SUPERFLUIDITY

A SUPER-FLUID, CLOUD-NATIVE, CONVERGED EDGE SYSTEM

Research and Innovation Action GA 671566

DELIVERABLE I.2.1:
EARLY USE CASES ANALYSIS

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Abstract: This deliverable provides a first version of the use cases and related analysis for the Superfluidity system. A survey on ongoing efforts on use cases definitions for NFV-based architecture is also given. A set of 25 use cases contributed by the Superfluidity partners is reported. For each use case a rough analysis has been performed to identify the features that will be relevant to the process of architecture definition. The possible categorization dimensions are discussed, then the use cases have been classified according to few selected approaches. This categorization is needed to further progress toward the functional analysis and functional decomposition of the Superfluidity system.

Keyword List: 5G use cases, NFV use cases, use case definition and analysis

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Glossary

(TO BE FILLED OUT IN THE FINAL VERSION OF THE DELIVERABLE)

SUPERFLUIDITY DICTIONNARY	
TERM	DEFINITION

Table 1: SUPERFLUIDITY Dictionary.

1 Introduction

1.1 Deliverable Rationale

The goal of this interim deliverable is to provide a first version of the use cases and related analysis, to be utilised as a working document toward deliverable D2.1, together with I2.2, and to provide input for Tasks T2.2, T2.3 and WP3.

This is the first report of WP2. It is not based on previous project reports/deliverables. The aim of this deliverable is to collect use cases generated by the project, in a draft form, and to point to relevant use cases produced by other projects/initiatives/fora. It also includes a preliminary analysis focused on identifying, for each use case: i) related architecture and/or networking and/or technical challenges; ii) benefits and innovation; iii) expected system components, functions, or primitives; iv) foreseen system requirements, performance issues. Finally, it proposes a classification of collected use cases.

1.2 Quality Review

Review Team member responsible of the deliverable: Pedro Andres Aranda Gutierrez (TID).

Version Control Table			
Version N.	Purpose/Changes	Author	Date
V01	Initial TOC	BT/CNIT	1/9/15
V02	First draft	BT/CNIT	24/9/15
V03	Second draft/Revision after call conference	BT/CNIT	28/9/15
V04	Third draft/Internal review	BT/CNIT	29/9/15
V05	Final version	BT/CNIT	1/10/15

1.3 Executive summary

1.3.1 Deliverable description

This deliverable aims to identify a set of use cases for the Superfluidity system, provide their textual description and an initial analysis. The analysis consists in the identification of characteristic features of each use case and in a comparative analysis across all the provided use cases, with the aim to classify them according to a set of dimensions. This work is a fundamental input to be used for the functional analysis and functional decomposition process needed for the Superfluidity architectural design. In section 2, we discuss use cases coming from the external world, mostly focusing on use case collection provided by Standard Defining Organizations (SDOs), but also reporting a couple of collection from non-SDOs. Section 3 discusses the different categorization dimensions that we have considered for the analysis of the provided use cases. In section 4 the results from the classification and clustering of use cases are presented. Section 5 contains two useful tables: a list of 8 generic use cases that had been introduced already in the technical annex, and a list of the new 25 detailed use cases provided by the partners. For the reader's convenience, section 6 reports the short description of the 8 generic use cases as contained in the technical annex. Section 7 collects the detailed use case description and first analysis contributed by the partners.

1.3.2 Summary of results

The main result of this deliverable is the description of the 25 use cases collected in section 7 and the classification of the use cases described in sections 3 and 4. The work on functional analysis and functional decomposition will be based on these classification results, allowing to properly cover all the features of interest for the design of the Superfluidity system.

2 Use cases collected from the external world

2.1 ETSI NFV ISG

The activity of ETSI NFV ISG has been divided in a number of phases. The document "Network Functions Virtualisation (NFV); Use Cases" (ETSI) [1] has provided the following list of use cases for phase 1.

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

Table 2: ETSI NFV ISG phase 1 use cases.

Phase 2 is still ongoing and in general the documents are not finalised nor publicly available. The document "Network Functions Virtualisation (NFV); Acceleration Technologies; Report on

Acceleration Technologies & Use Cases;" [2] is a phase 2 document published as draft. It reports a set of use cases related to acceleration, as listed in Table 3.

COMPUTE ACCELERATION
IPSec tunnels termination VNFC
Next Generation Fire Wall (NGFW) Acceleration
Virtual Base Station (VBS) L1 Acceleration
Virtual Acceleration Interface for VNFs
Transcoding
Deep Packet Inspection
NETWORK ACCELERATION
Load Balancing and NAT
NFVI Virtual Networking Offload
NFVI Secure Overlay Offload
Dynamic Optimization of Packet Flow Routing
STORAGE ACCELERATION
NVMe Over Fabric Enabled Acceleration
High Performance Persistent Memory on Compute Node

Table 3: ETSI NFV ISG phase 2 doc with use cases related to Acceleration Technologies

2.2 ETSI MEC ISG

The ETSI MEC (Mobile Edge Cloud) ISG is working on a detailed document ("Mobile-Edge Computing (MEC); Technical Requirements") with 23 use cases, categorised according to three sets: "Consumer-oriented services", "Operator and third party services" and " Network performance and QoE improvements". This document, as its name indicates, extracts requirements and identifies features ("A feature is defined as a group of related requirements"). The document is not yet publicly available; hereafter we have collected information coming from public documents and presentations.

A public technical white paper (Mobile-Edge Computing – Introductory Technical White Paper [3]) contains the set of use cases listed in Table 4.

Active Device Location Tracking
Augmented Reality Content Delivery
Video Analytics
RAN-aware Content Optimization
Distributed Content and DNS Caching
Application-aware Performance Optimization

Table 4: Use cases from the Introductory Technical White paper of ETSI MEC ISG

A presentation about MEC goals [4]includes the use cases listed in Table 5.

Network-Centric Applications Distributed Content and DNS Caching RAN-aware & Application-aware Content Optimization
Enterprise and Vertical Applications Active Device Location Tracking Intelligent Video Analytics
Efficient Delivery of Local Content Augmented Reality Content Delivery

Table 5: Use cases from a presentation about MEC goals

ETSI White Paper No. 11 [5] considers the use cases listed in Table 6.

Augmented Reality
Intelligent Video Acceleration
Connected Cars
Internet of Things Gateway

Table 6: Use cases from the ETSI White Paper No. 11

2.3 3GPP

3GPPP's Technical Specification Group "Services and System Aspects" has produced the document "Feasibility Study on New Services and Markets Technology Enablers;" [6]. It has similarities to MEC's approach but more broad in scope since it "aims to identify the market segments and verticals whose needs 3GPP should focus on meeting, and to identify groups of related use cases and requirements that the 3GPP eco-system would need to support in the future". This is a very broad and wide-ranging endeavour, not specifically referred to NFV. The complete list of 59 use cases are outlined in Table 7.

