Target: Radio access Technologies and Networks Stage 3 Standardisation
WP4 Light DC Design & Implementaion					Design				Implementation		Target: Distributed systems standardisations
WP5 Infrastructure Virtualisation & Management					Design				Implementation		Target: Management of Infrastructure Standardisation
WP6 Orchestration & Service Level Management					Design				Implementation		Target: Management of Services and Orchestration Standardisation

Figure 3: Planned envisioned by the SESAME Consortium for standardization

3.3 Target standardization forums and organizations

This section focuses on the initial set of standardisation groups and open source forums, on which the SESAME project may have a potential impact. The section is structured into 5 subsections each focusing on different aspects of standardisation and based on the traditional stages of standardisation, at least in those associated with some of the relevant communication standards.

3.3.1 Use Cases & Requirements Related Standardisation (Stage 1)

3.3.1.1 Overview

In the SESAME project, the initial focus is on use cases and requirements (Task 2.1) which is scheduled to deliver a report in December 2015. Three initial target scenarios were identified during the proposal preparation and these are forming the basis for the use cases in SESAME. These target scenarios will be the basis for the formulation of a number of specific use cases and the derivation of the requirements that will "drive" the definition and specification of the SESAME architecture. The 3 target scenarios are:

- Scenario 1: Enterprise services in multi-tenant large business scenarios.
- Scenario 2: Enhanced service experience on the move.
- Scenario 3: Service provisioning in flash events.

This section considers ongoing work in the standards bodies on related use cases, some specifically focusing on 5G and others based on new network architectures relevant to the SESAME future activities.

3.3.1.2 Relevant Standards Bodies

In this section the focus is on the objectives and timescales of standards bodies and working groups that are developing use cases, specifications and resulting requirements for future 5G related networks.

3.3.1.2.1 Next Generation Mobile Network (NGMN)

NGMN has issued a white paper that includes their vision on 5G applications and services (https://www.ngmn.org/uploads/.../NGMN_5G_White_Paper_V1_0.pdf). This briefly describes a set of 5G Applications and Services that can be categorised as follows:

- Broadband Access in Dense Areas.
- Broadband Access Anywhere.
- Higher User Mobility.
- Massive IoT.
- Extreme Real-Time Communications.
- Lifeline Communications.
- Ultra-Reliable Communications.
- Broadcast Like Services.

NGMN has also developed roadmap and milestones towards the deployment of 5G networks targeting commercial systems in 2020 with initial system design scheduled for 2017.

3.3.1.2.2 3GPP System Architecture Working Group 1 (SA1)

3GPP SA1 is responsible for developing requirements for 3GPP future systems in particular focusing on new services and market technology enablers that may impact future cellular specifications. A study item (SMARTER) is already in place focusing on user cases and requirements for 5G and being captured in a technical report TR22.891 scheduled for completion in December 2015. Currently over 50 use cases have been captured each with a description and a set of service and operational requirements.

Based on this study, 3GPP SA1 is expected to develop a number of technical specifications -scheduled for March 2016- which will capture the requirements for technology enablers that will be specified by other 3GPP working groups. Currently SA1 are consolidating the use cases to form groupings of related use cases, each group potentially forming an input into a separate technical specification focusing on the 5G requirements.

The target for the specifications of the technology enablers derived from the requirements is expected to be included in Release 14 of the 3GPP specifications (target mid 2017).

3.3.1.2.3 3GPP Radio Access Network (RAN) WGs

ETSI RAN Plenary initiated a new study item on scenarios and requirements for Next Generation Access (NGA) Technologies. This will at least provide some of the RAN related requirements for work items in future 3GPP releases. The target date for completion of the study item is June 2016, giving SESAME opportunity to identify potential inputs from Task 2.1 on *Use Cases and Requirements*.

The tentative timeline for 3GPP RAN 5G standardisation can be found at: http://www.3gpp.org/images/articleimages/2015_03_5G-timeline-in-3GPP_v3_2000px.jpg

3.3.1.2.4 Small Cell Forum (SCF)

We should note initially that the Small Cell Forum is explicitly not a Standards Body (SDO), but is a Forum in which standards-relevant consensus is formed. Such consensus is then taken to the relevant SDO by its members who are also members of that SDO. SCF does create documents to express that consensus, which may be adopted as a de facto standard, but they do not have normative force in the way that 3GPP or BBF documents do.

Small Cell Forum is organised in a matrix form, with specialist WGs providing material into Themes led by Champions, of which three are of significance to SESAME.

Theme: "The Role of Small Cells in 5G, IoT and M2M", championed by Huawei and Reliance Jio:

"There are two key aspects of the 5G process, where the Forum has existing experience of defining operator requirements and platforms. One is ultra-density, where the groups will continue and evolve work in areas like Virtualization, automation, backhaul/fronthaul and HetNet. The other is the emergence of

fully service-oriented networks, which are so flexible that thousands of different services may be launched simply and dynamically using open APIs."

Theme: "Multi-Operator Support", championed by Truphone and ip.access:

"… the Champions will be encouraging Working Group activities focused on the business model, as well as developments in technology (DAS, MOCN, MORAN etc.), regulation and spectrum (e.g. shared access), standards bodies (e.g. 3GPP RAN sharing enhancements), and deployment case studies."

Theme: "Virtualisation of Small Cells", championed by China Mobile, Cisco and ip.access:

"[the Theme] is already examining Virtualization models which deliver key benefits over a baseline distributed RAN approach, and the work item will look to enhance this architecture further, taking account of important capabilities like elastic operations (allowing the functions to be scaled up or down as required). In turn, that will support new flexible deployment models, like network-as-a-service or per-cell licensing, which can lower the barriers to large-scale small cell roll-out."[5]

The main interface to SCF is via IPA, which chairs the Radio and Physical Layer Working Group (RPH), is one of the "Multi-Operator" Theme Champions, is vice-chair of the Networks group (NET), is a co-Champion of the "Virtualisation of Small Cells" Theme, and is vice-chair of the Marketing Group (MKT).

We plan to submit (and are already submitting) material to the Themes activities, via the Forum Plenary sessions (held quarterly) and the Working Groups themselves.

Areas of significant agenda overlap include:

Multi-Operator Neutral Host: The SESAME architecture for the creation of network resource slices overlaps very strongly with the "Multi-Operator Support" theme, and the use cases and architecture developed in SESAME is being promoted into that theme as use cases and candidate architectures. Small Cell Forum is also active in examining the Market Drivers behind the Neutral Host business case, the regulatory aspects of Neutral Host around the world, with the emergence of Citizen's Broadband in the US and LSA in Europe.

5G: The Forum's agenda regarding 5G is evolving, but we expect there to be relevant material emerging from the Forum for the SESAME work programme, and we will also keep the 5G Theme Champions informed regarding the 5G results and deliverables. One significant contribution of the Forum so far is a representation to 3GPP 5G RAN Workshop in Phoenix[6].

Services: The Forum has an active Services Group, which in the past has contributed to the adoption of the GSMA OneAPI for Small Cell services. As the Services aspects of SESAME develop, we expect to make contributions to the Forum to extend the adoption of Service APIs, taking account of the SESAME use cases and architectures and other deliverables as identified.

RAN Virtualisation: While most of the SESAME agenda is about service layer virtualisation, there is a definite overlap also in the way the RAN is virtualised. The Forum has already done significant work in identifying the functional splits between Physical and Virtual Network Functions in the RAN, and these are taken into account in designing the SESAME work items. More importantly for this work package, the SESAME experience will be fed back into the RAN Virtualisation Theme via the IPA membership to promote the SESAME vision.

3.3.1.2.5 ETSI Network Function Virtualisation (NFV) ISG

ETSI NFV has developed a number of use cases based on virtual network functions that can be dynamically deployed within a future network. In this respect, the use cases developed within the ISG NFV have the flavour of virtualisation within the network infrastructure. ETSI NFV is not specifically focused on a 5G deployment, nevertheless the flexibility expected from a softer approach to future networks means that there is a strong relevance to the SESAME project. The defined use cases captured by ETSI NFV in the Group Specification on Virtualisation Use Cases (ETSI GS NFV 001) are:

[5] Quoted text taken from http://www.smallcellforum.org/site/wp-content/uploads/2015/11/Rome-Champions-Day-report.pdf

[6] Available online http://bit.ly/1FZS5Wf

- Network Functions Virtualisation Infrastructure as a Service.
- Virtual Network Function as a Service (VNFaaS).
- Virtual Network Platform as a Service (VNPaaS).
- VNF Forwarding Graphs (VNFFG).
- Virtualisation of Mobile Core Network and IMS.
- Virtualisation of Mobile base station (BS).
- Virtualisation of the Home Environment.
- Virtualisation of CDNs (vCDN).
- Fixed Access Network Functions Virtualisation.

3.3.1.2.6 ETSI Mobile Edge Computing (MEC) ISG

ETSI MEC ISG is focusing on the specification of an API to interface a MEC Server to nominally an LTE RAN infrastructure although certain aspects may be more generally applicable to other types of RAN.

The ISG has targeted a set of Use Cases as a means of driving the API definition and has captured these in a specification (DGS/MEC-002TechReq (GS MEC 002)) approved in September 2015. The initial set of requirements derived from these use cases will be used as a basis for defining the first version of an API between a 3GPP RAN (nominally LTE) and locally hosted applications. SESAME is focusing on a Small Cell infrastructure co-located with a light data centre so there is likely to be some synergy with the MEC approach.

Three main categories have been identified for use cases. Requirements on the architecture are generally quite similar for use cases within a category, and quite different between the categories. However, all these categories should be supported.

The three categories are:

- Consumer-oriented services: These are innovative services that generally benefit directly the end-user, i.e. the user using the UE. This can include gaming, remote desktop applications, augmented and assisted reality, cognitive assistance, etc.
- Operator and third party services: These are innovative services that take advantage of computing and storage facilities close to the edge of the operator's network. They are usually not directly benefiting the end-user, but can be operated in conjunction with third-party service companies: active device location tracking, big data, security, safety, enterprise services, etc.
- Network performance and QoE improvements: These services are generally aimed at improving performance of the network, either via application-specific or generic improvements. The user experience is generally improved, but these are not new services provided to the end-user: content/DNS caching, performance optimisation, video optimisation, etc.

In summary the current set of MEC use cases cover:

- Mobile Delivery Optimisation.
- Cell Congestion Reduction.
- Local Content Caching.
- Mobile Backhaul Optimisation.
- Traffic De-duplication in the Mobile Network.
- Local Breakout to CDN.
- Bandwidth Allocation Manager.
- D2D Transcoding.
- User Behaviour Prediction.

A set of MEC requirements is currently being defined (in GS MEC 002). These cover network integration, application services, application portability, security, performance and operational management of the mobile edge platform itself.

The current plan is for ETSI MEC to complete the specification for the API by June 2016. It is still under discussion if there will be a phase 2 set of specifications in which case there may be opportunities for SESAME to contribute towards both new use cases and requirements for the extension of the MEC activity.

3.3.1.2.7 Open Cloud Computing Interface (OCCI)

The OCCI is a set of open community-led specifications delivered through the Open Grid Forum. OCCI is a Protocol and API for the management of cloud service resources. OCCI was originally initiated to create a remote management API for IaaS model-*based* Services, allowing for the development of interoperable tools for common tasks including deployment, autonomic scaling and monitoring. It has since evolved into a flexible API with a strong focus on integration, portability, interoperability and innovation while still offering a high degree of extensibility. The design of OCCI focuses on:

- Simplicity: Not mandate a large number of requirements for compliance with the specification. Look to provide the lowest common denominator in terms of features and then allow providers supply their own differentiating features that are discoverable and compliant with the OCCI core model,
- Extensibility: Enable providers to flexibly specify and expose their own service features that are discoverable and commonly understood (via the OCCI core model). As the specification is extensible it is important for those extensions to be discoverable.
- Discoverability: The service provider must be able to signal to clients what features and capabilities, standard and extensions, are available. To understand the extensions, those extensions must share a common model. As such the extensions are self-describing.
- Modularity: Allows for clear separation of concerns and allows for separate specification documents used independently to varying degrees.

A key aim of OCCI is to leverage existing SDO specifications and use them to leverage the existing work. It is done so in a way where an OCCI feature is needed then a more capable one can be used. An example of this is the integration of both CDMI and OVF. The specification itself currently comprises of three modular parts:

- Core: This specifies the basic types and presents them through a meta-model. It dictates the common functionality and behaviour that all specialisations of it must respect. It specifies how extensions may be defined.
- Infrastructure: This specification is an extension of Core (provides a good example of how other parties can create extensions). It defines the types necessary to provide a basic infrastructure as a service offering.
- HTTP Rendering: This document specifies how the OCCI model is communicated both semantically and syntactically using the RESTful architectural-style.

3.3.1.2.8 Relationship to SESAME

SESAME is focusing on use cases that will impose requirements and impact the architecture of the CESC system, including both the Small Cell node and the management of the CESC network in particular, use cases demonstrating requirements for multi-tenancy deployments. The project is due to deliver D2.1 ("*System Use Cases and Requirements"*) in December 2015. At that point the project will evaluate the resulting requirements and identify any gaps with the requirements being developed in the standardisation arena.

The most immediate opportunity will be the 5G requirements being developed in 3GPP RAN study item which is scheduled for June 2016.

For higher level service related use cases targeting inputs to 3GPP SA1 would be possible although it may be more appropriate to target later 3GPP releases as SESAME results become more mature.

Input to other standardisation groups such as ETSI MEC and ETSI NFV are now focusing on the architecture specifications and protocol specifications respectively, so that there are limited opportunities to input new use cases and requirements at this stage. However as SESAME work progresses and potential gaps are identified to meet 5G requirements, SESAME use cases may be submitted into these standards groups as a basis for requirements of future releases.

3.3.2 Architecture Standardisation Aspects (Stage 2)

3.3.2.1 Overview

SESAME is scheduled to deliver the initial system architecture in month 9 (March 2016) which should cover the main functional components and their interfaces necessary to support the SESAME use cases. The SESAME Architecture will be updated based on the detailed design of the different components and delivered in Month 18 (Dec. 2016). This section provides an initial view on ongoing standards 5G activities on future network architectures that may provide opportunities for SESAME to contribute to the industry discussions.

3.3.2.2 Relevant Standards Bodies

In this section the focus is on the objectives and timescales of standards bodies and working groups that are developing network architectures for future 5G related networks.

3.3.2.2.1 3GPP System Architecture (SA2)

3GPP has initiated a study on alternative network architectures that will be led by the SA2 working group for new and emerging use cases and associated service requirements emanating the work in 3GPP SA (Smarter). In addition the study will consider the operational efficiencies to handle the expected massive increase in data traffic and number of devices. The target for completion of the work is March 2017.