1 Ultra-reliable communications	31 Temporary Service for Users of Other Operators in Emergency Case
2 Network Slicing	32 Improvement of network capabilities for vehicular case
3 Lifeline communications / natural disaster	33 Connected vehicles
4 Migration of Services from earlier generations	34 Mobility on demand
5 Mobile broadband for indoor scenario	35 Context Awareness to support network elasticity
6 Mobile broadband for hotspots scenario	36 In-network caching
7 On-demand Networking	37 Routing path optimization when server changes
8 Flexible application traffic routing	38 ICN Based Content Retrieval
9 Flexibility and scalability	39 Wireless Briefcase
10 Mobile broadband services with seamless wide-area coverage	40 Devices with variable data
11 Virtual presence	41 Domestic Home Monitoring
12 Connectivity for drones	42 Low mobility devices
13 Industrial Control	43 Materials and inventory management and location tracking
14 Tactile Internet	44 Cloud Robotics
15 Localised real-time control	45 Industrial Factory Automation
16 Coexistence with legacy systems	46 Industrial Process Automation
17 Extreme real-time communications and the tactile internet	47 SMARTER Service Continuity
18 Remote Control	48 Provision of essential services for very low-ARPU areas
19 Light weight device configuration	49 Network capability exposure
20 Wide area sensor monitoring and event driven alarms	50 Low-delay speech coding
21 IoT Device Initialization	51 Network enhancements to support scalability and automation
22 Subscription security credentials update	52 Wireless Self-Backhauling
23.Access from less trusted networks	53 Vehicular Internet & Infotainment
24 Bio-connectivity	54 Local UAV Collaboration
25 Wearable Device Communication	55 High Accuracy Enhanced Positioning (ePositioning)
26 Best Connection per Traffic Type	56 Broadcasting Support
27 Multi Access network integration	57 Ad-Hoc Broadcasting
28 Multiple RAT connectivity and RAT selection	58 Use Case for Green Radio
29 Higher User Mobility	59 Massive Internet of Things M2M and device identification
30 Connectivity Everywhere	

Table 7: Use cases list from the 3GPP's document on New Services and Markets Technology Enablers

2.4 IETF SFC Work Group

The Internet Engineering Task Force (IETF) has a group that is defining Service Function Chaining (SFC) [7]. Of specific relevance to Superfluidity is the work on use cases and more concretely the draft on Service Function Chaining Use Cases in Mobile Networks [8], from which we have extracted the list shown in Table 8.

Service chain model for Internet HTTP services
Service chain for TCP optimization
HTTP header enrichment in mobile networks

Table 8: Use cases list from IETF SFC's draft on Mobile Networks

2.5 Use cases from non-SDOs

2.5.1 Use cases from SDx Central

SDx Central [9] considers a list of use cases [10], that we have reported in Table 9.

Network Access Control - Set appropriate privileges for users or devices accessing the networks, including access control limits, incorporation of service chains as well as appropriate quality of service. Generally follows the user/device as they connect from different parts of the network.
1. Campus NAC 2. Remote Office / Branch NAC 3. M2M NAC 4. Unified Communications Optimization
Network Virtualisation - Creates an abstracted virtual network on top of a physical network, allowing a large number of multi-tenant networks to run over a physical network, spanning multiple racks in the datacenter or locations if necessary, including fine-grained controls and isolation as well as insertion of acceleration or security services
1. Data Center Virtual Networks 2. Campus / Branch Virtual Networks 3. Data Center Micro Segmentation 4. Network Functions as a Service
Virtual Customer Edge - Virtualising the customer edge either through creation of a virtualised platform on customer premises or by pulling in the functions closer to the core on a virtualised multi-tenant platform hosted either in a carrier point-of-presence, regional datacenter, central datacenter (enterprise, telco or over-the-top cloud SP)
1. On-premises vCPE 2. On-premises vCPE (OTT) 3. vCE (Telco) 4. vCE (OTT) (aka: Cloud CPE)
Dynamic Interconnects - Creation of dynamic links between locations, including between DCs, enterprise and DCs, and other enterprise locations, as well as dynamically applying appropriate QoS and BW allocation to those links.
1. BWoD 2. Virtual Private Interconnects / Cloud Bursting 3. Dynamic Enterprise VPN 4. Cross Domain Interconnect 5. Multi-Layer Optimization
Virtual Core and Aggregation - Virtualised core systems for service providers including support infrastructure such as vIMS, vEPC, as well as dynamic mobile backhaul, virtual PE and NFV GiLAN infrastructure
1. vEPC & vIMS 2. vPE 3. GiLAN 4. Mobile Network Virtualisation
Datacenter Optimization - Using SDN and NFV, optimizing networks to improve application performance by detecting and taking into account affinities, orchestrating workloads with networking configuration (mice/elephant flows)
1. Big Data Optimization 2. Mice/Elephant Flow Optimization

Table 9: Use cases from SDX central

2.5.2 Use cases from a vendor's perspective

Table 10 reports the list of use cases described in [11].

1. Mobility Virtualisation Virtualisation of the packet core and GiLAN
2. Virtual CPE and Service Chaining Deliver CPE services from the cloud. SDN to automate the processes for creating new services
3. NFV and Service Orchestration Operating in a hybrid, physical/virtual environment. orchestration sits at the centre of this
4. WAN Optimisation & Innovation Better traffic engineering. holistic view across the different transport and IP network layers The innovation of SDN, in association with NFV, gives us the possibility to create simpler network designs, making the “delayering” of networks achievable
5. Policy Driven Application Provisioning & Delivery Delivery of applications from a data centre. Turning the manual process of provisioning and delivering applications into a simplified, automated, policy-driven process

Table 10: Use cases list from a CISCO web page

3 Classification of the use cases

We have started our work from the set of 8 use case samples contained in the Technical annex and from a new set of 25 detailed use cases provided by the partners.

The list of the eight use cases samples from the Technical Annex are reported in section 5.1, the full description in section 6. These use case samples are described in a concise manner and provide indicative categories of use cases rather than very specific and detailed use cases.

The new 25 detailed use cases provided by the partners have been prepared following a standard use case description template, which guided the partners through an initial rough analysis of the use case as preparatory work in relation to the functional decomposition of the Superfluidity system. The list of the 25 use cases are reported in section 5.2, the full descriptions provided by the partners are reported in section 7.

3.1 Categorisation by primary client actor

This categorization takes into account the primary actor or beneficiary of the considered use cases. We took into account three proposals for the classification based on the set of actors, than we converged on a fourth proposal. For the record, we first report the three proposals which have been discussed, and then the one that we have currently used for this categorization.

Proposal 1 :

a) Residential end user
b) Business end user
c) “a thing” end user (i.e. IoT)
d) Internal user within the Superfluidity system: the provider that operates the Superfluidity system
e) Internal user outside the Superfluidity system e.g. a (virtual) Network Provider (carrier), Network operator, or the like

Proposal 2, a variant of proposal 1 with a different definition of d) and e) actors.

a) Residential end user
b) Business end user
c) “a thing” end user (i.e. IoT)
d) A Superfluidity component
e) Network/Service operator using the Superfluidity system

Proposal 3 was derived from a similar classification of use cases proposed by ETSI MEC

a) "Consumer-oriented services",
b) "Operator and third party services"
c) "Network performance and QoE improvements"

We tried to apply the different proposal to the classification of the use cases, however it was difficult to differentiate cases d) and e) in proposals 1) and 2) and therefore the decision was made to merge them in a single one. It was found that differentiating between residential and business end users was useful, so we maintained it throughout the process, and the network performance category from proposal is also included 3), the final categories are listed hereafter.

a) Residential end user
b) Business end user
c) "a thing" end user (i.e. IoT)
d) Network operator / Service provider (also virtual)
e) Network performance and QoE improvements

3.2 Classification by network section

The following categories were identified with respect to the affected network sections:

a) Wireless access / RAN /fronthaul
b) MEC
c) Backhaul (anything between the radio access and core)
d) Core (includes everything behind the packet GW)

The "MEC" section refers to the elements that are capable of providing processing or storage resources close to the RAN elements.

3.3 Classification based on a harmonized set of tags

In the use cases provided by the partners, each partner has independently proposed a set of tags, indicated as "secondary classification labels". We have selected a subset of these labels and tried to reclassify the use cases based on it. We report hereafter the set of tags that have been selected and then the tags that have been "discarded". This classification is somehow redundant with respect to the one described in the next section, based on "classes" or use cases. Anyway, it has been a useful exercise to understand the different aspects of the uses cases and to identify a good set of use case categories.

These are the tags that have been considered:

- *Reprogrammable RAN / RAN slicing*
- *Layer 1 services / Mac services*
- *Dynamic rates and topology*
- *Usage/Service/platform monitoring and analytics*
- *Location Based Services / Mobile edge computing*
- *Local breakout (Corporate/Campus - Big Events/Crowd)*
- *Caching Services*

- *TCP/http Optimization / Adaptive media delivery*
- *Content encryption / content processing*
- *M2M communication*
- *IoT /IoT virtual network*
- *Low Latency /High Throughput Applications*
- *Tactile Communication Services (*)*
- *Functions Orchestration / Service chaining*
- *Security*

(*) The Tactile Internet will require extremely low latency combined with high availability, reliability and security.

The tags that have been left out are the following:

- *Context and Location based services*
- *Autonomous intelligent services*
- *Enhanced Platform Awareness*
- *Scheduling as a service*
- *MIMO as a services*
- *SON as a service*
- *User following services*
- *Cloud offloading*
- *Transparent CDN*
- *Re-routing of network traffic*
- *Low resource overhead hypervisor*
- *Massive consolidation of VMs*
- *Communication and shared resources across hypervisor instances*
- *Advertisement*
- *Private Virtualised CDN*
- *TV contents*
- *Small Cells*
- *Services platforms*
- *Enterprise/operator converged services*
- *Community services*
- *Hardware Accelerators*
- *Enhanced group communications*
- *Intrinsic security mechanisms*
- *Advertisement*
- *Targeting*
- *Origin caching*

3.4 Classification based on classes of use cases

Using the 8 use case samples provided in the technical annex and reported in in section 5.1, we classified the 25 contributed use cases. We found that this classification was not satisfying, because some contributed use cases were not fitting in the sample use cases, and some sample use cases were duplicated, because they were matching the same set of contributed use cases. We considered a different set of classes, as listed hereafter:

C1	*RAN, wireless access (TA-2) (TA-6)*
C2	*On-the-fly Monitoring (TA-7)*
C3	*MEC / Localised services – processing (TA-3)*
C4	*MEC / Localised services – storage (TA-3, TA-1, TA-8)*
C5	*MEC / Localised service – local breakout (TA-3)*
C6	*Edge offloading (TA-5)*
C7	*Emergency communications*
C8	*Security*

In section 4 we show how the new classes are able to provide a better clustering of the contributed use cases.

3.5 Categorisation by layer in dynamic design lifecycle

Another approach that is to be proposed for use-case categorization is the application of a dynamic design lifecycle. With this approach, the resource/service stack is divided into layers such that there is a recursively layered relationship between the runtime and design phases required for service delivery. This principle is depicted in Figure 1, where the dynamic runtime actions in one layer, i.e. host layer, create service entities that are used for the design of another layer, i.e. the client layer. In contrast with traditional approaches where the design phases are always assumed to be static, this approach will enable fluidity, flexibility, and dynamic reconfiguration.

	Static Elements	Dynamic Operations	Service Entities	Abstracted Dynamics
Network Service Layer (Service Chains)	▪ Virtual Network Functions (VNFs)	▪ Create VNFs ▪ Configure VNFs ▪ Connect VNFs	▪ Interconnected Network Services	▪ Instantiate Components ▪ Connect Components ▪ Configure Components in Context
	Client	⟷	Host	
Virtual Network Function Layer	▪ Virtual Network Functions Component Instances (VNFCIs)	▪ Create VNFCIs ▪ Configure VNFCIs ▪ Connect VNFCIs	▪ Interconnected VNFs	▪ Instantiate Components ▪ Connect Components ▪ Configure Components in Context
	Client	⟷	Host	
Network Function Virtualization Infrastructure Layer	▪ Virtual Machines (VMs) ▪ Virtual Networks (VNs)	▪ Create VMs & VNs ▪ Configure VMs & VNs ▪ Connect VNs to VMs	▪ Interconnected VNFCI hosts	▪ Instantiate Components ▪ Connect Components ▪ Configure Components in Context
	Client	⟷	Host	
Infrastructure Isolation Layer	▪ Hypervisor ▪ Operating System (OS) ▪ Network Transport Paths	▪ Install OS & Hypervisor ▪ Configure Hypervisor ▪ Create vSwitches ▪ Create Transport Paths ▪ Join Transport Paths to vSwitches	▪ VM Host ▪ VN Host	▪ Instantiate Components ▪ Connect Components ▪ Configure Components in Context
	Client	⟷	Host	
Physical Infrastructure Layer	▪ Servers ▪ Storage ▪ Fibre, Cable ▪ Switches etc.	▪ Install Hardware Devices ▪ Plug Interface Connectors ▪ Boot & Configure Hardware Devices	▪ Compute Machine ▪ Network Transport Infrastructure	▪ Instantiate Components ▪ Connect Components ▪ Configure Components in Context

Figure 1: Recursively layered design and runtime layers for service delivery

4 Results from classification and clustering

The results from the mapping the 25 contributed use cases into the original set of classes provided in the technical annex is shown in Figure 1. An “X” in the intersection between a use case and a use case class indicates a strong matching, an “/” indicate a loose matching.