The new architectures are expected to at least consider new RAT(s), the evolved LTE, non-3GPP accesses and to minimise access dependencies. Proposals for the new architecture may include both an evolution of the current 3GPP architectures or based on a “clean slate” approach.

3.3.2.2.2 Small Cell Forum

See earlier section (3.3.1.2.4) for a general discussion of Small Cell Forum and SESAME interaction.

In particular, for the architectural aspects of the SESAME output, we expect to present the SESAME architectures at RAN, Service, Management and Virtualisation layers to the Forum on a regular basis, as one aspect of its consensus forming activities, with the objective of seeing the adoption of the SESAME architectural models as a reference in the SCF industry-facing material and SDO contributions.

3.3.2.2.3 ETSI NFV ISG

ETSI Network Function Virtualization (NFV) developed a high level functional architecture framework for network virtualised functions and the supporting infrastructure [ETSI GS NFV 002]. This was published at the end of 2013 and is generally accepted by the industry as the reference architecture for virtualisation of future networks. ETSI NFV is not specifically focusing on 5G but given the expectation that future networks will require the flexibility offered through virtualised functions, it can be assumed that the underlying concepts will form a strong input into 5G thinking.

The NFV architecture has a strong Management flavour (see next section) however the architecture interfaces are defined between the management system and the infrastructure components as well as between infrastructure components. The infrastructure components in the ETSI NFV Architecture are:

- The Physical Hardware Resources – Compute, Storage and Networks.

- The Virtualised Infrastructure – Virtualised Resources and Hypervisor.
- The Network Virtualised Functions (deployed function on the Virtualised Infrastructure).

In summary the interfaces between these infrastructure components identified in the NFV Architecture are:

- Interface between the Physical Hardware Resources and the Virtualised Infrastructure (VI-Ha).
- Interface between the Virtualised Infrastructure and the Network Virtualised Functions (Vn-Nf).

In addition, the NFV architecture identifies a number of interfaces between the Infrastructure components and the management and orchestration (MANO) systems:

- Interface between the Virtualised Infrastructure and MANO (Vf-Ni).
- Interface between the Network Virtualised Functions (Ve-Vnfm).

3.3.2.2.4 ETSI MEC

ETSI MEC ISG is working on an architecture to deliver an API between a radio access network (primarily LTE-A) to be provided by a server at the edge of the network. The MEC Reference Architecture (GS MEC 003) is scheduled to be submitted for approval in February 2016. This document is planned to provide a framework and a high-level reference architecture for Mobile Edge Computing enabling MEC applications to be deployed across MEC platforms from multiple vendors.

The architecture shall depict a platform operating in an IT service environment with cloud-computing capabilities located at the edge of the mobile network, within the Radio Access Network and in close proximity to mobile subscribers. It is characterized by low latency, proximity, high bandwidth and real-time insight into radio network information and location awareness. It will be an open environment that will allow efficient and seamless integration of third-party applications across multi-vendor platforms.

3.3.2.3 Relationship to SESAME

SESAME is focusing on both Small Cells and the Light data centre and incorporating these into a single coherent architecture. In this respect the resulting architecture should be relevant both in the communications domain as well as the distributed cloud domain and the interactions between the two. From the 5G infrastructure perspective the more immediately opportunities for SESAME will be to contribute towards the 3GPP study on new network architectures. The timescales for this study should enable the SESAME project to mature the SEASAME architecture before considering potential contributions to standards in the second half on 2016.

Additionally, the project will evaluate the SESAME architecture and consider impacts on the 3GPP RAN Architecture. This will need to be coordinated with the RAN study on scenarios and requirements for Next Generation Access Technologies. Architectural impacts on the RAN will likely be discussed in the second half on 2016.

As the SESAME project matures the requirements and component designs, OCCI can be considered for adoption in the definition of protocols and APIs for the interaction with the cloud computing components of SESAME (e.g., within the CESCM and the VIM). Feedback to the OCCI standardization WG is proposed.

3.3.3 Protocols Consideration (Stage 3)

3.3.3.1 Overview

SESAME is scheduled to deliver the initial component designs in June 2016 and subsequent implementations a year later. During this phase of the work the project will conduct an assessment of the relevant existing and emerging protocols and APIs that will be impacted by the SESAME project.

3.3.4 Management Standardisation

3.3.4.1 Overview

Substantial effort in the SESAME project will be on the Management of the Light Data Centre infrastructures, Networks and Services derived from the SESAME use cases. In this respect existing and emerging Management standardisation will play an important role in the project.

3.3.4.2 Relevant Standards Bodies

In this section the focus is on the objectives and timescales of standards bodies and working groups that are developing management standards for future 5G related networks.

3.3.4.2.1 3GPP SA5

SA5 is the Operations and Management Standardisation Group within 3GPP, and IPA expects to contribute the management architecture and TR196 extensions developed in the SESAME project for the configuration and performance management of the Small Cells, the associated Network Slices and the Resource Sharing Policy Management.

3GPP works by consensus, and in order to make progress it is necessary to involve as large a group of stakeholders as possible. The involvement of a mobile operator is of course essential. Therefore, we will work with the OTE team to formulate a clear plan to carry the OAM relevant contributions from SESAME into SA5 at the appropriate time.

3.3.4.2.2 Small Cell Forum

See earlier section (3.3.1.2.4) for a general discussion of Small Cell Forum and SESAME interaction.

Regarding Management Standardisation, there is no specific work item or group within SCF that addresses OAM issues, but its role in consensus forming will be useful in improving the quality of the submissions to 3GPP. IPA will lead discussions within SCF on this topic to this objective.

3.3.4.2.3 ETSI NFV ISG

The ETSI NFV high level functional architecture framework for network virtualised functions defines [ETSI GS NFV 002] three high level functions in the management plane as follows:

- Virtualised infrastructure Manager (VIM) responsible for the management of the control and management of the interaction, between a VNF and the virtualised resources (computing, storage, networking).
- Virtualised Network Functions Manager (VNFM) responsible for the lifecycle management of the Virtualised Network Functions.
- Orchestrator - responsible for the orchestration and management of the NFV Infrastructure and software resources and realising network services on a Virtual Infrastructure.

The **Network Orchestrator** enables new Network Functions and Services to be introduced into a system. Key elements of this Orchestrator will be the Service, VNF and Infrastructure Descriptors that enable the Orchestrator to decide where to best deploy an instance of a network function. The functions provided by the Network Orchestrator are accessed through 2 reference points:

- The Os-Ma-nfvo reference point (GS NFV-IFA012) is used by the OSS/BSS to access the functions provided by the Network Orchestrator.
- The Or-Vnfm reference point (GS NFV-IFA007) is used by the VNF Manager to access the functions provided by the Network Orchestrator.

Interfacing to OSS/BSS

A key interface for the virtualised network system is the interface to the external OSS/BSS. The Os-Ma-nfvo reference point (GS NFV-IFA012) is used for exchanges between OSS/BSS and NFV Orchestrator, and enables external OSS/BSS access to the following Network Orchestrator functions:

- Network Service Descriptor management.
- Network Service lifecycle management and lifecycle change notification.
- Network Service performance management notification.
- Network Service fault management notification.
- VNF package management.

VNF software image management:

- VNF lifecycle management and lifecycle change notifications.
- Policy Administration.

Interfacing to a VNF Manager

The Or-Vnfm reference point is used for exchanges between Orchestrator and NFV Manager. The interface enables the VNF Manager to access the following Network Orchestrator functions:

- VNF Package Management.
- VNF Lifecycle Operation Granting.
- Virtualised Resources Management.

Virtualised Network Functions Manager (VNFM) responsible for the life cycle management of the Virtualised Network Functions. The functions provided by the Network Orchestrator are accessed through 2 reference points:

- The Or-Vnfm reference point (GS NFV-IFA007) is used by the Network Orchestrator to access the functions provided by the VNF Manager.
- The Ve-Vnfm reference point (GS NFV-IFA008) is used by an EMS or Virtualised Network Function to access the functions provided by the VNF Manager.

Interfacing to the Network Orchestrator

The Or-Vnfm reference point is used for exchanges between Orchestrator and NFV Manager. The interface enables the Network Orchestrator to access the following VNF Manager functions:

- VNF Lifecycle Management.

VNF Lifecycle Change Notification

- VNF Performance Management.
- VNF Fault Management.
- Policy administration.

Interfacing to the EMS/VNFs

The Ve-Vnfm-em reference point (GS NFV-IFA008) is used for exchanges between EMS/VNF and VNF Manager. The interface enables the EMS/VNF to access the following VNF Manager functions:

- VNF Lifecycle Management.
- VNF Lifecycle Change Notifications.
- Virtualised Resources Performance Management.
- Virtualised Resources Fault Management.

Note that this reference point also enables a VNF to provide limited configuration information to the VNF Manager.

Virtualised infrastructure Manager (VIM) responsible for the management of the control and management of the interaction between a VNF and the virtualised resources (computing, storage, networking). The functions provided by the VIM are accessed through 2 reference points.

- The Or-Vi reference point (GS NFV-IFA005) is used by the Network Orchestrator to access the functions provided by the VIM.
- The Vi-Vnfm reference point (GS NFV-IFA006) is used by a VNF Manager to access the functions provided by the VIM.

Interfacing to the Network Orchestrator

The Or-Vi reference point is used for exchanges between NFV Orchestrator and VIM. The interface enables the Network Orchestrator to access the following VIM functions:

- VNF software Image Management.
- Virtualised Resources Catalogue Management.
- Virtualised Resources Capacity Management.
- Virtualised Resources Management.
- Virtualised Resources Change Notification.
- Virtualised Resources Performance Management.
- Virtualised Resources Fault Management.
- Policy administration.
- Network Forwarding Path Management.

Interfacing to the VNF Manager

The Vi-Vnfm reference point is used for exchange of information elements between the Virtualized Infrastructure Manager (VIM) and VNF Manager (VNFM), and the following functions are provided by the VIM at the reference point.

- VNF software image management.
- Virtualised resources catalogue management.
- Virtualised resources management.
- Virtualised resources change notification.
- Virtualised resources performance management.
- Virtualised resources fault management.

ETSI NFV is scheduled to deliver the interface protocol specifications by the end of 2016. So far their focus has been on the interfaces towards the Virtualised Infrastructure Manager (VIM) which is being used as a basis for OpenNFV and OpenStack implementations. Other interfaces are less well specified and completion of the specifications in the 2016 timeframe may be challenging

3.3.4.2.4 Broadband Forum

Small cell (femto) management in existing standards have converged on the Broadband Forum specified Technical Report-069 (TR-069). This was extended to meet the management requirements for 3GPP defined Home eNBs (Small cells).

3.3.4.2.5 Distributed Management Task Force (DMTF)

The DTMF is an industry standards organization working to simplify the manageability of network-accessible technologies. DMTF implementations enable the management of diverse traditional and emerging technologies including cloud, virtualisation, network and infrastructure

These goals have some similarity with NFV and the DMTF have a number of technologies that may influence SESAME.

3.3.4.3 Relationship to SESAME

The SESAME architecture is based on a virtualised network infrastructure and many on the management concepts and interfaces being developed in ETSI NFV can be expected to have a high degree of relevance. ETSI NFV expectations are that virtualised infrastructure and its management will be based on an Open Source approach which is being handled through the Open Platform for NFV and various open source projects. SESAME can expect to leverage such open source initiatives and feed-back any impacts that multi-tenancy may have on the ETSI NFV standards.

The reference points for the Network Orchestrator and VNF Manager are still being developed and as the SESAME project defines the management interfaces in more detail there are likely to be opportunities to influence these emerging standards.

3.4 Open Source Initiatives

In this section, open source initiatives of interest in the context of SESAME are described in detail.

3.4.1 OpenDayLight, ONOS, OpenContrail

OpenDaylight

OpenDaylight (ODL) [4][5] is an open source framework aimed to facilitate software defined networking programmability platform to network developers, end-users and customers. OpenDaylight is hosting one of the biggest growing communities for network programmability and NFV support that has gone beyond being just an SDN controller. It supports variety of networking projects, standards and protocols and has already taken a leading role in the SDN world.

OpenDaylight has been actively supported by 12 founding members from telcos, enterprise and academia. It is organized in a modular way consisting of various components. Being extensible allows the inclusion of new north or southbound projects, standards and protocols. ODL is implemented in Java and can be deployed and run on hardware supporting JVM over different production environments. It provides Karaf container as OSGi-*based* runtime to import different bundles in the runtime controller environment to achieve a specific functionality. ODL has used the OSGi runtime until the Hydrogen release and has switched to Karaf in the Helium and the current, Lithium release.

The image below shows the integral components of the ODL project in the current Lithium release, together with the supported northbound applications and southbound protocols.

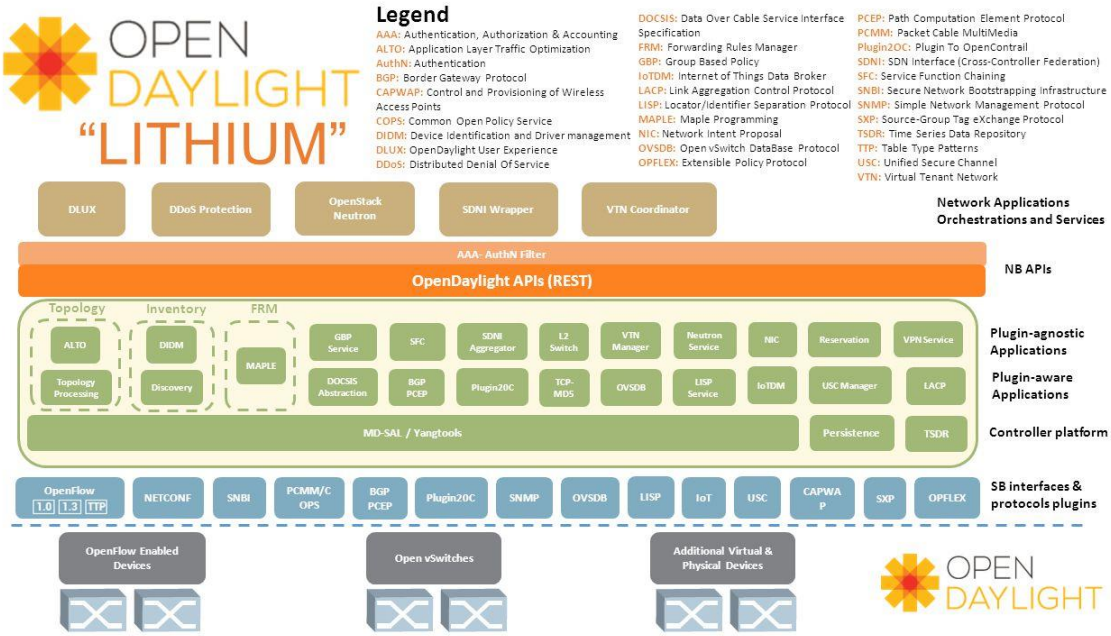

Figure 4: Architecture of ODL (source: https://www.opendaylight.org/lithium)

ODL includes full support of the OpenFlow protocol on the southbound interface. Among the other protocols supported on the southbound are: OVDSB, Netconf, BGP, etc. There is a northbound API interface exposed to applications that use the ODL controller to perform different analytics over the network, enforce novel algorithms, monitoring the performance, etc.