	Minimum-Delay Cloud storage (TA-1)	RAN As A Service (TA-2)	Localized services (TA-3)	Pooling (TA-4)	Edge offloading (TA-5)	Portable signal processing (TA-6)	On-the-fly Monitoring (TA-7)	Virtualized CDN operators (TA-8)
Wireless Software Defined fronthauling (ALUBL-2)		X		X		/		
On-the-fly monitoring (BT-1)							X	
S/Gi-LAN Services on the Edge (CITRIX-1)			X		/			X
Dynamic MAC services allocation in Cloud RAN (ALUIL BGU-1)		X		X				
Internet of Things (IoT) & SUPERFUIDITY Platform Scenario (CNIT-1)			X					
Context-adapted data delivery (CNIT-2)			X					X
Mobile Based Augmented Reality for User Experience Enhancement (Intel-1)			X		/			
Performance Optimization for Distributed Multimedia Content Delivery (Intel-2)			X					X
Context Aware Smart Living (Intel-3)			X					
Mobile services offloading (NEC-1)	X				X			
Transparent web service acceleration (ONAPP-1)			X					
Rapid and massiv.-scalable instant. of high perf (virt.) applic. instances (ONAPP-2)			X					
Local Breakout (LBO) (PTIN-1)	X							
virtual Convergent Services (vCS) (PTIN-2)								
Video Orchestration and Optimization (PTIN-3)			X					
Virtual CDN for TV contents distribution (PTIN-4)	X		X					X
Business Communication Services (TPIN-5)			X					
Anti NDP Spoofing software implementation (Telcaria-1)								
Protection against DDoS (Telcaria-2)								
Emergency communications (TID-1)		/	/					
Late transmuxing (USTR-1)			X		/			
Remix (USTR-2)			X					
Backend Storage Caching (USTR-3)	?		/					/

Figure 1: Mapping between the contributed use cases and the use case classes from the technical annex

Figure 2 shows the relations between the contributed use cases. The use cases are not properly ordered, because the matrix appears almost random.

	5G RAN "network slices" (ALUBL-1)	Wireless Software Defined fronthauling (ALUBL-2)	On-the-fly monitoring (BT-1)	SIGHLAN Services on the Edge (CITRIX-1)	Dynamic MAC services allocation in Cloud RAN (ALUIL BGU-1)	Internet of Things (IoT) & SUPERFLUIDITY Platform Scenario (CNIT-1)	Context-adapted data delivery (CNIT-2)	Mobile Based Augmented Reality for User Experience Enhancement (Intel-1)	Performance Optimization for Distributed Multimedia Content Delivery (Intel-2)	Context Aware Smart Living (Intel-3)	Mobile services offloading (NEC-1)	Transparent web service acceleration (ONAPP-1)	Rapid and massiv.-scalable instant. of high perf (virt.) applic. instances (ONAPP-2)	Local Breakout (LBO) (PTIN-1)	virtual Convergent Services (vCS) (PTIN-2)	Video Orchestration and Optimization (PTIN-3)	Virtual CDN for TV contents distribution (PTIN-4)	Business Communication Services (TPIN-5)	Anti NDP Spoofing software Implementation (Telcaria-1)	Protection against DDoS (Telcaria-2)	Emergency communications (TID-1)	Late transmuxing (USTR-1)	Remix (USTR-2)	Backend Storage Caching (USTR-3)
5G RAN "network slices" (ALUBL-1)		/			/																/			
Wireless Software Defined fronthauling (ALUBL-2)	/				/									/										
On-the-fly monitoring (BT-1)																								
SIGHLAN Services on the Edge (CITRIX-1)						/	X	X	X	/		X	X		/	X	X	X				X	X	X
Dynamic MAC services allocation in Cloud RAN (ALUIL BGU-1)	/	/																						
Internet of Things (IoT) & SUPERFLUIDITY Platform Scenario (CNIT-1)				/						X			/	X										
Context-adapted data delivery (CNIT-2)				X					X			X				X		X				X	X	/
Mobile Based Augmented Reality for User Experience Enhancement (Intel-1)				X								X	X			X	X					X	X	X
Performance Optimization for Distributed Multimedia Content Delivery (Intel-2)				X			X					X	X			X	X	X				X	X	X
Context Aware Smart Living (Intel-3)				/		X								X										
Mobile services offloading (NEC-1)														/								/		/
Transparent web service acceleration (ONAPP-1)				X			X	X	X				X			X	/	X				X	X	/
Rapid and massiv.-scalable instant. of high perf (virt.) applic. instances (ONAPP-2)				X		/		X	X			X				X	/	X				X	X	/
Local Breakout (LBO) (PTIN-1)		/				X				X	/							X			X			/
virtual Convergent Services (vCS) (PTIN-2)				/												X	/	X				X	X	
Video Orchestration and Optimization (PTIN-3)				X			X	X	X			X	X		X		/	X				X	X	
Virtual CDN for TV contents distribution (PTIN-4)				X				X	X			/	/		/	/						/	/	X
Business Communication Services (TPIN-5)				X			X		X			X	X	X	X	X								
Anti NDP Spoofing software Implementation (Telcaria-1)																				X				
Protection against DDoS (Telcaria-2)																			X					
Emergency communications (TID-1)	/													X										
Late transmuxing (USTR-1)				X			X	X	X		/	X	X		X	X	/						X	/
Remix (USTR-2)				X			X	X	X			X	X		X	X	/					X		/
Backend Storage Caching (USTR-3)				X			/	X	X		/	/	/	/			X					/	/	

Figure 2: Correlation between the contributed use cases, in the original order.

With a proper reordering of the use case, which was based on the analysis of the correlation among the use cases, as well as on the classifications using the network section and the main actor criteria, we obtained the correlation matrix shown in Figure 3. The matrix is almost block-wise diagonal, showing that a satisfactory ordering of the use cases has been reached.

	5G RAN "network slices" (ALUBL-1)	Wireless Software Defined fronthauling (ALUBL-2)	Dynamic MAC service allocation in Cloud RAN (ALUIL BGU-1)	On-the-fly monitoring (BT-1)	S/Gi-LAN Services on the Edge (CITRIX-1)	Context-adapted data delivery (CNIT-2)	Performance Optimization for Distributed Multimedia Content Delivery (Intel-2)	Transparent web service acceleration (ONAPP-1)	Rapid and massiv.-scalable instant. of high perf (virt.) applic. instances (ONAPP-2)	virtual Convergent Services (vCS) (PTIN-2)	Video Orchestration and Optimization (PTIN-3)	Mobile Based Augmented Reality for User Experience Enhancement (Intel-1)	Virtual CDN for TV content distribution (PTIN-4)	Business Communication Services (TPIN-5)	Late transmuxing (USTR-1)	Remix (USTR-2)	Backend Storage Caching (USTR-3)	Local Breakout (LBO) (PTIN-1)	Context Aware Smart Living (Intel-3)	Internet of Things (IoT) & SUPERFLUIDITY Platform Scenario (CNIT-1)	Mobile services offloading (NEC-1)	Anti NDP Spoofing software implementation (Telcaria-1)	Protection against DDoS (Telcaria-2)	Emergency communications (TID-1)
5G RAN "network slices" (ALUBL-1)		/	/																					/
Wireless Software Defined fronthauling (ALUBL-2)	/		/															/						
Dynamic MAC services allocation in Cloud RAN (ALUIL BGU-1)	/	/																						
On-the-fly monitoring (BT-1)																								
S/Gi-LAN Services on the Edge (CITRIX-1)						X	X	X	X	/	X	X	X	X	X	X	X		/	/				
Context-adapted data delivery (CNIT-2)					X		X	X			X			X	X	X	/							
Peformance Optimization for Distributed Multimedia Content Delivery (Intel-2)					X	X		X	X		X		X	X	X	X	X							
Transparent web service acceleration (ONAPP-1)					X	X	X		X		X	X	/	X	X	X	/							
Rapid and massiv.-scalable instant. of high perf (virt.) applic. instances (ONAPP-2)					X		X	X			X	X	/	X	X	X	/			/				
virtual Convergent Services (vCS) (PTIN-2)					/						X		/	X	X	X								
Video Orchestration and Optimization (PTIN-3)					X	X	X	X	X	X		X	/	X	X	X								
Mobile Based Augmented Reality for User Experience Enhancement (Intel-1)					X			X	X		X		X		X	X	X							
Virtual CDN for TV contents distribution (PTIN-4)					X		X	/	/	/	/	X			/	/	X							
Business Communication Services (TPIN-5)					X	X	X	X	X	X	X							X						
Late transmuxing (USTR-1)					X	X	X	X	X	X	X	X	/			X	/				/			
Remix (USTR-2)					X	X	X	X	X	X	X	X	/		X		/							
Backend Storage Caching (USTR-3)					X	/	X	/	/			X	X		/	/		/			/			
Local Breakout (LBO) (PTIN-1)		/												X			/		X	X	/			X
Context Aware Smart Living (Intel-3)					/													X		X				
Internet of Things (IoT) & SUPERFUIDITY Platform Scenario (CNIT-1)					/				/									X	X					
Mobile services offloading (NEC-1)															/		/	/						
Anti NDP Spoofing software implementation (Telcaria-1)																							X	
Protection against DDoS (Telcaria-2)																						X		
Emergency communications (TID-1)	/																	X						

Figure 3: Correlation between the contributed use cases, properly reordered

The mapping of the uses case into the newly proposed classes is shown in Figure 4. Also in this case the matrix is more regular than the one in Figure 1 and allows identifying clusters of correlated use cases.

	RAN, wireless access	On-the-fly Monitoring (TA-7)	Localized services, processing	Localized services, storage	Localize services, local breakout	Edge offloading (TA-5)	Security	Emergency communications
5G RAN "network slices" (ALUBL-1)	X							
Wireless Software Defined fronthauling (ALUBL-2)	X							
Dynamic MAC services allocation in Cloud RAN (ALUIL BGU-1)	X							
On-the-fly monitoring (BT-1)		X						
S/Gi-LAN Services on the Edge (CITRIX-1)			X	X		/		
Context-adapted data delivery (CNIT-2)			X	X				
Performance Optimization for Distributed Multimedia Content Delivery (Intel-2)			X	X				
Transparent web service acceleration (ONAPP-1)			X					
Rapid and massiv.-scalable instant. of high perf (virt.) applic. instances (ONAPP-2)			X					
virtual Convergent Services (vCS) (PTIN-2)								
Video Orchestration and Optimization (PTIN-3)			X					
Mobile Based Augmented Reality for User Experience Enhancement (Intel-1)			X			/		
Virtual CDN for TV contents distribution (PTIN-4)			X	X				
Business Communication Services (TPIN-5)			X					
Late transmuxing (USTR-1)			X			/		
Remix (USTR-2)			X					
Backend Storage Caching (USTR-3)			/	X				
Local Breakout (LBO) (PTIN-1)				X	X			
Context Aware Smart Living (Intel-3)			X					
Internet of Things (IoT) & SUPERFUIDITY Platform Scenario (CNIT-1)			X					
Mobile services offloading (NEC-1)			/	/		X		
Anti NDP Spoofing software implementation (Telcaria-1)							X	
Protection against DDoS (Telcaria-2)							X	
Emergency communications (TID-1)	/		/					X

Figure 4: Mapping between the (reordered) contributed use cases and the new classes

Figure 5 provides the classification of the use cases according to the selected set of tags. Finally, Figure 6 provides the classification of the contributed use cases with respect to the main actor and to the affected network section.

	5G RAN "network slices" (ALUBL-1)	Wireless Software Defined fronthauling (ALUBL-2)	Dynamic MAC services allocation in Cloud RAN (ALUILBGU-1)	On-the-fly monitoring (BT-1)	S/Gi-LAN Services on the Edge (CITRIX-1)	Context-adapted data delivery (CNIT-2)	Performance Optimization for Distributed Multimedia Content Delivery (Intel-2)	Transparent web service acceleration (ONAPP-1)	Rapid and massiv.-scalable instant. of high perf (virt.) applic. instances (ONAPP-2)	virtual Convergent Services (vCS) (PTIN-2)	Video Orchestration and Optimization (PTIN-3)	Mobile Based Augmented Reality for User Experience Enhancement (Intel-1)	Virtual CDN for TV contents distribution (PTIN-4)	Business Communication Services (TPIN-5)	Late transmuxing (USTR-1)	Remix (USTR-2)	Backend Storage Caching (USTR-3)	Local Breakout (LBO) (PTIN-1)	Context Aware Smart Living (Intel-3)	Internet of Things (IoT) & SUPERFUIDITY Platform Scenario (CNIT-1)	Mobile services offloading (NEC-1)	Anti NDP Spoofing software implementation (Telcaria-1)	Protection against DDoS (Telcaria-2)	Emergency communications (TID-1)
Reprogrammable RAN / RAN slicing	X	X																						
Layer 1 services / Mac services	X	X	X																					
Dynamic rates and topology		X																						
Usage/Service/platform monitoring and analytics				X			X																	X
Location Based Services / Mobile edge computing					X	X			X	X				X	X	X	X				X			X
Local breakout (Corporate/Campus - Big Events/Crowd)										X				X				X						
Caching Services					X	X					X		X		X		X				X			X
TCP/http Optimization / Adaptive media delivery					X	X		X			x		X		X	X								
Content encryption / content processing						X								X										
Low Latency /High Throughput Applications					X		X					X									X			
Tactile Communication Services(*)					X				X			X												
Functions Orchestration / Service chaining					X		X		X			X												
M2M communication																			X	X				
IoT /IoT virtual network																			X	X				
Security																						X	X	X

Figure 5: Classification of the contributed use cases, based on the selected tags

	a) residential end user	b) business end user	c) a thing end user (ie IoT)	d) Network operator / Service provider (also virtual)	e) "Network performance and QoE improvements"	a) Wireless access / RAN / fronthaul	b) MEC	c) Backhaul	d) Core
5G RAN "network slices" (ALUBL-1)				X		X		X	
Wireless Software Defined fronthauling (ALUBL-2)				X		X			
Dynamic MAC services allocation in Cloud RAN (ALUIL BGU-1)				X		X			
On-the-fly monitoring (BT-1)				X	X	X	X	X	X
S/Gi-LAN Services on the Edge (CITRIX-1)	/	/	/	X			X		X
Context-adapted data delivery (CNIT-2)	X	X			X		X		
Performance Optimization for Distributed Multimedia Content Delivery (Intel-2)	X	X			X		X		
Transparent web service acceleration (ONAPP-1)	X	X					X		
Rapid and massiv.-scalable instant. of high perf (virt.) applic. instances (ONAPP-2)	X	X	/				X		
virtual Convergent Services (vCS) (PTIN-2)	X	/					X		
Video Orchestration and Optimization (PTIN-3)	X	/					X		
Mobile Based Augmented Reality for User Experience Enhancement (Intel-1)	X	X			X		X		
Virtual CDN for TV contents distribution (PTIN-4)				X			X		
Business Communication Services (TPIN-5)		X					X		
Late transmuxing (USTR-1)	X	/					X		
Remix (USTR-2)	X	/					X		
Backend Storage Caching (USTR-3)	X	/					X		
Local Breakout (LBO) (PTIN-1)				X	X	X		X	/
Context Aware Smart Living (Intel-3)			X				X		
Internet of Things (IoT) & SUPERFUIDITY Platform Scenario (CNIT-1)			X				X		
Mobile services offloading (NEC-1)	X	X			X		X		
Anti NDP Spoofing software implementation (Telcaria-1)				X	X	X	X		
Protection against DDoS (Telcaria-2)				X	X	X	X		
Emergency communications (TID-1)				X	X	X	X	X	X