The recent trend of building telco cloud deployments based on virtualised network functions and open interfaces, has contributed significantly towards merging the gap between the telco and the cloud operators. Moving network elements closer to the base station to allow lower latency, is an example basic use case that justifies the need of employing SDN principles and the use of NFVs in the 5G world.

Raising the question of 5G support in the OpenDaylight community is a major focus brought out for example by Nokia as one of the main contributors, both in the ODL and the 5G community. According to a statement from Henri Tervonen - *a vice president of Mobile Broadband Architecture from Nokia Networks*, they have a long experience in building telco cloud deployments based on virtualised network functions. This turns their focus directly towards raising up the attention in the ODL community for support of the 5G technology. Although currently as incubated idea, there is a strong tendency in the academic world and among the community to provide support for virtual functions and networking libraries for control plane programmability within a 5G "cloudified" environment scenario. This is however yet an ongoing work and significant progress is to be expected in the upcoming year.

3.4.2 OpenStack, OCCI

OpenStack

OpenStack software controls large pools of compute, storage, and networking resources throughout a DC, all managed through a dashboard that gives administrators control while empowering their users to provision resources through a web interface. As an open source solution, OpenStack is developed and supported by a global collaboration of developers and cloud computing technologists [6]. The project seeks to deliver solutions for all types of clouds by being simple to implement, scalable, and feature rich. The technology consists of a series of interrelated projects delivering various components for a cloud infrastructure solution. All OpenStack source code is available under an Apache 2.0 license.

OpenStack has a modular design that enables integration with legacy and third-party technologies. It is built on a shared-nothing, messaging-based architecture with modular components, each of which manages a different service; these services together provide the abstraction of IaaS Cloud.

The primary component of the cloud operating environment is the Nova compute service. Nova compute manages the creation and deletion of compute/VM instances. Nova is designed to operate as much as possible as hypervisor-agnostic. It works with open source libraries such as libvirt. Similar to other OpenStack components, Nova is based on a modular architectural design where services can be co-resident on a single host or, more commonly, on multiple hosts.

The core components of Nova include the following:

- **nova-api:** Accepts and responds to end-user compute API calls. It also initiates most of the orchestration activities (such as running an instance) as well as enforcing some policies.
- **nova-compute:** A worker daemon that creates and terminates VM instances via hypervisor APIs (XenAPI for XenServer/XCP, libvirt for KVM or QEMU, VMwareAPI for vSphere, etc.).
- **nova-scheduler:** Process that keeps a queue of VM instance requests and determines, for each request, where the VM instance should run (specifically, which compute node it should run on).

The Nova service itself does not come with a hypervisor, but manages multiple hypervisors, such as KVM or ESXi. Nova orchestrates these hypervisors via APIs and drivers. For example, Hyper-V is managed directly by Nova and KVM is managed via libvirt, while Xen and vSphere can be managed directly or through management tools such as libvirt and vCenter for vSphere, respectively.

OpenStack controls network resources through its Neutron component, which aims at providing a scalable, on-demand, technology-agnostic network abstraction. Neutron provides OpenStack tenants with the functionality to create flexible network topologies between interface devices, by defining virtual components that manage both L2 and L3 functionality. The rich availability of plugins allows Neutron to be easily expanded with advanced networking capabilities and support external commercial and open source network technologies.

OpenStack virtualises storage with the Cinder service, which is used to provide block storage (Cinder volumes) to VMs. OpenStack defines two basic types of block storage: ephemeral and persistent. Ephemeral storage is directly associated with VMs and its lifetime is not independent from that of VMs (if a VM is destroyed, ephemeral storage is lost). Persistent storage is defined in terms of volumes, which can be attached/detached to/from VMs and whose lifetime is independent from that of VMs (a persistent volume exists even if the VM to which it is attached is destroyed). Persistent volumes can be attached to different VMs (at different times).

OpenStack Cinder can virtualise storage from the locally available resources at the OpenStack compute nodes or it can interface to external storage systems through the use of dedicated drivers, which exist for both open source solutions (such as Ceph[7]) or commercial ones.

OpenStack is seen to play a key-role in the 5G era, as highlighted by SKT at the latest OpenStack summit held in Tokyo [7], where virtualisation has been identified as a fundamental technology for the definition of the next generation mobile networks. Thanks to the flexibility obtained with Software-Defined Networking and the ability to operate a virtualised infrastructure, numerous advantages can be obtained to mark a clear advancement towards mobile networks that are able to offer a better service to an increasing number of users. Among them is the flexible definition of policies based on real-time analysis of the network flows, or the fast reconfiguration of the Virtual Network Functions to adapt to varying loads.

Using SDN and NFV based on OpenStack, 5G will benefit from increased flexibility and interoperability, where virtual dedicated network slices can be carved out for specific applications.

In the context of this project, Nova and Neutron will be extended by VOSYS to support SESAME computing and networking accelerations.

Open Cloud Computing Interface (OCCI)

OCCI is a set of open community-led specifications delivered through the Open Grid Forum. OCCI is a Protocol and API for the management of cloud service resources. OCCI was originally initiated to create a remote management API for IaaS model-based Services, allowing for the development of interoperable tools for common tasks including deployment, autonomic scaling and monitoring. It has since evolved into

[7] http://ceph.com/

a flexible API with a strong focus on integration, portability, interoperability and innovation while still offering a high degree of extensibility. The design of OCCI focuses on:

- Simplicity: Not mandate a large number of requirements for compliance with the specification. Look to provide the lowest common denominator in terms of features and then allow providers supply their own differentiating features that are discoverable and compliant with the OCCI core model.
- Extensibility: Enable providers to flexibly specify and expose their own service features that are discoverable and commonly understood (via the OCCI core model). As the specification is extensible it is important for those extensions to be discoverable.
- Discoverability: The service provider must be able to signal to clients what features and capabilities, standard and extensions, are available. To understand the extensions, those extensions must share a common model. As such the extensions are self-describing.
- Modularity: Allows for clear separation of concerns and allows for separate specification documents used independently to varying degrees.

A key aim of OCCI is to leverage existing SDO specifications and use them to leverage the existing work. It is done so in a way where an OCCI feature is needed, then a more capable one can be used. An example of this is the integration of both CDMI and OVF. The specification itself currently comprises of three modular parts:

- Core: This specifies the basic types and presents them through a meta-model. It dictates the common functionality and behaviour that all specialisations of it must respect. It specifies how extensions may be defined.
- Infrastructure: This specification is an extension of Core (provides a good example of how other parties can create extensions). It defines the types necessary to provide the basic infrastructure as a service offering.
- HTTP Rendering: This document specifies how the OCCI model is communicated both semantically and syntactically using the RESTful architectural-style.

OCCI sits on the boundary of a service provider. It does not seek to replace the proprietary protocols/APIs that a service provider may have as legacy.

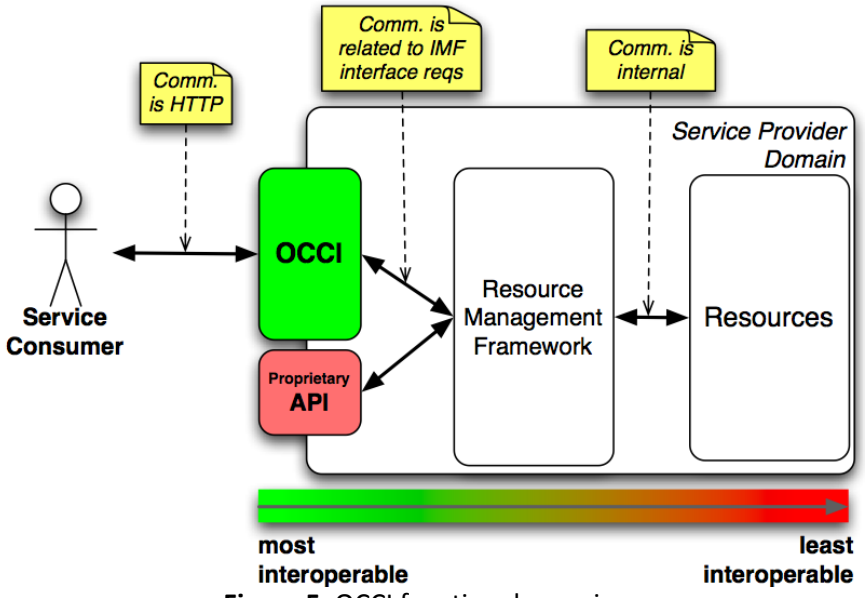

Figure 5: OCCI functional overview

The communication between the service consumer and the OCCI implementation is carried out over HTTP and both exchange serialised renderings of the OCCI model, however the use of HTTP is not mandatory.

3.4.3 OPNFV

Open Platform for NFV Project - OPNFV

After creating the OpenDaylight Project in April 2013 as a leading framework to boost adoption of software-defined networking (SDN) and network functions virtualisation (NFV), the Linux Foundation announced another initiative in 2014 – the Open Platform for NFV (OPNFV) [8]- [14]. OPNFV is a carrier-grade, integrated, open source platform to accelerate the introduction of new NFV products and services, by essentially bringing together service and NFV providers, cloud and infrastructure vendors, developers communities, and customers into a new NFV ecosystem. OPNFV was motivated by the European Telecommunications Standards Institute (ETSI) and will follow the ETSI NFV to achieve consistency among open standards, and performance and interoperability among virtualised network infrastructures. OPNFV will promote an open source network that leverages existing technologies to accelerate innovation and collaboration between the participating communities.

The first milestone of OPNFV is the creation of NFV Infrastructure (NFVI) and Virtualized Infrastructure Management (VIM) using building blocks from upstream projects. Some of the major upstream projects where collaboration with- and their role in OPNFV is important, are:

- Virtual Infrastructure Management: OpenStack, Apache CloudStack, etc.
- Network Controller and Virtualization Infrastructure: OpenDaylight, etc.
- Virtualization and hypervisors: KVM, Xen, libvirt, LXC, etc.
- Virtual forwarder: Open vSwitch (OVS), Linux bridge, etc.
- Data-plane interfaces and acceleration: Dataplane Development Kit (DPDK), Open Dataplane (ODP), etc.
- Operating System: Linux, etc.
- Storage: Ceph.

The following diagram shows the ETSI NFV architecture marking the initial focus area of the OPNFV group and the two building blocks: NFV and NFVI.

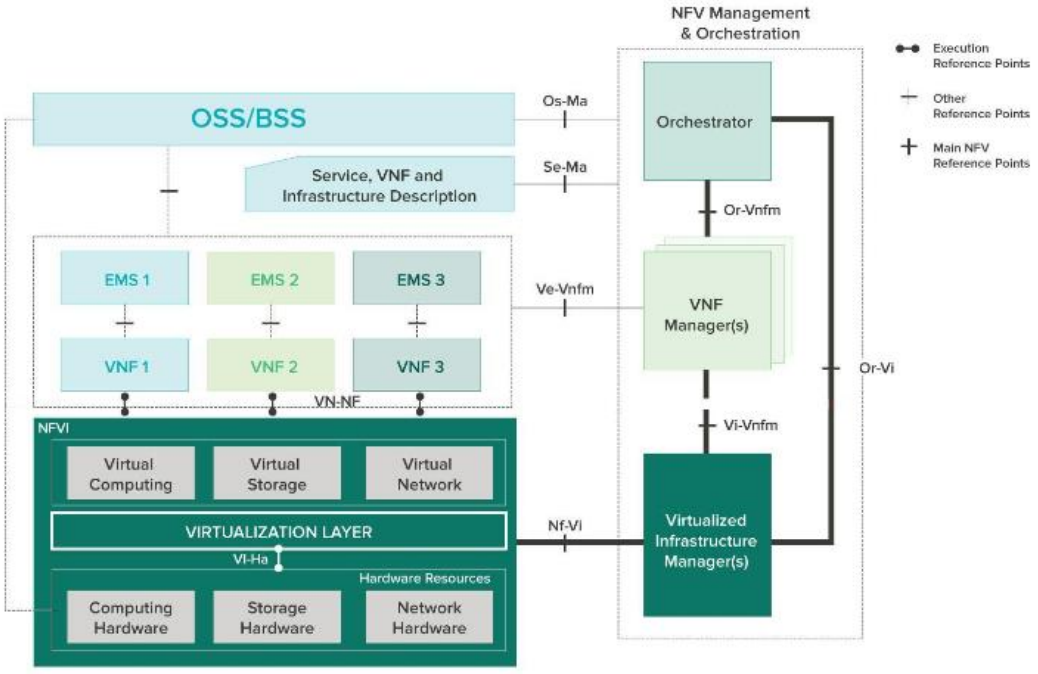

Figure 6: ETSI MANO [11] (source: https://www.opnfv.org/software/technical-overview)

NFVI: Provides access to basic resources—compute, storage and networking—through hypervisors and SDN functions.

VIM: Manages the VNFI and provides the management capability required to deploy applications running in a virtual environment, commonly referred to as VNFs (virtual network functions).

The OPNFV platform is designed in a modular way in order to allow composing various proprietary components or extensions to community components. To support several implementation models and ensure interoperability, the community will provide APIs and interfaces between these components.

With respect to support and future vision of 5G within the OPNFV community, Myung-Soon Park, *Head of Emerging Technology R&D Center from SK Telecom*, has recently stated that "OPNFV plays an increasingly important role in accelerating timely and efficient innovative telecom solutions including 5G by defining tightly integrated and standardized environment" [12]. This shows that SK Telecom is highly interested in combining OPNFV with 5G networking. SK Telecom will make a 5G solution where OPNFV will play an important role in the 5G era. They see Arno release to be a good candidate towards materializing the specifications.

Arno [13] is the first release of the OPNFV project that includes initial implementation of the NFV Infrastructure (NFVI) and Virtual Infrastructure Manager (VIM) components of ETSI NFV architecture. The diagram bellow shows Arno's architecture with components from the upstream projects (on the left) and OPNFV projects (on the right) [14]. It is aimed for developers to develop and test-case the performance of their Virtual Network Functions (VNF) applications.

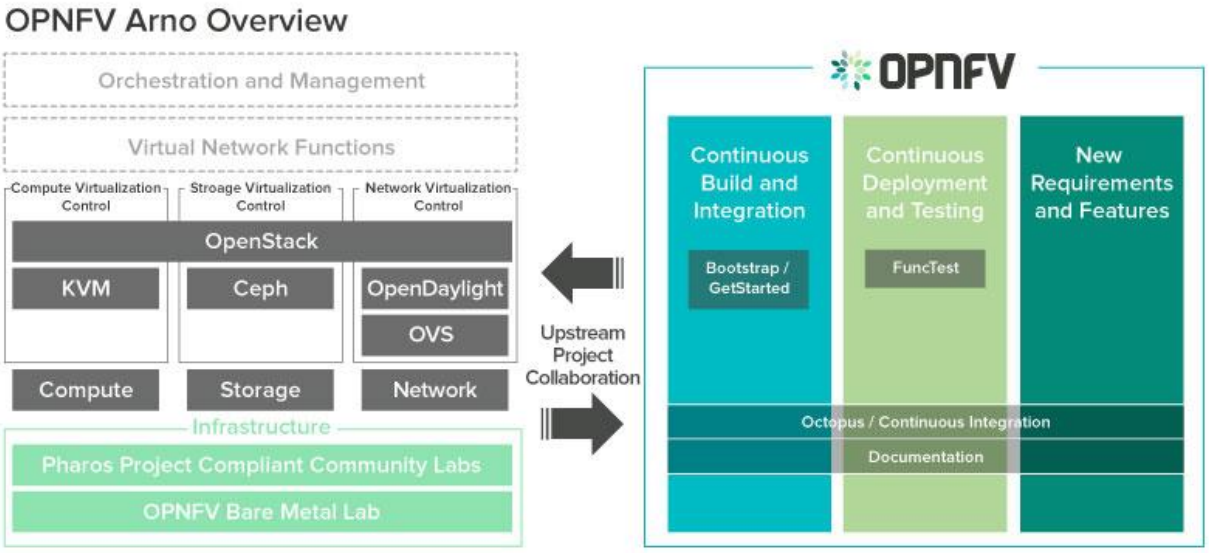

Figure 7: Architecture of OPNFV ARNO VIM [15]

Currently, up to 37 projects [16] compose the OPNFV platform categorized as: Requirements, Integration and Testing, Collaborative Development, and Documentation. In continuation some of them are described. Some of the projects that might be of interest for SESAME are described below.

In SESAME, the operation of virtualised Small Cell resources and their provisioning as autonomous virtual networks will be based on state-of-the-art network virtualisation frameworks such as OPNFV.

SESAME will study the possibility of contribution to OPNFV through its new approach in which, instead of using traditional compacted x86 servers, virtual functions are instantiated in a distributed CESC cluster platform consists of Light DC resources (formed by a cluster of CESC micro servers) and small cell virtualised resources, both simultaneously managed/orchestrated by a local hypervisor, CESC manager. That includes an effort to develop new components to extend the existing open source OPNFV platform for a comprehensive CESC VNFs (i.e., light DC VNFs and SC VNFs) management/orchestration while taking care of energy efficiency, instruction simplicity and space limit problems.

i2CAT, ATOS, NCSRD and VOSYS are the partners within the SESAME consortium who will examine the possibilities of contribution to OPNFV. The scope of this activity may include the following aspects:

- Development of reliable networking and computing virtualisation extensions for the SESAME NFVI to OPNFV components.
- Implementation of OPNFV VIM extensions. For example trough the integration of VOSYS SESAME Light DC KVM-on-ARM hypervisor additions in OPNFV.
- Check the possibility of contribution to OPNFV VNFM projects. In general, there are two possible VNFM realization approaches under SESAME: (i) A centralized approach in which the CESCM is a separate network element that manages the CESC cluster, and; (ii) a distributed approach in which the CESCM features are carried out by the CESCs themselves as VNFs. The centralized option, which is simpler, may allow the operator a greater control of the network functions that run over the cluster but could present scalability issues. The distributed approach, on the other hand, seems challenging and the efficiency should be further studied, since such a dynamic scenario would require the duplication of information across CESCM within the cluster increasing

the signalling. Both options will be discussed with the OPNFV community to identify the most suitable/feasible approach.

Pharos project

The Pharos project [17] creates disperse community labs offering tools, libraries of workloads, and documentation to support integration on different hardware across enterprises and community premises. It serves as a federated testbed for integration, testing and collaborative development projects.

OpenStack Based VNF Forwarding Graph

Leveraging the OpenStack work on VNFFG (Service Function Chain) and ONF OpenFlow work on service chaining, this project [18] tends to show automatic set up of end-to-end VNF services through VNFFG so that different tenants' flows can be steered through different sequence of VNFs (Service Function).

Service Function Chaining

This collaborative development project [19] will base on the previous framework "OpenStack Based VNF Forwarding Graph" to create a link between two Linux Foundation projects, OpenDaylight (ODL) and OPNFV. It will provide service chaining capabilities in the OPNFV platform; that is it will provide an ordered set of abstract service functions (e.g. NAT, load balancing, QoS, firewall) and ordering constraints that must be applied to packets and/or frames and/or flows selected as a result of classification [20].

3.4.4 Linux Kernel

The Linux kernel is an open source Unix-*like* operating system, created in 1991 by Linus Torvalds. Today it is widely used in virtualised environments, High Performance Computing servers, networking equipments and NFV. The Linux kernel embeds KVM, a full virtualisation hypervisor which leverages on specific virtualisation instruction set extensions (i.e., Intel VT, ARM VE) to provide high performance and strong isolation for virtual machines. KVM is implemented as a Linux module and it is used in conjunction with user space tools such as QEMU to run virtual machines.

VOSYS plans to extend the Linux kernel to develop KVM extensions tailored on SESAME needs. These extensions are related to the following aspects:

- Implementation of performance and power consumption optimizations for the LightDC (e.g., host/guest kernel drivers, kernel modules, etc.).
- Design and implementation of kernel space extensions for hardware accelerators virtualisation using API remoting, Direct assignment and HW assisted virtualisation.
- Development of specific KVM enhancements in kernel space aiming to provide better security for VNFs.
- Hypervisor support for specific SESAME accelerators, such as FPGA, GPU, NPU, etc.

3.4.5 ONOS

ONOS is an open source SDN network operating system, architected to provide a resilient, high performance SDN control plane featuring northbound (Intent Framework) and southbound (Open-Flow, NETCONF, OVSDB, etc.) abstractions and interfaces for a diversity of management, control, service applications and network devices. ONOS is a multi-module project whose modules are managed as OSGi bundles inside an Apache Karaf framework. Applications interact with ONOS through the Intent Framework that allows specifying their network control desires in form of policy rather than mechanism. The ONOS core accepts the intent specifications and translates them into device-specific operations (e.g. OpenFlow rules). Since October 2015, ONOS and Linux Foundation established a strategic partnership to create open source SDN and NFV platforms and solutions.

Currently, the community is focusing on several projects and proof-of-concepts, mainly driven by real use-cases faced by service providers and vendors. These scenarios vary from the re-architecture of an ISP

Central Office as a Data centre, to a central management of a multi-layer packet optical network, up to the interaction with standard IP-BGP networks. The full list of PoCs and scenarios is available on the ONOS Wiki pages (ON.LAB. ONOS Use Cases. https://wiki.onosproject.org/display/ONOS/Use+Cases, Nov. 2015).

Partners and external developers could easily extend and customize ONOS though the following process:

- Design an initial solution, both focusing a new feature or a core improvement and write it down inside the specific section in the ONOS Wiki (ON.LAB. ONOS Feature Proposals. https://wiki.onosproject.org/display/ONOS/Feature+Proposals, Nov. 2015).
- Formulate a brief proposal in writing to the Technical Steering Team (TST) (ON.LAB. ONOS Technical Steering Team. https://wiki.onosproject.org/display/ONOSST/Technical+Steering+Team, Nov. 2015).
- Submit new or changed Java APIs for review via Gerrit, following the procedure explained here (ON.LAB. ONOS Gerrit Workow. https://wiki.onosproject.org/display/ONOS/Sample+Gerrit+Workow, Nov. 2015).
- Adjust the Java APIs based on the feedback from the TST and from the broader ONOS community.
- Proceed with implementation and submit code for review via Gerrit.

CNET is active in the ONOS community mainly through the project NetIDE (www.netide.eu). The activities of ONOS are relevant to SESAME project as they could be used as basis for the development of the VIM used inside the SESAME architecture.

3.4.6 QEMU

The KVM hypervisor relies on Quick Emulator (QEMU)[8] to provide user space support for the execution of virtual machines. QEMU is used by KVM to virtualise/emulate IO and system devices, as well as to instantiate and control virtual machines. Moreover, thanks to the libvirt library which is used as an OpenStack Nova driver, QEMU is the component which interacts with OpenStack to control KVM guests.

In addition, QEMU is also the component which will implement the VMs' access to the system accelerators. For this reason, VOSYS plans to monitor and contribute to QEMU with:

- Specific SESAME extensions which enhance IO performance and security of the VNFs (paravirtualised devices, API remoting and direct assignment support, etc.).
- Design and implementation of user space extensions for hardware accelerators virtualisation using API remoting, Direct assignment and HW assisted virtualisation.
- Design and implementation of a zero copy shared memory mechanisms which target both networking communication and accelerators data offload.
- In the context of this project, VOSYS will extend QEMU to develop the SESAME networking and computing hypervisor extensions.

3.4.7 ODP

The OpenDataPlane (ODP)[9] is an open-source, cross-platform set of application programming interfaces (APIs) which works with the Linux kernel and vendor specific SDKs to accelerate networking applications. The ODP APIs aim to improve portability of networking functions (e.g., VNFs) while providing high performance thanks to the exploitation of the platform's hardware accelerators.

[8] QEMU, a Fast and Portable Dynamic Translator, F. Bellard, USENIX Annual Technical Conference, FREENIX Track, 2005

[9] About ODP, http://www.opendataplane.org/about/

ODP, together with Intel DPDK, is one of the OPNFV targets for the data path acceleration. However, while DPDK is more focused on x86 architecture, ODP is targeting ARMv8, Intel, MIPS and PowerPC platforms.

VOSYS plans to monitor and contribute to ODP in the regards to the following SESAME related aspects:

- Implementation of SESAME's accelerators support for ODP, aiming to improve VNFs performance and portability on ARMv8 platforms.
- Development of the ODP port for the SESAME ARMv8 target platform.

3.4.8 NSP

The NSP (Next Generation Network Service Platform) Consortium is an initiative which targets to evaluate, test and benchmark existing platforms for NFV, in order to propose the missing parts/technologies based on real operations. By means of evaluation reports, proof of concepts and whitepapers, the consortium targets to influence standardization activities such as IETF SFC, NVO[10], NFVRG, vnfpool, i2nsf and ETSI NFV. NSP consortium members include Intel, IXIA, HP, Dell, Cisco as well as Virtual Open Systems[11].

VOSYS plans to monitor and to disseminate SESAME results within the NSP consortium, targeting to leverage on the consortium resources in terms of expertise and know-how, to better exploit the outcomes of the project.

3.4.9 OpenFastPath

OpenFastPath (OFP)[12] is an open source implementation of a portable user space high performance TCP/IP stack which uses OpenDataPlane to interact with hardware accelerators. It aims maximising throughput and scalability by minimising overhead of the Linux OS. The project has been publically announced in December 2015, and thus it is in an early development stage.

VOSYS will examine the possibilities of contribution to OFP. The scope of this activity includes the following aspects:

- Networking performance improvement and acceleration of the KVM hypervisor, VNFs and of the LightDC virtual switch.

3.4.10 SnabbSwitch

SnabbSwitch[13] is an open source (Apache 2.0 license) virtual switch for the KVM hypervisor, written in a high level programming language (Lua) and designed to run in user space. SnabbSwitch uses the LuaJIT (Lua Just In Time) trace compiler to optimize the source code compilation at runtime depending on the packets passing through the switch. In addition, SnabbSwitch is completely independent from Intel DPDK and Open Virtual Switch (OVS), and provides high performance[14] thanks to vhost-user, the technology developed by Virtual Open Systems to connect the switch with the KVM guests.

VOSYS plans to monitor, enhance and improve SnabbSwitch to support the SESAME networking acceleration techniques. The scope of this activity may include the following aspects:

- Design and Implementation of Ethernet based VM to VM communication mechanisms.
- Development of SESAME HW acceleration support for the LightDC virtual switch.
- Implementation of SESAME networking acceleration support for the LightDC virtual switch.

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[10] NSP website: Http://www.next-nsp.org/?lang=en
[11] NSP members, NSP website: http://www.next-nsp.org/?page_id=178&lang=en
[12] OFP technical overview, http://www.openfastpath.org/index.php/service/technicaloverview/
[13] SnabbSwitch Official website: https://github.com/SnabbCo/snabbswitch
[14] Paolino et al., SnabbSwitch user space virtual switch benchmark and performance optimization for NFV, IEEE NFV-SDN Conference 2015.

3.4.11 OMiLab

The Open Models (OMi) Laboratory[15] is a dedicated research and experimentation space for modelling method engineering. Both a physical and virtual place, it is equipped with tools to explore method creation and design, experiment with method engineering and deploy software tools for modelling.

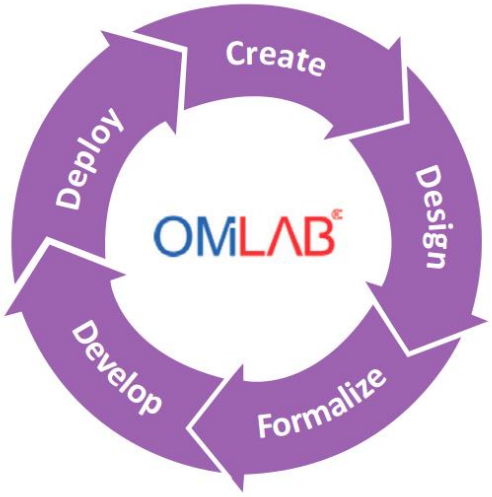

Figure 8: OMiLaboratory Lifecycle

Open to all those interested, the laboratory is a platform where all participants can bring in ideas related to modelling and engage in the exploration process. The lab's idea is to "act" as a facilitator to the development and application of scientific methods to communities who value models, and implicitly modelling methods. It is open to all application domains which can benefit from the use of models; it promotes openness of community projects and encourages communities to share their projects to the extent feasible.