Figure 6: Classification of the (reordered) contributed use cases with respect to: main actor (on the left), network section (on the right)

5 Use cases summary tables

5.1 Sample use cases from the SUPERFLUIDITY Technical annex.

TA-1	*Minimum-Delay Cloud storage (TA-1)*
TA-2	*RAN As A Service (TA-2)*
TA-3	*Localised services (TA-3)*
TA-4	*Pooling (TA-4)*
TA-5	*Edge offloading (TA-5)*
TA-6	*Portable signal processing (TA-6)*
TA-7	*On-the-fly Monitoring (TA-7)*
TA-8	*Virtualised CDN operators (TA-8)*

Table 11: Sample use cases from the Technical annex

5.2 Use cases provided by the partners

1	ALUBL-1	*5G RAN "network slices" (ALUBL-1)*
2	ALUBL-2	*Wireless Software Defined fronthauling (ALUBL-2)*
3	BT-1	*On-the-fly monitoring (BT-1)*
4	CITRIX-1	*S/Gi-LAN Services on the Edge (CITRIX-1)*
5	ALUIL BGU-1	*Dynamic MAC services allocation in Cloud RAN (ALUIL BGU-1)*
6	CNIT-1	*Internet of Things (IoT) & SUPERFUIDITY Platform Scenario(CNIT-1)*
7	CNIT-2	*Context-adapted data delivery(CNIT-2)*
8	Intel-1	*Mobile Based Augmented Reality for User Experience Enhancement (Intel-1)*
9	Intel-2	*Performance Optimization for Distributed Multimedia Content Delivery (Intel-2)*
10	Intel-3	*Context Aware Smart Living (Intel-3)*
11	NEC-1	*Mobile services offloading (NEC-1)*
12	*ONAPP-1*	*Transparent web service acceleration (ONAPP-1)*
13	*ONAPP-2*	***Rapid and massively-scalable instantiation of high performance (virtual) application instances (ONAPP-2)***
14	PTIN-1	*Local Breakout (LBO) (PTIN-1)*
15	PTIN-2	*virtual Convergent Services (vCS) (PTIN-2)*
16	PTIN-3	*Video Orchestration and Optimization (PTIN-3)*
17	PTIN-4	*Virtual CDN for TV contents distribution (PTIN-4)*
18	PTIN-5	***Business Communication Services (TPIN-5)***
19	Telcaria-1	*Anti NDP Spoofing software implementation (Telcaria-1)*
20	Telcaria-2	*Protection against DDoS (Telcaria-2)*
21	TID-1	*Emergency communications (TID-1)*

22	USTR-1	*Late transmuxing (USTR-1)*
23	USTR-2	*Remix (USTR-2)*
24	USTR-3	*Backend Storage Caching (USTR-3)*
25	UPB-1	*Third-party network processing in operator clouds (UPB-1)*

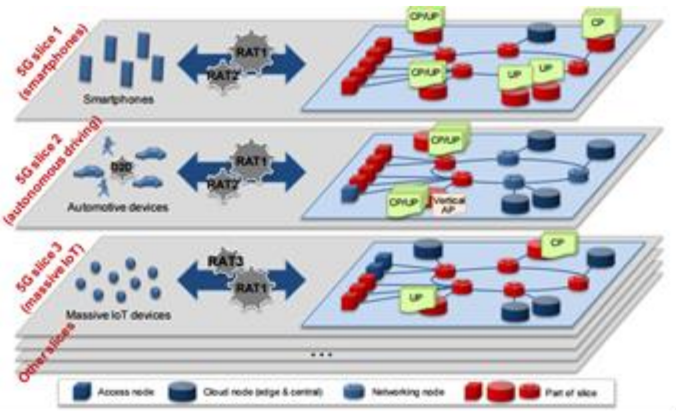
Table 12: Detailed use cases provided by the partners

6 Description of the sample use cases from the technical annex

Minimum-Delay Cloud storage (TA-1) Cloud storage has the potential for finally allowing people to throw out all of the clumsy hard drives, memory cards and USB sticks cluttering homes and travel bags. Unfortunately, the high data volumes and relatively low throughputs and high delays to the core/data center mean that there is still a difference in the experience between local and cloud storage; deploying cloud storage services at the network edges would finally close this gap.
RAN As A Service (TA-2) individual functions constituting a Cloud RAN would be readily deployed, following a dynamic life cycle (creation, attachment to core network and antenna site / RRH, hot upgrade, etc) involving optimized placement decisions about CPU, NIC, memory, hardware-acceleration capabilities; Moreover, a RAN could be flexibly build and adapted to the context using different types of schedulers, different physical layer blocks pointing to various waveforms, etc.
Localised services (TA-3) Many services that require some sort of mixing server (e.g., video conferencing, online gaming, to name a few) often end up using a distant one in terms of delay. Instead, such a virtualised server could be deployed on-the-fly at the edge, drastically reducing delays and improving user experience.
Pooling(TA-4) User-specific functions attached to various cells (and even baseband computation units [Wer13]) can be pooled in a same host so as to maximize the host load / minimise the required number of hosts; intra-cluster live migration of functions would optimize system KPIs (pooling gain, total radio capacity, energy efficiency, etc), and would comply with RRM handover requirements (e.g. the current intra LTE handover < 50ms would be readily attained by our technology);
Edge offloading (TA-5) One of the drawbacks of mobile devices is their short battery life. Many services (e.g., firewalling, anti-virus software, ad blockers) could be offloaded to the edge to reduce battery consumption.
Portable signal processing(TA-6) platform independence would permit portability of signal processing tasks between the edge cluster and the antenna site so as to minimise fronthauling requirements and maximize radio capacity (as fronthauling requirements increase for larger radio bandwidth using carrier aggregation, more massive MIMO, more network MIMO…).
On-the-fly Monitoring (TA-7) On-the-fly Monitoring: The owner of the infrastructure could deploy a monitoring service in order to track usage of its tenants' services, or to for instance instantiate a DPI service on a particular suspicious flow.
Virtualised CDN operators (TA-8) Virtualised CDN operators: It is well known that the performance of CDNs improves the

closer that content is from users. This, however, is an expensive proposition, and so restricts all but the biggest players from the market. Instead, newcomers could deploy (virtualised) content caches at network edges, effectively renting out infrastructure and growing it as their business grows.