As the construction of modelling methods is a complex task, the OMi Laboratory introduces the OMiLaboratory Lifecycle which uses the "Conceptualization Process" as a framework for developing modelling methods. Starting with the "Creation" step and ranging until the "Deployment" of the modelling method as an IT-tool, the laboratory provides the conceptual steps, the collaborative environment and the necessary working resources. For the "Design", "Formalization" and "Development" steps the OMi Laboratory makes an open use of the ADOxx meta-modelling platform (https://www.adoxx.org). Such a platform allows the use of concepts that support the modelling method engineering process (e.g. patterns, DSML) and formalisms which favour the re-use/evolution/variants of modelling methods. It also grants openness to other tools and open source add-ons.

As part of SESAME, UoB will contribute to the OMiLab with the development of security-*aware* methods and tools for the definition and analysis of security at conceptual level and relevant to the scenarios and domain of the SESAME project. In particular, we will build on our previous work on the Secure Tropos methodology[16] (www.troposproject.or/node/301) and will enhance both the theoretical framework and the tool and will make it available through the OMiLab repository.

[15] Open Models Laboratory (OMiLab) - http://www.omilab.org/

[16] See, for example: Mouratidis H., Giorgini P. (2007). Secure Tropos: a security-oriented extension of the Tropos methodology. *International Journal of Software Engineering and Knowledge Engineering, 17*(02), 285-309.

3.5 Initial plan for standardization

In general, SESAME will coordinate our standardisation activities with the 5G-PPP pre-standardisation group especially focusing on 5G-*specific* standardisation. However, within the SESAME scope, the following section provides the projects initial plan and actions for potential input into standards and liaison with 5G-PPP.

At the end of 2015, SESAME has developed a set of 5G use cases and requirements focusing on multi-tenancy in edge networks consisting typically of a light data centre and a number of small cells including the management of the edge network components that make up the CESC system.

In early 2016, SESAME will evaluate the use cases and resulting requirements and will identify any gaps with the requirements being developed in the identified standardisation groups. This will provide clear opportunities for taking SESAME use cases and resulting requirements to the standardisation arena. In parallel, the respective use cases can be socialised with the 5G-PPP team.

The most immediate opportunity will be the 5G requirements being developed in 3GPP RAN study item which is scheduled for June 2016 which the project will consider again in conjunction with the 5G-PPP team. The scope of this group is the Radio Access Network for 5G and the cases will be evaluated, based on this.

The opportunity for related use cases targeting service and management requirements will also be considered. However, the discussion at least in 3PPP is moving towards the 5G (next generation) system architecture so any new use cases identified within SESAME may need to be considered in a later release, towards the end of 2016.

Similarly for other relevant groups, such as ETSI NFV and ETSI MEC where gaps are identified to meet 5G requirements, SESAME use cases may be submitted into these standards groups as a basis for requirements of future releases.

The initial SESAME Architecture is scheduled for March 2016. At this point, the project will “conduct” an initial gap analysis with the standardisation groups identified in the previous sections. In addition, the SESAME architecture will be “synchronised” with the 5G-PPP team architecture activity.

From the 5G infrastructure perspective the more immediately standardisation opportunities for SESAME will be to contribute towards the 3GPP study on new network architectures. The timescales for this study should enable the SESAME project to “mature” the SEASAME architecture before considering potential contributions to standards in the second half on 2016.

Additionally, the project will evaluate the SESAME architecture and consider impacts on the 3GPP RAN Architecture. This will need to be coordinated with the RAN study on scenarios and requirements for Next Generation Access Technologies. Architectural impacts on the RAN will likely be discussed in the second half on 2016.

SESAME is scheduled to deliver the initial component designs in June 2016 and subsequent implementations a year later.

During this phase of the work, the project will conduct an assessment of the relevant existing and emerging protocols and APIs that will be impacted by the SESAME project. In addition to the communication infrastructure standards, cloud standardisation such as OCCI can be considered for adoption in the definition of protocols and APIs for the interaction with the cloud computing components of SESAME.

It is likely that ETSI NFV will be influential in the design of the Management of the CESC. As the design of the SESAME management components progress we will conduct a gap analysis with the management standardisation groups identified in the previous section. This will be carried out in the second half of 2016.

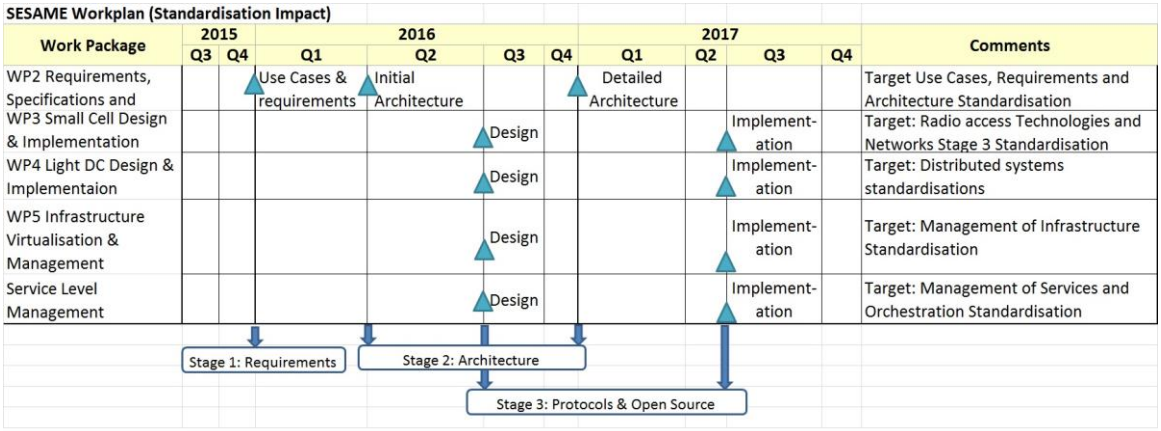

Figure 9: Initial timeline for SESAME impact on Standards

4. Exploitation

In this section, the exploitation of project results including the use of foreground IPR is described. All IPR issues related to the project are governed by the Consortium Agreement. Industrial partners will mainly lead the exploitation endeavour. On the other hand, non-industrial partners will exploit project's achievements through other routes such as know-how development and patent licensing in the field of 5G networking.

4.1 Plan for exploitation of SESAME results

4.1.1 Consortium objectives

The exploitation of the results is essential for the economic impact of SESAME's research. All involved manufacturers, operators and technology providers are committed to the exploitation of the results for the planning of future communication systems and devices. The exploitation of the results has different objectives:

4.1.1.1 General objectives

Dissemination of SESAME technology as a global standard – As described in Section 3, several standardization bodies and organizations that are relevant to SESAME have already been identified. It should be noted that this list of bodies will be constantly adapted during the life-time of the project. Partners of the SESAME consortium have already representation and key delegates in these standardisation bodies.

Contribution to Open Source Results – Since many of the SESAME components are built in Open Source logic, parts of the project results will be available as open source. Although open source is almost equivalent to free, it can be usually accompanied by significant potential for consultancy services and other support actions (i.e. customization, professional support licenses, richer feature editions vs. community editions, etc.). Industrial and other partners can thus transform their commercial business model by bundling consultancy services with Open Source software.

Furthermore, sustainability and continuity of project's results can also be enhanced through their open source nature. SESAME results can also be used, complemented and improved by other projects. By engaging a critical mass of developers and end-users, the products will be sustained without incurring in any costs.

Develop and market new product lines – A quick roll out of the SESAME technology is among the main objectives of the exploitation plan. SESAME results are expected to influence partners' (especially industrial) portfolios. The exploitation through each partner's own organisation is the obvious and natural way to benefit from the results of the project.

Development of a new entity – The cooperation between all partners is intended to be based on shared and strong business interests. The consortium is committed to explore and compare the viability, sustainability and scalability of a large number of different exploitation schemes (e.g., direct exploitation by the partners, creation of new ventures) and take clear "go" and "non-go" decisions as far as those are concerned, which will be reflected at the end of the project in the SESAME business plan. Among other plans, the consortium may potentially form an entity (e.g. a start-up) offering the developed SESAME platform.

4.1.1.2 Objectives by partner type

Network operators –After successful completion of the SESAME project, the operators in the consortium will roll out SESAME technology when available in their core business continents and develop new market opportunities in other regions.

Exploitation of results by manufacturers – Exploitation of project results offers to manufacturers a key strategic opportunity for the longer-term development of their business, both in Europe and globally. SESAME will offer a demonstration platform enabling the transformation of this investment and participation into a substantial commercial opportunity in the time frame beyond 2017.

Technology providers – Technology providers plan to develop services and platforms based on the results of SESAME. They will vastly benefit from SESAME, and they will be able to collaborate with leading companies. This close collaboration will facilitate their strategic position and gain an early-entrant advantage within the market of 5G NFV and SDN. The virtualisation and "cloudification" will result in deep transformation of the network domain, unleashing a high demand of IT and cloud computing expertise.

Universities and research institutes – Universities will exploit the SESAME results through an increase in know-how and ability to support the European telecommunications industry. These organisations will be in a strong position to supply technical support and trained engineers to the European workforce in communications. The research centres within the consortium will create competencies to continue to support industrial partners and SMEs. Several academic partners have experience in the incubation of SMEs and will investigate opportunities with SESAME results.

4.2 Plan for exploitation of SESAME results

In addition to the common objectives, the individual SESAME consortium partners are working to achieve their own commercial or academic objectives:

4.2.1 Operators

4.2.1.1 Hellenic Telecommunications Organization S.A. (OTE)

Hellenic Telecommunications Organization S.A. (OTE) is the incumbent telecommunications provider in Greece, and together with its subsidiaries forms one of the leading telecom groups in South-Eastern Europe. OTE is also an active member of the Deutsche Telekom (DT) Group of Companies in the broader European/international framework. OTE's aim is to deliver increasing value to its shareholders, while improving the quality and value of its services to customers. To this end, OTE seeks to be the "first choice" of consumers in the markets in which it operates.

OTE's key strategic priorities are to optimize all processes by means of sustainable cost reductions, while making ongoing improvements in flexibility and productivity; expand broadband penetration in the domestic market, while safeguarding OTE's leading role, with maximum utilization of the Company's competitive advantages through the provision of innovative products, services and integrated solutions; make the most of technological convergence by creating commercial proposals, and constantly improve customer care, and; focus on domestic and international activities with the best growth potential.

OTE's capital expenditure program currently focuses on mobile services, Internet Protocol services and broadband, expanding backbone network capacity by using DWDM and network dimensioning to maintain quality. The primary aim of OTE's research and development activities is to introduce new technologies and services to its network in a systematic and efficient manner, to examine and test new technologies and products and to maintain active testing grounds of the technologies used in its network(s).

Under this scope, and taking into consideration the fact that over the last years the Company has been investing in enhancing the capability of its telecommunications networks, OTE's increased interest for active participation in promising, ambitious research initiatives becomes more than simply "evident". Promotion, implementation and deployment of innovative research ideas, in cooperation with distinguished partners from the academic and business world, lies within the priorities of OTE's strategic plans. Such a collaborative effort is in fact a proper way to achieve a targeted, integrated, successful outcome, through the united expertise of various from different sectors.

The overall goal of the SESAME project is to exploit NFV and Cloud Computing (CC) for introducing intelligence to the network edge, to enhance the Small Cell concept and to consolidate multi-tenancy in

communications infrastructures. Virtualization and cloud technologies are indeed of great interest for a modern and competitive operator, such as OTE. These technologies can improve the current core networks in terms of capacity, flexibility and network design optimization, which can bring a lot of savings in the respective Group of companies that are extended in the South-Eastern Europe, also being in parallel with related policies and strategic aims of the DT Group of Companies. Except for the capacity and performance improvement, OTE aims to exploit the outcomes of the project in order to apply a better network design process.

Furthermore, OTE will disseminate expected benefits for the market sector, directly in the marketplace. Relevant results shall be presented in the scope of business and scientific fora and other events, at national, European and international level.

OTE plans to "integrate" proposed (SESAME-*based*) technologies into its current network in order to improve the overall network operation as well as to provide more sophisticated services to its customers. The ultimate goal is to make wireless heterogeneous networks "work together" in order to achieve the best performance, both from the network perspective as well as referring to the clients' experience.

To conclude, the work that will be carried in the project will aid to "face" important challenges expected for future network deployments and future implemented services that have to be flexible and dynamically adjustable in order to provide CAPEX and OPEX cost reduction and performance benefits. OTE will use the results of the project for improving and optimizing network resources and services offered to its users.

4.2.2 Manufacturers

4.2.2.1 IP Access Limited (IPA)

IPA has identified the multi-operator vertical applications market as a "key" to its future product strategy. Specifically, the MOCN - *based* Network Slicing technology and associated Management Architecture and solution have a strong place in our roadmap.

We have trademarked MOCN with enhanced management and active resource sharing as Super-MOCN™ or SUMO™ and will be offering it to our customers as part of our roadmap. The intent is to deliver a first release of this to a first customer in 2016, which is a date accelerated by the SESAME funding. Subsequent releases should follow in 2017.

The RAN Virtualisation aspects of SESAME we expect to exploit in a longer timeframe, when the customer benefits and fronthaul requirements become clearer. At present, we can see some technical benefits to a Virtualised Small Cell, but they are offset by the cost of the high performance fronthaul.

Thirdly, if the Light-DataCentre architecture shows a strong customer benefit, we are likely to incorporate that into our roadmap in a future release, coupled with SUMO™ to offer a specifically multi-operator solution for both RAN access and Mobile Edge Applications Hosting, aligned with the industry trend towards Mobile Edge Computing (MEC).

None of these aspects should be taken as a commitment to implement by IPA at this early stage in the project, but as roadmap ideas to be explored and exploited as the benefits emerge.

4.2.2.2 Italtel S.p.A. (ITL)

ITL designs, develops and implements, in Italy and in many countries worldwide, products and solutions for Next-Generation Networks services, based on IP protocol. Its offer includes proprietary products, engineering and network consultancy services, managed services and solutions such as VoIP, unified communications & collaboration, HD video communication, interconnection solutions, Next-Generation Data Center, Mobile Broadband and Internet of Things solutions. SDN, NFV and WebRTC are among the focus areas of its R&D activities. The know-how gained in the management of complex networks allows Italtel to operate where ICT and telecommunications converge to define new solutions for the communication needs of each of us, both in the workplace and in private and social spheres.

Leveraging the innovation carried out by SESAME project, ITL will exploit it for the innovation of its product line getting high performance Edge Cloud solutions at lower costs, enabling a possible expansion towards mobile market.

First step will be taken in enhancing the ITL commercial offer of VNFs related to Multimedia Communication (e.g. audio and video transcoding) at the network edge increasing performance and lowering costs.

The deploy of VNFs within the SESAME architecture, as envisioned in this project, can offer promising opportunities to improve Italtel's solutions in the Unified Communication sector, offering highly innovative services especially in the Enterprise sector (including public administrations, university campuses, hospitals, etc.).

4.2.2.3 Fujitsu Laboratories of Europe Limited (FLE)

Background for Exploitation

FLE is the UK headquarters of the Fujitsu European Research Laboratories working with other regional Fujitsu research groups in Japan, US and China. The mission of the laboratories is to provide innovation that can be exploited within Fujitsu's business units worldwide but with a focus on supporting the local business units; in FLEs case this is the various business units throughout the EMEA region.

More specifically, the Future Networking Research Division, who is involved in the SESAME project, focuses on innovation in next generation mobile networks and standardisation particularly focusing on the future radio access networks (in 3GPP). In this area, we work closely with Fujitsu network products business units in Japan who develop radio base station technology (femtos, micros, macros) and radio access network nodes.

The European business units have a focus on Services and Solutions, particularly focusing on the large enterprises in a wide range of vertical markets. To support these businesses, FLE is focusing on innovative services and solutions in particular those that build on the expected increase in performance in future 5G networks, i.e. the next generation of services and solutions.

Finally, FLE is engaged in collaboration activities such as the 5G-IC test beds based in the University of Surrey, in building proof of concept demonstrators and supporting field trials. These are seen as essential steps towards the future engagement with the Fujitsu business units and subsequent exploitation of the underlying technologies.

Exploitation with SESAME

Our primary area for exploitation is based around the use cases derived from the Enterprise Scenarios that are being defined within the project. In particular, use cases that exploit the features of the 5G/SESAME architecture, such as reduced latency through deployment at the edge in the Light Data centre, will be used as both a "source of innovation" and a means to illicit strong interest from Fujitsu businesses. The value proposition for these use cases will be developed in FLE.

Another important area for FLE will the impact on standardisation based on the SESAME architecture and specifications for the Small Cells and Light Data Centre. FLE will evaluate the benefits and value of such impacts and propose standards contributions, in conjunction with Fujitsu standardisation team and take these to the relevant standardisation bodies. In particular, successful contributions to standards that impact our network products (small cells) will be exploited by our business units.

From a demonstration perspective, FLE's plan is to focus on Service Level virtualised functions that can be used to demonstrate 5G-*enabled* use cases, based on light data centre architecture both externally and with the Fujitsu business units. This is seen as a key step towards exploitation from a business point of view. For FLE the following step would be to take such proof of concept demonstrators towards a limited field trial based on available 5G platforms.

Another aspect that FLE will exploit within our European businesses is services based on orchestration and virtualised network/service functions. In particular, managed network services for enterprises that deploy a light DC infrastructure are seen as a potential business opportunity.

Finally, within FLE we are keen to promote innovative services and apply these to different vertical market sectors based on the SESAME's concepts and solutions.

4.2.2.4 STMicroelectronics Grenoble 2 SAS (STMicroelectronics)

STMicroelectronics -or ST- is a world leader in providing the semiconductor solutions that make a positive contribution to people's lives, both today and in the future. ST is one of the world's largest semiconductor companies offering one of the industry's broadest product portfolios. ST serves customers across the spectrum of electronics applications with innovative semiconductor solutions by leveraging its vast array of technologies, design expertise and combination of intellectual property portfolio, strategic partnerships and manufacturing strength.

ST focuses its product strategy on sense and power technologies, automotive products, and embedded-processing solutions. The Embedded Processing Solutions provides turnkey SoCs that can be used in different markets. Since its creation, ST has maintained an unwavering commitment to R&D. Almost one fifth of its employees work in R&D and product design. Last but not least ST draws on a rich pool of chip fabrication technologies, including advanced FD-SOI (Fully Depleted Silicon-on-Insulator) CMOS (Complementary Metal Oxide Semiconductor) providing outstanding power efficiency at all operating levels, including fan-less designs, along with highly-efficient RF and analog integration.

Leveraging the activities performed in SESAME, ST has the opportunity to work on our silicon platform 3 year in advance before the real 5G field trials. ST is proposing very high performance silicon platform using multiple 64-bit ARM® CPUs to deliver >10K DMIPS, line-rate networking support on every port, and hardware acceleration for routing and switching, allowing Multiple System Operators to build future-proof Light Data Centre with plenty of headroom to support the new 5G services. This silicon platform is unique in the sense that is implemented in FDSOI therefore enabling the low cost solution required by the 5G infrastructure. This platform is going to be exploited by Embedded Processing Solutions organization to expand the current business lines to address the networking and in particular the 5G market. Thanks to SESAME, our silicon can be used by companies such as Italtel to realize their 5G product lines.

4.2.3 SMEs

4.2.3.1 Virtual Open Systems SAS (VOSYS)

VNFs computing acceleration and high performance networking are what Telecom operators are looking for to transform the mobile broadband industry. As a matter of fact, their involvement in fora and consortia such as NFV, OPNFV, MEC, NSP, etc. is mainly focusing on hardware accelerators, VNFs portability and network performance optimization.

Virtual Open Systems SAS (VOSYS), a start-up company expert in virtualisation technologies, plans to exploit SESAME's outcomes by entering into the NFV market with a product which combines NFV and MEC concepts. Moreover, thanks to the skills and the experience coming from the SESAME efforts, VOSYS will be able to offer new and more competitive virtualisation service solutions to the NFV market.

In fact, low power consumption, high performance, HW accelerators such as FPGA, GPU, etc. are of general interest in virtualised systems. As a consequence, the networking and computing virtualisation extensions developed by VOSYS in the context of SESAME, will be also exploited in markets different from NFV, i.e., High Performance Computing, Cloud computing and Data Centers, Mobile computing, etc.

Finally, VOSYS plans to use European Patent Office (EPO) IPR protection for innovative technologies developed during the project.

4.2.3.2 ORION Innovations Private Company (ORION)

In order to handle the increasing 3G/4G data traffic and the emerging full-scale Machine-to-Machine (M2M) communications, the Mobile Network Operators (MNOs) have to transform their networks radically in the coming five years. Both network transformation directions (either the Traditional or the Virtualized ones) have high corresponding costs. In a five-year cost comparison between networks that

employed Traditional and Virtualized means to transform mobile core (i.e., EPC), ACG Research uncovered these key findings[17]:

- Network operators cut their CAPEX spending more than half (68%) by choosing a Virtualized Approach for their Evolved Packet Core (EPC) solution;
- Moving to an NFV-based mobile core platform reduced MNOs' operating expenses by 67%;
- MNOs who moved to an NFV-based platform began saving money in Year 1 with a payback of their investment in 3 years;
- MNOs that adopted a Virtualized Approach were able to turn up services much faster (<6 months) than MNOs that used a Traditional Approach (15 months).

Apart from studies, facts behind NFV plainly suggest that telecom industry as a whole is moving quickly to LTE network virtualisation:

- AT&T recently announced that it will migrate 75% of its customer-facing network to a virtual, Software-controlled platform by 2020[18].
- China Mobile announced similar plans to move its global network to an NFV-based architecture[19].
- Vodafone Spain recently built, tested, and launched its new Mobile Virtual Network Operator (MVNO) service in only three months using a virtualised approach — 4x times faster than a traditional MVNO service launch[20].
- Leading NFV vendor Affirmed Networks reports more than 20 network operators have purchased virtualised mobile core technology for their networks, with another 40 operators in the testing and development phases[1].

In this context, ORION recognized early the emerging decoupling of software and hardware via NFV technologies, and the introduction of successful, open source software stacks for networks. The participation of ORION in SESAME is fully aligned with the company strategic decision to move towards the software-*driven* telecom segment. ORION is willing to participate to open network ecosystems, like the platform proposed in SESAME project, that no longer are limited to the large manufacturers and their telecom customers. In this context, ORION is involved in the area of 5G networking, and it is one of the few European SMEs that achieved to participate in the H2020 5G-PPP Program. The company's involvement will be to exploit its experience for development of a multi-tenant Caching VNF.

ORION expects to obtain significant insight from the results of SESAME project, which will reinforce the company's position in the communication and networking field through the upgrade of existing software solutions as VNF suitable for the network edge. Specifically by participating in SESAME project, ORION aims to understand, evolve and exploit its existing caching software for virtualised usage. This will enable the capacity of transforming company's current line of business applications in the field of networking solutions to virtualisation specific.

4.2.3.3 Athonet SRL (ATN)

ATN will take advantage of the SESAME project to give more pace to the design of 5G future networks and to cater for innovation from the VNF/SDN solutions that will be exploited in the project. This will bring new business opportunities for the internal network of customers, and will help strengthen Athonet's position in the internal Italian market, and worldwide.

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17 ACG Research, Total Cost of Ownership Study Virtualizing the Mobile Core, July 2015, http://www.affirmednetworks.com/wp-content/uploads/2015/07/TCO-Report_7.13.15_ACGTemplate.pdf

18 The Wall Street Journal, AT&T to Virtualize 75% of its Network by 2020, http://blogs.wsj.com/cio/2014/12/16/att-to-virtualize-75-of-its-network-by-2020/

19 Mobile World Congress 2014 - NFV on LTE Network from China Mobile, https://www.youtube.com/watch?v=IyIJO9RNCr4

20 Vodafone Spain: Virtual in more ways than one, http://www.telecomtv.com/articles/mobilecore/vodafone-spain-virtual-in-more-ways-than-one-12121/

4.2.3.4 INCITES Consulting S.A.R.L. (INCITES)

As a market research company, INCITES Consulting S.A.R.L. will take advantage of SESAME project to enhance its future market reports and seminars related to 5G, with specific focus on business cases and opportunities via advanced innovative services / use cases. Those market reports will be used by stakeholders involved in the industry to better understand the opportunities in the new era of 5G networking, VNF, SDN, softwarization and cloudification. The SESAME project will then help strengthen INCITES Consulting S.A.R.L. position as reference international centre of excellence for 5G.

4.2.4 Universities and research institutes

4.2.4.1 CNET

CNET (Center for Research and Telecommunication Experimentation for Networked Communities) is a research centre which pursues innovation among its key objectives, with increasing focus on Future Internet (FI) applications and services. CNET has already created five spin-off companies coming from the experience within past framework research projects; and the local public bodies are encouraging and provide strong support to these initiatives. Further, through the TrentoRISE and EIT ICT Labs involvement, CNET has been able to attract angel investment for its start-ups. Within SESAME project, CNET will develop competences toward the development and implementation of 5G systems, with the latter materialized by an open programmable test-bed with the aim of creating a scalable platform for testing cutting edge technologies. Indeed, the test-bed shall rely on cutting-edge Software-Defined Networking and Network Functions Virtualization approaches to enable a programmable platform where to experiment advanced control and management functions. The innovations from SESAME will be candidate for further business exploitation in collaboration with Italian (and international) SMEs and companies based on the application scenarios, with a broader impact and market target. Furthermore, CNET plans to exploit the results of the project by: (i) Exploring the patenting of innovative algorithms and approaches developed throughout the project, and; (ii) licensing the exploitation of results to third parties.

4.2.4.2 University of Surrey (UNIS)

The Institute for Communication Systems at the University of Surrey is an academic research institute which is also home to the 5G Innovation Centre (with currently 25 industry members). Being a University institute in the area of mobile and wireless communications and services, project findings are directly included in the curriculum of our communications related courses, in the case of the results we expect to produce in SESAME, they are foreseen to be included in the 5G Systems M.Sc. course that has been started in the academic year 2015/6. In addition, the SDN/NFV related work is expected to flow into our communications network courses and will be considered for the updated curriculum in the academic year 2017/8. As an academic research institution, our main focus is on producing scientific papers and to publish them in the suitable venues, yet beyond this academic pathway to impact, we have also established, as part of the 5G Innovation Centre, a so called special purpose vehicle (SPV) company that helps securing and marketing IPR produced in different projects. The inventions our researchers are expected to make in SESAME will be scrutinised for their commercial applicability and impact potential and -where viable- will be supported and exploited through licensing through this SPV company we have established.

4.2.4.3 University of Brighton (UoB)

UoB has individual exploitation strategy, which is based on two main directions:

a) Commercialisation and Industrial Collaboration.

The University of Brighton is committed to the development of an “innovation culture” based on the generation of knowledge, some of which will need to be protected. The results of the SESAME project will allow UoB to improve its existing tool portfolio in the area of security and threat analysis for 5G architectures. The University of Brighton is planning to explore the commercial potential of those tools and services and decide on the most appropriate route for exploiting those results. Such route might take

the form of licensing, assignment, or sale, to existing or newly formed entities. We also expect to exploit the results of the project through industry events (e.g. exhibitions) as well as by contributing to relevant Open Source initiatives (such as the OMiLab described Section 3.4.11). Furthermore, UoB plans to disseminate the results of the project to the Gatwick Diamond Initiative (http://www.gatwickdiamond.co.uk) through direct dissemination activities with selective set of companies.

b) Consultancy, Training and Technology Transfer

Over the last few years, UoB has been engaged in several research and technology transfer activities including the Knowledge Transfer Partnership (KTP) programme funded by the UK government, industry organisations and research councils. Programmes such as KTP, is a good basis for a proactive commercialisation of the results of SESAME. Moreover, the results of the project will bring an important added value to UoB consultancy services and tools and solutions developed within the project will be used for such activities. UoB will also explore the organization of relevant training events to further make use of the SESAME project results in a commercial manner. Furthermore, involvement in the software development, integration and testing stages of the project will contribute to the educational activities of UoB. In particular, the results of SESAME will inform teaching content within the realm of UoB's M.Sc. Information Security programme. SESAME will be presented and act as the basis for motivating 5G security in multi-tenant wireless communications infrastructures

4.2.4.4 EHU

The University of the Basque Country (UPV/EHU), as an academic and research institution focuses its H2020 objectives on the exploitation of outcomes through the dissemination and communication activities, benefiting the research community and the society in general.

At the same time, the transfer of knowledge and technology to the industry (with special focus in the Basque industry) is of utmost importance, especially in this global competitive era.

The EHU Innovation and Transference Office supports different alternatives to convert research results into market opportunities. For innovative research outcomes, patenting is the usual approach in order to exploit the solution through partnering companies. In case that significant products or modules are to be developed during the project, the alternative to create a spin-off to directly exploit the product/service is always considerable.

The individual knowledge and expertise acquired in SESAME may be exploited by the research group to engage other regional and national companies aiming at proposing specific technology transferring projects.