7 Detailed description of the new use cases provided by the partners

.Name of the scenario or use case	***5G RAN "network slices" (ALUBL-1)***
Rough Classification	**Main:** • *Flexible RAN architecture* **Secondary classification labels:** • *Reprogrammable RAN* • *Containers and FPGA* • *Micro services* • *Elasticity*
Source of the scenario	*5G will be more than a new air interface, it will be a new and disruptive network architecture that will offer flexibility in the services and great scalability. The Network Slices is a way to split the RAN into different functions, one for multimedia, another for M2M, another for IOT… each having its own "size" of the resources. This requirement has been identified by the NGMN [https://www.ngmn.org/uploads/media/NGMN_5G_White_Paper_V1_0.pdf].* 
Scenario description in a nutshell	*Ability to split the 5G Access Network into chained microservices that can be instantiated and scheduled dynamically over a combination of embedded systems and "cloudlets". For instance, we should be able to support different types of slices and dynamically change the size of each type of slice.*
Extended description and examples	*We start with 1 slice for multimedia handset, then introduce a slice for IOT. As the number of IOT devices grow, the second slice also grows. These 2 slices are "centralized" (i.e. located in a cloudlet via an Ethernet network).*

		Then we add a new slice for M2M where latency is key. This slice is partially executed on an embedded system located "next to the antenna" for latency purposes. .
Architecture and/or networking and/or technical challenges		*1) micro-services decomposition of the 5G RAN* *2) instantiation in IT atomic entities (such as containers, see www.docker.com) and embedded atomic entities (such as partial reconfiguration HW accelerator, see* http://www.xilinx.com/support/documentation/application_notes/xapp1159-partial-reconfig-hw-accelerator-zynq-7000.pdf*) in a unified way* *3) orchestration, scheduling, service chaining capabilities* *4) live and dynamic recomposition*
Benefits and innovation		*The high flexibility of the proposed use case will make it possible to deploy fully "programmable networks" able to support an infinite number of usages of the access network. Therefore, thanks to the flexibility, access network will be an excellent "substrate" for new innovative services.*
ANALYSIS (rough)	**Foreseen components, functions, or primitives**	*1) Elementary functions decomposing the RAN, both in the server and the front end sides* *2) Middleware for supporting atomic entities on x86 and FPGA* *3) Controllers for orchestration, service chaining, scheduling…* *4) Measurement tools for validating performance*
	Foreseen Requirements, Performance issues	*1) Speed of reconfiguration, on server side, on front end side, between both sides* *2) Speed for scaling up and down*
Any other note or comment		*This use case is challenging (!!) and will require strong interaction with other projects (FOSS or H2020) to delineate what is the "best" functional decomposition of the 5G RAN, deploy and test it.*

Name of the scenario or use case	***Wireless Software Defined fronthauling (ALUBL-2)***
Rough Classification	**Main:** • *Software Defined Wireless fronthauling* **Secondary classification labels:** • *Fronthaul network* • *Dynamic rates and topology* • *Network integration* • *Slicing*
Source of the scenario	*Fronthaul network is experiencing a strong "reboot" (see http://labs.chinamobile.com/cran/2015/07/13/the-1st-ngfi-next-generation-fronthaul-interface-workshop-2/). In this context we consider the fronthaul network to be an integral part of the 5G RAN and, as such, it has to be fully "reprogrammable". Due to the high data rates, only fiber and "wireless line of sight" can contend.*
Scenario description in a nutshell	*We propose to deploy a fully reprogrammable (via SDN) hybrid fixed and wireless fronthaul expected to be representative of a future 5G fronthaul system. In this scenario, we have a number of 10GbE switches and wireless relays, all controlled by an SDN controller (OpenDayLight). They connect RRH on one hand, server on the other hand. Due to some modification in the access network (e.g. slices update), the traffic conditions change and need to be reconfigured 'on the fly'. The wireless relay is connected by the Ethernet port.*
Extended description and examples	*There is a change in the slices, for instance after a 'multimedia slice' we add a 'low latency' slice (such as M2M) requiring to add a new flow in addition to existing "multimedia flows". According to the use case 1 (5G network slice), we need to add a "fast lane" for doing the new service chaining. A new flow is instantiated over wireless and wireline using OpenFlow. As traffic pattern change, the flows need to evolve also. At some point, the multimedia slice is recomposed to be more centralized (at least some of its components). This changes again the configuration. Parallel transmission over wireline and wireless may be needed to cope with capacity.* .
Architecture and/or networking and/or technical challenges	1) *Plugins to control wireless relays via SDN* 2) *Coherent function service (re)chaining and flow (re)configuration in order to avoid service disruption* 3) *Additional failover mechanisms for the wireless link* 4) *Unified wireless and wireline controller & applications* 5) *Parallel transmission over wireless and wireline* 6) *Integration of "server side components" and embedded systems*

Benefits and innovation		*5G will borrow its capacity from various technologies like massive MIMO, larger bandwidths and frequencies, more efficient phy processing (network MIMO) and denser network (frequency reuse). All of this puts a larger burden on the fronthaul – the link between the antenna and the cloudlet. Optical links may not be able to reach all sites and wireless relays can be a good way to complement and keep up with the increase, provided it is well integrated with the rest of the network (capacity to change dynamically, SDN integration, Ethernet interfaces…).*
ANALYSIS (rough)	**Foreseen components, functions, or primitives**	- *Ethernet port* - *SDN agent* - *Load balancing functions (parallel)* - *Interface and sync with micro services management*
	Foreseen Requirements, Performance issues	- *No loss, low latency, high throughput* - *Reconfigurability speed*
Any other note or comment		*This use case will enable live scenarios, provide we have 5G receivers The setup will be complex (wireless and wireline). It will be connected to the other use cases (for the service part).*

Name of the scenario or use case	***On demand network monitoring (BT-1)***
Rough Classification	**Main:** • *Dynamic & optimal placement of network monitoring probe instances* **Secondary classification labels:** • *Usage monitoring* • *Service monitoring* • *Network planning information* • *Per user/per-line usage analysis*
Source of the scenario	*Network-wide deployment of traditional DPI solutions is very expensive for most operators. However, operators have a strong requirement to understand how customers are utilizing their products and services. This is a business interest for BT*
Scenario description in a nutshell	*DPI solutions provide detailed views of network usage allowing operators to generate insights into capacity and service usage, and also to proactively plan for network evolution e.g. capacity uplifts, cache placement, peering and transit. However, the costs of achieving network-wide deployments of traditional DPI solutions are prohibitive for most operators. Therefore, alternative approaches such as the dynamic placement of monitoring probes to specific segments of the network are becoming increasing important. This is especially useful as different segments of the network potentially have customers with varying characteristics of the entire customer base.*
Extended description and examples	*A network operator wishing to observe different segments for usage monitoring, service monitoring, and network evolution. The operator is able to dynamically place monitoring probes in segments where the customer base is representative of the population for the metric being analysed.* *For usage monitoring, this involves observing the network bandwidth usage per application, per product* *For service monitoring, this relates to performance and quality metrics per application, and also per device type* *For network evolution e.g. CDN deployment, peering and transit, this involves being able to monitor bandwidth delivered from CDN caches on- and off-net, and also to identify services carried over peering and transit networks to ensure quality requirements are satisfied*
Architecture and/or networking and/or technical challenges	*1) identification of network primitives for this application* *2) automated integration of monitoring probes into already existing service chains* *3) algorithms for dynamic placement of monitoring probes* *4) need to segment the network into appropriate sample spaces if entire network cannot be covered by monitoring probes*