Finally, the research group involved in SESAME is active in several standardization bodies. Mainly, different outcomes of previous projects have been contributed to ITU-T SG12 and SG13 and are in the process of adoption as recommendations and technical reports. Besides, they participate in the Multimedia Communications Technical Committee (MCTC) of the IEEE Communication Society and are member of ETSI and 3GPP. Depending on the specific results of the project, different standardization initiatives could be undertaken.

4.2.4.5 Fundació Privada i2CAT, Internet i Innovació Digital a Catalunya (i2CAT)

Being a non-profit technology centre, which promotes R/D/I activities in the field of information and communication technologies and future internet, i2CAT plans to use the results obtained within the SESAME project in order to: a) further enhance its knowledge and competence in the field of network function virtualisation and orchestration; b) spread this knowledge through participation in the project dissemination activities, focusing on the potential regional exploitation opportunities.

To achieve the first target, i2CAT will take the advantage of the established collaboration network within the SESAME project to gain a valuable experience and understanding on the deployment of reliable SESAME NFVI, which consists of Light DC and small cell resources. Furthermore, the work that will be carried out in the SESAME project will aid i2CAT to extend its know-how and portfolio on the NFV orchestration and management. The second goal will be reached through i2CAT efforts on promoting

project achievement dissemination via publication in reputed conferences and journals as well as appearance in related wireless realm workshops, focusing on the small cell design and virtualisation, and also those events related to the NFV and dynamic orchestration topics. Additionally, i2CAT plans to spread the SESAME outcomes among its board members, which represent well-known industrial stakeholders in the telecom market at a national and regional level.

4.2.4.6 National Center for Scientific Research "Demokritos" (NCSRD)

NCSRD will exploit the outcomes of SESAME in the area of virtualised software networks, as a step towards the establishment of a high research and scientific status in all the layers of the NFV Management and Orchestration framework. Through its involvement in the activities of SESAME, NCSRD will be in a position to enlarge the previously established expertise in Management and Orchestration to the 5G environment. Its demonstrations will enrich the developments stemming from FP7 ICT T-NOVA project, thus allowing the constitution of an innovative Orchestration framework. NCSRD intends to build upon the management interfaces and evaluate innovative Use Cases where VNF based solutions can apply. The vDPI use case as defined by the project is of particular interest towards this. NCSRD hosts a fairly large Technological Park called "Lefkipos", acting as an incubator for small start-ups and spin-off SMEs. In this context NCSRD will explore further exploitation possibilities, through the establishment of spin off or start-ups. NCSRD will make use of SESAME results in its research activities and in introducing new topics for Ph.D. Theses.

4.2.4.7 Zürcher Hochschule für Angewandte Wissenschaften (ZHAW)

The InIT Cloud Computing Lab (ICCLab) at ZHAW follows a structured approach to research that is based on three driving principles: Scientific Foundation, Strategic Impact and Knowledge Transfer.

The Scientific Foundation is where the ICCLab research strategy and portfolio is defined, through the participation in funded research projects that provide the ground for the development of research initiatives that have been identified by the group as notable and eligible for further investigations. This foundation principle consequently provides the opportunity for the acquisition of new knowledge and for the consolidation of existing research areas or the establishment of new ones.

The research advancements obtained at the Scientific Foundation layer are then transformed in tangible impact (Strategic Impact principle), concretely represented by publications, open source releases, products and contributions to standardization committees. Since ZHAW is an applied research institute, the generation of impact and the community uptake of our results is an extremely important target to be achieved in our roadmap. Open Source releases are then a fundamental mean to facilitate this process and they also prove useful to collect direct feedback on our activities. In the industrial context, the goal of the ICCLab is to transfer knowledge acquired through foundational research and validated with its strategic impact to Swiss and European companies. This is achieved by consultation or through the definition of specific transfer projects.

Alongside the three principles outlined above, research results obtained at the Foundation, Impact or Transfer layers are constantly transposed to education where students are reached in classes, thesis works and internships. Figure 10 outlines the ICCLab research approach.

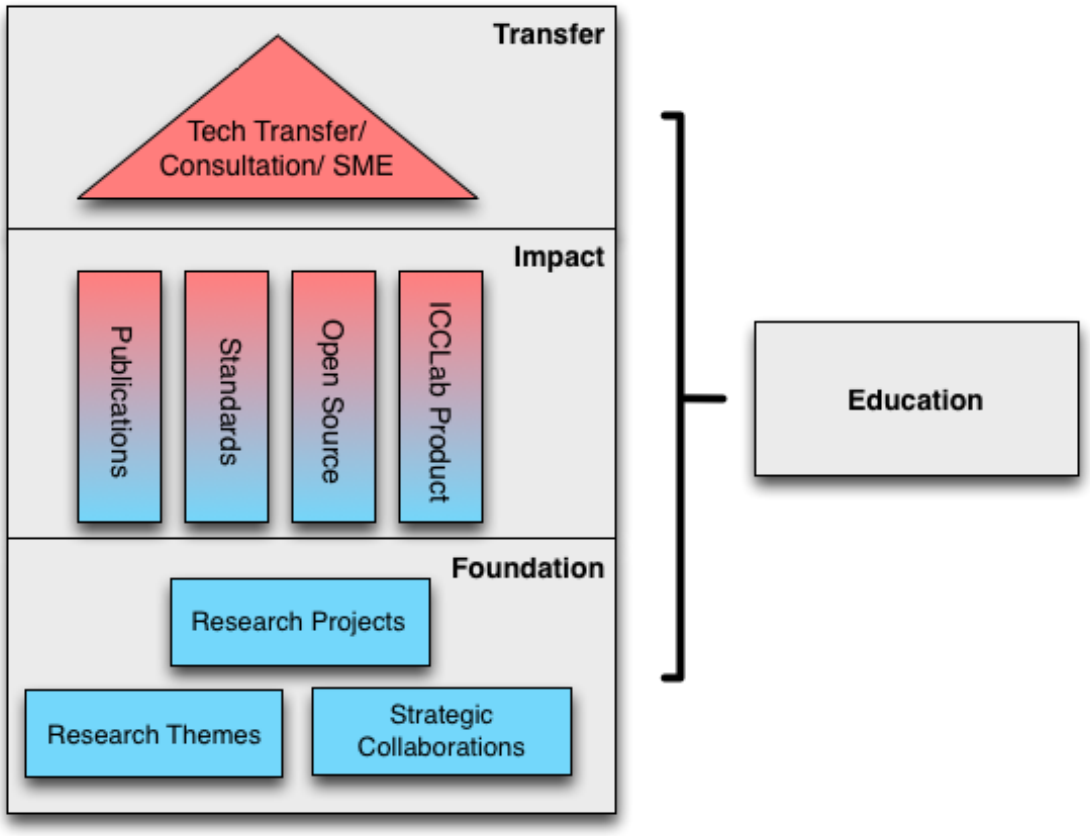

Figure 10: ICCLab Research Approach

The SESAME project perfectly integrates within this scheme, and the ICCLab at ZHAW will use the results of the project to consolidate and expand three research initiatives operating in the broader IaaS (Infrastructure as a Service) research theme. In particular the SDN research initiative will exploit SESAME as an opportunity to further develop the studies on NFV and the flow-based interconnection of the virtual functions managed by SDN controllers (Service Function Chaining). The project also provides a unique opportunity for this initiative to explore concepts that are more tightly coupled with Radio Access Network technologies and identify ways to merge cloud computing designs with the requirements coming from the sphere of telco operations, an aspect which will prove to be fundamental for the development of 5G architectures, especially since mobile operators multi-tenancy is considered in the project scope.

The Cloud Orchestration initiative will take-up the results that will be obtained in the design and development of the CESCM component of SESAME, which will manage the service composition aspects and the deployment and monitoring of resources across the CESC clusters. Acquired knowledge will be used for the further expansion of the already released open source Hurtle project [19].

Finally, the cloud storage initiative will adopt project results that will be obtained in researching optimal ways to design the peculiar infrastructure constituting the LightDC, with specific requirements dictated by the heterogeneous hardware to be employed, the distributed nature of the deployment (operating at the network edge) and the constraint necessary to satisfy energy efficiency requirements.

To summarize, ZHAW plans to exploit SESAME results in three research initiatives at the ICCLab: Software-Defined Networking, Cloud Storage and Orchestration. With respect to the SESAME architecture, the following elements will be respectively exploited in each initiative: NFV chaining and Cloud RAN, LightDC design, CESCM and service orchestration.

The exploitation of such expected results across the initiatives will then be applied according to the driving principles of our research: the ICCLab will generate impact with open source developments, publications and contributions to standards, while consolidated work coming from the research exploration conducted in SESAME will enable the definition of new transfer schemes with industrial

partners. In addition to this, project results of SESAME also represent a mean to validate the research efforts already spent within the initiatives.

4.2.4.8 Universitat Politècnica de Catalunya UPC

Universitat Politècnica de Catalunya (UPC), as a public institution dedicated to higher education and research including telecommunication engineering, is forward-looking and seeks to teach high quality technical courses that are responsive to the training needs and requirements of traditional, evolving and newly-developing production sectors. Therefore, as a reference institution in Spain, UPC is going to exploit its participation in the project in order to further strengthen its ability to pursue research, development and teaching activities both for its own benefit and for the benefit of its country and the EU in general. In particular, the obtained expertise by UPC in SESAME is expected to be applied to:

- Bring the forefront of technological development into their syllabuses to educate future engineers. Specific SESAME concepts that are identified as relevant in this respect include the introduction of virtualisation technologies for deploying small cell networks, the novel models derived from the use of multi-tenancy and the application of AI-based concepts for enhancing *self-x* functionalities. It is expected that consolidated contents can be brought to teaching programmes already for the academic year 2016-17, as part of the courses on "Telecommunication Systems" and "Resource Management in Wireless Communications".
- Carry out doctoral and post-doctoral research in areas related to the SESAME project.
- Disseminating main results in conferences and relevant forums as well as through publications in magazines and journals. UPC is committed to keep a proactive role in identifying and contributing to any relevant dissemination opportunity.
- Continue a close collaboration with the Spanish non-profit institution COIT (Official College of Telecommunications Engineers), which contributes to bringing together and reinforcing the different institutions and companies of the telecommunications sector in Spain, including acting as an advisor to the Ministry of Industry. Currently, specific activities are envisaged at the COIT related to 5G views, to which UPC expects to contribute highlighting the relevance of the introduction of virtualisation technologies in the small cell deployments.
- As a result of the work that is envisaged in WP3, it can arise the opportunity to fill patent applications for some selected algorithmic solutions proposed and assessed in the framework of SESAME, and pursue its exploitation through interested companies, with particular emphasis for industrial partners in SESAME.
- To improve the UPC's postgraduate and customized training courses, facilitating the convergence between research departments and public or private companies.
- Stay competitive for future research initiatives in different domains (H2020, national programmes, etc.).

4.2.5 Technology providers

4.2.5.1 ATOS Spain S.A. (ATOS)

Currently, ATOS' Telecom sector provides services to more than 220 telecommunication companies worldwide, including solutions for Next Generation Intelligent Networks (NGIN), service platforms, Big Data, Smart Mobility, Cloud computing, e-transactional services and system integration. A horizontal goal for these portfolios is to prepare and expand them for 5G, and in the context of SESAME, to deliver optimized services that leverage telecom customers' improved integration of virtualised Small Cell access networks.

The CESCM is a new network element in charge of managing the computing capabilities of the CESCs and optimizing the use of network resources and service delivery according to the overall status of the network and computing parameters.

This will constitute a new asset for ATOS, based on the Small Cell Manager concept developed in the scope of the Tropic project [www.ict-tropic.eu].

Atos intends to be strategically positioned to help customers willing to adopt this approach. Market triggers would include evolution of the CESC concept, support in the small cell manufacturer supply chain, and proof of concept deployments, where the company would be able to service as a first-mover technology provider through cloud computing, smart mobility and system integration services.

NFV and SESAME bring the possibility of evolving the Mobile Edge Computing (MEC) a model further. SESAME allows a myriad of applications to be executed remotely but close to the end user. The offloading of applications to a near small cell cloud as proposed by SESAME can be exploited to implement a number of existing services and applications (e.g. location-*based* context, advertisement, gaming, etc.) moving the intelligence from remote clouds or the terminal itself to the network. This also allows a faster and optimal service delivery considering jointly radio and cloud and, *at the same time*, relieving the scarce resources of the end terminal preserving the battery lifetime.

Based on these possibilities, SESAME is an opportunity for ATOS to explore new ways of exploiting some of its key global offerings, mainly in the domain of cloud and smart mobility:

- Smart Mobility and Journey Management solutions are examples of global portfolios that could be extended changing the intelligence from the mobile device to the CESC.
- Worldline's Tempo21 (part of the ATOS group) specialized in mobile applications for both the public and private sector. Knowledge and technology transfer include requirements gathering for a variety of future 5G scenarios, including next generation small cell environments.
- Media content distribution in smart stadiums and Olympic Games, a key deployment scenario for small cells.
- Big Data solutions by ATOS can also leverage from SESAME taking some of the analysis computation close to the sources where the data is produced.
- Cloud system integration, supporting telecom provides or third-party service providers to exploit a CESC deployment.

4.3 Activities and Processes

4.3.1 Management of IPR

All IPR issues relevant to SESAME's project results are ruled by the Consortium Agreement.

4.3.2 Evaluation of effectiveness

SESAME will establish an evaluation process that is meant to document the achievement of objectives in the exploitation of project results, e.g. in the area of standardisation.

5. Interaction with 5G-PPP

SESAME has adopted the commitment to support and participate in the 5G-PPP as well as to the WG defined by it. In particular, it acknowledges the roles and commitments of the European Commission, the PPP partnership board, the Networld2020 ETP, the 5G Infrastructure Association, the Industry Advisory Group and commits to constructive interactions with these bodies. Research results from 5G-PPP projects will be contributed to the global 5G debate via established channels to the international standardisation and regulatory process.

In addition SESAME partner ATOS is member of the 5G-PPP and NetWorld2020 Steering Board, capable to facilitate an effective interaction with these bodies.

5.1 Objectives

The overall strategic objective of the 5G-PPP is to support harmonization activities on the 5G vision and requirements as well as system concepts and architectures in order to build consensus ahead of future standardisation. This includes the following operational objectives:

- To establish liaisons with other national and European R&D programs (e.g. Eureka clusters) for the inclusion of the 5G related topics as appropriate and foster the creation of synergies.
- To analyse international activities on 5G and ensure proper positioning of the European 5G-PPP initiative so as to identify and pursue collaboration opportunities e.g. by means of MoUs.
- To establish and maintain necessary contacts and cooperation on global level with similar initiatives in other regions and countries like China, Japan, Korea, North America and others, if new initiatives emerge.
- To ensure coherence and maximum impact of the 5G-PPP and its projects through liaison with other relevant R&D programs.
- Support joint events between 5G Infrastructure Association / 5G-PPP projects and activities in other regions and countries for information exchange and consensus building activities.

The objectives of SESAME communication and dissemination activities include the establishment of links within the 5G-PPP programme, with the aim to exploit synergies for enhancing collaboration and KPI advances, building also a coherent 5G architectural framework. For this purpose, SESAME will participate to the 5G-PPP steering board and different working groups, presenting SESAME advances, comparing and contrasting approaches, material (leaflets, brochures, etc.), reporting contractual KPIs and organizing joint dissemination events.

5.2 5G-PPP projects relevant to SESAME

This section provides an overview of other 5G projects which the SESAME Consortium has identified as relevant to SESAME at the current state of the project. Therefore, the partners will explore the possibility to establish connection, share information on project progresses and whenever possible plan joint activities in the form of joint scientific papers, the organization of joint workshops and technical panels organized in international conferences relevant to the projects (e.g. EUCNC). Possible joint activities will be explored by SESAME through key partners and evaluated on a step-by-step basis as the project evolves.

- **5G NORMA**: 5G Novel Radio Multiservice adaptive network Architecture. 5G NORMA will develop a novel mobile network architecture that provides the necessary adaptability in a resource efficient way able to handle fluctuations in traffic demand resulting from heterogeneous and dynamically changing service portfolios and to changing local context. This “mobile network multi-tenancy” approach will leverage the adaptability and efficiency of network functions and enable an inherent and dynamic sharing and distribution of network resources between operators. These objectives are enabled by innovative approaches in the wireless edge RAN

space through "adaptive (de-)composition and allocation of mobile network functions", "software-defined mobile network control", as well as "joint optimization of mobile access and core network functions". SESAME focuses on the network edge through the CESC concept while 5G-NORMA addresses the 5G E2E architecture. Potential areas for collaboration (e.g. workshop topics) may include: (i) System architecture for provisioning of multi-tenant (multi-operator) Small Cell networks based on computing-enhanced (or cloud-enabled) Small Cells, including the service, MANO, control and data layers; (ii) virtualised infrastructure supported by the CESC clusters, and; (iii) RAN/CORE VNFs for edge-based 5G services. (https://5gnorma.5g-ppp.eu/)

- **5GEX (5G Exchange)**: 5GEx enables cross-domain orchestration of services over multiple administrations or over multi-domain single administrations. This will allow end-to-end network and service elements to mix in multi-vendor, heterogeneous technology and resource environments. 5GEx aims to enable collaboration between operators, regarding 5G infrastructure services. The focus of 5GEx on multiple domains is significant for future sharing models between operators, a common theme for SESAME but on the network edge, as the CESC concept is multi-operator by design. Approaches in NFV management and orchestration will also provide areas for comparison and discussion. (http://www.5gex.eu/)

- **Superfluidity**: Superfuidity proposes a converged cloud-based 5G concept that will enable innovative use cases in the mobile edge, empower new business models, and reduce investment and operational costs. The solutions are based decomposition of network components and services into elementary and reusable primitives; native, converged cloud-based architecture; virtualisation of radio and network processing tasks; platform-independent abstractions permitting reuse of network functions across heterogeneous hardware platforms while catering to the vendors' need for closed platforms/implementations; high performance software optimizations along with leveraging of hardware accelerators. Specific project objectives include i) deployment of service and applications close to users following their particular performance needs; ii) reduction of end-to-end latency; iii) development of 5G standards and production-quality open source code; iv) tools for system orchestration and management and for security, integrating the SUPERFLUIDITY system into one of the leading cloud management frameworks. Given its scope and objectives, Superfluidity has a high relevance to SESAME, since the similar objectives pursued by the two projects. Therefore, through the PB or individual partners, SESAME will make the attempt to establish connection with Superfluidity, evaluating the possibility to create bidirectional information flow, which is functional from time to time to explore opportunities such as joint concept papers and workshops co-sponsoring. (http://superfluidity.eu).

- **COHERENT**: The exponential growth of mobile traffic, drastically increasing of network complexity, and the strong need for internetwork coordination of wireless network resources call for breakthroughs in control, coordination and flexible spectrum management in 5G heterogeneous radio access networks driven by Software-Defined Networking. The COHERENT project aims to address these problems by researching, developing and validating a novel control framework for future mobile networks. The key innovation of COHERENT is to develop a unified programmable control framework to coordinate the underlying heterogeneous mobile networks as a whole. The COHERENT control framework has two unique features to deal with the insufficiency of current control solutions for inter-network coordination. First, theories and methods to abstract the low layer network states and behaviours of different underlying mobile networks are developed, which provides a simplified but sufficient abstracted network view for network-wide control and resource coordination. Second, based on the abstracted network view, common interfaces and software-development kits will be developed to enable programmability in controlling and coordinating heterogeneous mobile networks. The programmable control will provide operators a flexible and cost efficient way to implement new control functions and thus to support new services. The COHERENT project is relevant to SESAME in terms of the network-wide capability to control the network at various levels, to address for example multi-tenancy which is also in SESAME scope, and the interfaces between the radio access network and the control framework. (http://www.ict-coherent.eu/).

- **5G-Crosshaul**: This project aims to develop and provide experimental proof of concept of a programmable transport network which is part of the 5G ecosystem. Such intelligent network will be made of high capacity switches and heterogeneous transmission links (e.g. fibre or wireless optics, high-capacity copper, mmWave) to interconnect remote radio heads, 5GPoAs (e.g., macro and small cells), cloud-processing units (mini data centres), and points-of-presence of the core networks of one or multiple service providers. This transport network will flexibly interconnect distributed 5G radio access and core network functions, hosted on in-network cloud nodes. Multi-technology intelligent switches, or Crosshaul Forwarding Elements (XFEs), are the fabric of this transport network, and they are controlled by advanced applications developed on top of SDN controllers, which control the switch forwarding behaviour appropriately selecting the most adequate outgoing technology. The switching elements connect to base-band processing units, or Crosshaul Processing units (XPUs), which also cater other typical functions of an eNodeB. Such functions can be strategically instantiated within the transport network whereby the approach of NFV and connect them to operators' core network elements. 5G-Crosshaul is relevant to SESAME since it could interface with the key network components developed by SESAME to connect to the core networks of different operators, hence providing a solution complementing the work developed within SESAME (www.xhaul.eu).

- **CHARISMA** proposes an intelligent hierarchical routing and virtualised architecture that unites two important concepts: devolved offload with shortest path nearest to end-users and an end-to-end security service chain via virtualised open access physical layer security (PLS). CHARISMA is relevant to the proposed NFV concepts for positioning and managing the virtualised infrastructure and security by design. The CHARISMA architecture meets the goals of low-latency (<1ms) and security required for future converged wireless/wireline advanced 5G networking. This provides a cloud infrastructure platform with increased spectral and energy efficiency and enhanced performance targeting the identified needs for 1000-fold increased mobile data volume, 10-100 times higher data rates, 10-100 times more connected devices and 5x reduced latency. Fully aligned and committed to the 5G-PPP principles and KPIs, the CHARISMA proposal brings together 10G-wireless (via mm-wave/60-GHz & free-space optics, FSO) access and 100G fixed optical (OFDM-PON) solutions through an intelligent cloud radio-access-network (C-RAN) and intelligent radio remote head (RRH) platform with IPv6 Trust Node routing featuring very low-latency for the traffic management. Low-cost Ethernet is used across front- and backhaul, and end-user equipment (vCPE), and intelligence distributed across the back-, front-hauls, and parametric data transports. Ad-hoc mobile device interconnectivities (D2D, D2I, C2C etc.), content delivery network (CDN) and mobile distributed caching (MDC) offer an energy-efficient (better than x20 improvement possible) information-centric networking (ICN) architecture. Furthermore, caching will provide efficient utilization of scarce resources by early aggregating data or/and by executing communication locally. The CHARISMA approach will benefit user experiences with ground-breaking low-latency services, high-bandwidth, and mobile cloud resilient network security. SESAME prefigures possible cooperation in various ways which need to be identified during the lifecycle of SESAME. The similarity of the services developed by this project with those of SESAME prefigures possible cooperation in various ways which need to be identified during the lifecycle of SESAME. (http://www.charisma5g.eu/).

- **SONATA** targets both the flexible programmability of software networks and the optimization of their deployments. The NFV-focused project will support network function chaining and orchestration, allow service platforms to become more modular and easier to customize to the needs of different service providers, and introduce a specialized DevOps model for supporting developers. Its primary results will be a service platform with build-in NFV orchestrator, and an SDK for developers of VNF-chained network services. Areas of potential collaboration between SESAME and SONATA include comparing and contrasting techniques of NFV management and orchestration between different areas within the network. Also of joint interest could be programmability approaches of specialized VNF-based network services for SESAME's CESC concepts (www.sonata-nfv.eu).

Through its partners, SESAME is planning at least the following actions for cooperation with other H2020 5G projects, as envisaged at the early stage of the SESAME project.

COHERENT Project

- Action leader: CNET (set-up, maintenance, update)
- Action participants: ALL (for content provision)
- Action timing: ad hoc interaction between the two projects and specific partners.

5G-Crosshaul Project

- Action leader: CNET (set-up, maintenance, update)
- Action participants: ALL (for content provision)

Action timing: ad hoc interaction between the two projects and specific partners.

5.3 Plan for synergies with 5G-PPP

SESAME intends to participate in joint dissemination activities with other 5G projects(*) and actively contribute to the established 5G WGs. Table 10 summarizes the involvement of SESAME partners to the 5G-PPP WGs. As it may be observed, apart from the Spectrum WG which in general remains outside SESAME main objectives, all other WGs are closely followed by SESAME consortium.

Hereinafter, more detailed information on the WGs which will be followed by SESAME is provided, together with a description of the activities undertaken by each group considering the information available at the early stage of the 5G projects. The goals of the groups and pace of the activities are different with the general scope of each WG consisting in writing technical whitepapers and collaborate with, as well as federate efforts from different projects. The description reported hereinafter is expected to be updated and refined in the upcoming months.

Working Group	Participation	SESAME WP	Partners Involved
Vision and Societal Challenges	Y	WP8	INC
Pre-Standardisation	Y	WP8	FLE
KPI Management	Y	WP7, WP8	Ways of interacting with the working group have to be identified still
Architecture	Y	WP2, WP8	NCSRD,IPA
Spectrum	N	–	–
SDN/NFV	Y	WP2, WP5, WP8	ZHAW,CNET,FLE, ATOS
Network Management	Y	WP3, WP5, WP6, WP8	UPC,CNET
NetWorld2020	Y	WP8	ATOS

Table 10: Participation of specific SESAME WPs and partners following 5G-PPP Working Group activities

Vision and Societal Challenges WG: The working group "5G Vision and Societal Challenges" is working on the 5G vision and requirements, co-operation with vertical sectors, and for the definition of research programs. Moreover, within the scope of this WG are the assessment of the research portfolio in 5G-PPP projects, and also monitoring of performance KPIs (system capacity, energy consumption, privacy and security, reliability and availability, and service creation time).

On behalf of SESAME, INCITES is actively participating in "5G Vision and Societal Challenges" working group by contributing to business models and socioeconomic studies. INCITES will attend to the WG's conference calls, face to face meetings and workshops. The participation of vertical sectors in these meetings and workshops provides to INCITES the opportunity to exchange ideas about the business perspectives of 5G technology. Finally, INCITES will contribute to the production of group's white papers and promotional material (i.e.: brochures, etc.).

Pre-Standardisation WG: Pre-Standardisation WG is to identify standardization and regulatory bodies to align with ETSI, 3GPP, IEEE and other relevant standards bodies, ITU-R (incl. WPs) and WRC (including e.g. ECC PT1). Secondly, to develop a roadmap of relevant standardization and regulatory topics for 5G, to evaluate existing roadmaps at international level and to propose a roadmap for 5G being aligned at international level. Finally, in scope is influencing pre-standardization on 5G and related R&D and to potentially propose where topics should be standardized.

Architecture WG: The goal of the Architecture WG is to serve as a common platform to facilitate the discussion between 5G-PPP projects developing architectural concepts and components and foster the discussions on the basis of the KPI's described in the 5G-PPP contract. The group could also facilitate consensus building on the 5G architecture.

There are several 5G-PPP projects dealing with integration and unification of functional and non-functional requirements, deployable elements, wired and wireless interworking, control, management and operational architecture aspects or that are looking at fundamental pieces that have an impact on the overall 5G architecture. SESAME will be involved very actively in the development of 5G architectural concepts through collaboration, white papers, physical and phone meetings, etc.

SDN/NFV WG: The purpose of this WG 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.

SDN and NFV are core technologies in the transformation of networks for 5G. SDN and NFV could be seen as different expressions of an overall transformation trend, which is deeply impacting Telecom and IT industries. This trend is transforming several Industries, in using "softwarization" on general computing platforms to optimize operational processes and in bringing rapidly and efficiently new values in infrastructures. Their introduction aims to lower the cost of network and service operation and to reduce the time to market for new services while introducing higher flexibility. In addition, virtualisation of networking systems is a key enabler that offers a multitude of benefits for telecommunication and Data centre operators by decoupling network functions from proprietary hardware, as well as decoupling services from propriety service platforms.

Network Management (NM) WG: The purpose of the group is to bring together the projects within the 5G-PPP that have common interest in the development and progression of the projects which are working in a complementary manner towards consistent goals, exchanging ideas, minimising the duplication of effort, contributing towards relevant standards and where possible cooperating on the development of compatible components, demonstrators, the exchange of data and results and the interworking of communication layers. The following topics fall within the interest of this group:

- Network Management is focused on the control plane of the network to make sure all the services and operations running in the data plane are working properly.

- Network and Data Security covers areas such as the privacy, protection and trustworthiness of the end users communications, user profile information, and the overall resilience of the network to fraud and intrusion or efforts to undermine the operations or integrity of the network.
- Quality of Service covers areas such as networking, packet scheduling, traffic adaptation and any other technique implemented in both data and control plane.

6. Conclusions

This deliverable has outlined the SESAME communication, dissemination, standardization and exploitation strategies, which represent the planned processes of providing information on the Project SESAME generally and on its results, as well as the instruments to reach such an important promotion. Furthermore, this document discussed the plans of SESAME with respect to other H2020 5G projects, those which are more closely related and the actions of the SESAME Consortium to participate to the established 5G-PPP working groups. The plans have detailed specific actions already identified and described future opportunities matching to the time scales at which the main results of the project will be available. The plans serve as a "guide" throughout the duration of the whole project and will evolve as the project matures. Particularly, the report of the achievements and the update of the plans will be provided in M12, and M30.

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