Benefits and innovation		*Operators do not need to incur the high cost associated with network-wide deployment of DPI solutions to gain accurate insight of customer usage trends. The ability to dynamically instantiate such services in network segments of interest provides a cost effective approach.* *We also believe this will drive new business innovations in network monitoring such as alternatives to deep packet inspection. For example, applications that combine existing approaches such as NetFlow with network services such as DNS*
ANALYSIS (rough)	**Foreseen components, functions, or primitives**	*- function to determine optimal placement of monitoring probes* *- edge storage to capture data associated with usage and service monitoring* *- edge processing for monitoring logic* *- means to identify customer segment that is representative of population for metrics that should be monitored* *- function to collect data from distributed monitoring probes*
	Foreseen Requirements, Performance issues	*- privacy issues* *- requirement for extremely fast real time migration of probes* *- data corruption associated with migration of monitoring probes i.e. data is reported as being for user A after probe has been migrated to monitor user B*
Any other note or comment		

Name of the scenario or use case	***S/Gi-LAN Services on the Edge (CITRIX)***
Rough Classification	**Main:** • *Network/Application-Aware Transport/Content Optimization* **Secondary classification labels:** • *TCP Optimization* • *Adaptive Bitrate Video* • *Encrypted Content* • *RAN-awareness* • *Network Congestion* *MOVING PROCESSING (E.G. TCP OPTIMIZATION) FROM BEHIND THE PACKET GATEWAY TO THE RAN*
Source of the scenario	*One of the key use cases of ETSI Mobile Edge Computing ISG (see slide 5 of http://www.etsi.org/images/files/technologies/MEC_Introduction_slides__SDN_World_Congress_15-10-14.pdf).* *There are early IETF standardization activities that are also relevant (see https://www.ietf.org/proceedings/93/slides/slides-93-iccrg-3.pdf), but the focus seems to be on delivering a stop-gap solution.* *The company has collaborated, also in the context of lab/PoC activities, with mobile operators and RAN/other vendors on this subject area. The use case is thus in the business interests of Citrix ByteMobile.*
Scenario description in a nutshell	*In today's mobile networks, services involving traffic management/DPI and transport/content optimization have been traditionally deployed on the Internet side of the GGSN/P-GW, i.e. in the S/Gi-LAN.* *Even though the industry recognizes the utility of these services, always in the context of the Mobile Data Tsunami and the desire of operators to differentiate from their competitors on the basis of QoE, deploying such solutions in a scalable fashion is becoming increasingly challenging/costly.* *Moreover, the lack of accurate visibility on RAN conditions makes it very difficult to deliver traffic management and transport/content optimization in a way that achieves balance between network efficiency and QoE.* *The flattening and "IP-fication" of the network, in the evolution from UMTS to LTE and, eventually, to 5G, provides opportunities of pushing these services into the RAN and towards the Edge of the network.*
Extended description and examples	*The proposition is, instead of trying to forward information using various channels from the eNodeB to the Traffic Manager located in the S/Gi-LAN, to migrate relevant services closer to the Edge of the mobile network.*

		Examples of such services are deep packet inspection, content detection, TCP optimization and video optimization, the latter focusing primarily on Adaptive Bitrate Video formats (MPEG-DASH, Apple HTTP Live Streaming, MS Smooth Streaming, Adobe Dynamic Streaming, etc.). *In their new place, and with the provision of appropriate interfaces/APIs, the above services will be able to take into account network behaviours on a per data session basis (cell handovers, RAT changes, RRC states, etc.).* *By having an accurate picture of localised network congestion, we will be able to make better decisions on when/how to effectively apply the above, and potentially other, traffic management and optimization services.* .
Architecture and/or networking and/or technical challenges		*At least for the case of OTT content, deploying content optimization and content caching in front of the GGSN/P-GW has been always problematic, due to the billing/charging and lawful interception challenges.* *However, the introduction of faster networks, in conjunction with the increasing adoption of encryption by content providers, has moved focus on optimization schemes that are lighter-weight and largely transparent.* *This has increased the attractiveness/viability of the proposed use case.*
Benefits and innovation		*As mentioned above, the benefits to mobile operators will be immediate, both in terms of maximizing subscriber satisfaction, but also in terms of making the large-scale deployment of such services more affordable.*
ANALYSIS (rough)	**Foreseen components, functions, or primitives**	*- RAN conditions/congestion interface/API* *- example transport/content optimization services/applications*
	Foreseen Requirements, Performance issues	*- efficient virtualised implementation of the services of interest*
Any other note or comment		

<table>
<tr><td colspan="2">Name of the scenario or use case</td><td>Dynamic MAC services allocation in Cloud RAN (ALUIL BGU)</td></tr>
<tr><td colspan="2">Rough Classification</td><td>Main:
• Dynamic Radio Resource Management (RRM) services in Cloud RAN
• Life Cycle Management (LCM) of RRM services in the access and aggregation network
Secondary classification labels:
• scheduling as a service
• MIMO as a services
• SON as a service</td></tr>
<tr><td colspan="2">Source of the scenario</td><td>Wireless networks are highly dynamic with changes in load, positions of the mobile users, handovers, and changes in the interference paths, etc. Radio Resource management services should cope with such dynamicity of the wireless networks. This translates in instantiation, migration and termination of RRM services either in the access or aggregation networks. In addition to the NFV resource management and LCM it requires management of the networks and forwarding/load balancing boxes.</td></tr>
<tr><td colspan="2">Scenario description in a nutshell</td><td>Migration or instantiation of RAN/RRM services is a complex task that is initiated by the RRM and involves management of NFV and SDN resources. The LCM of the RRM services is at the heart of this scenario.</td></tr>
<tr><td colspan="2">Extended description and examples</td><td>Due to load changes or handovers there is a need to update and modify the collaborative MIMO schemes. This change may require migration of the scheduling and MIMO streaming from one access network to another. Once such a service is instantiated, the NFV management system should provide the service with the required performance in terms of bandwidth and delay guarantees.</td></tr>
<tr><td colspan="2">Architecture and/or networking and/or technical challenges</td><td>1) Instantaneous creation and migration of RRM services
2)Description of complex LCM operation of the RRM services (application specific operation to be performed in a generic VNFM)
3) QoS provision for the demanding RRM services</td></tr>
<tr><td colspan="2">Benefits and innovation</td><td>Tackling and solving those challenges will pave the road for a true cloud RAN solution with the operational benefits of NFV accompanied by the performance gain from a joint scheduling and collaborative MIMO across multiple RRH.</td></tr>
<tr><td rowspan="2">ANALYSIS (rough)</td><td>Foreseen components, functions, or primitives</td><td>- VNFM for RRM services
- SDN for RRM
- QoS provisioning</td></tr>
<tr><td>Foreseen Requirements, Performance</td><td>- High bandwidth and low latency networks between RRH and access and aggregation networks
- Instantaneous instantiation of containers/virtual machines</td></tr>
</table>

	issues	
Any other note or comment		

Name of the scenario or use case	***Internet of Things (IoT) & SUPERFUIDITY Platform Scenario (CNIT-1)***
Rough Classification	**Main:** • *IoT Platform* **Secondary classification labels:** • *Machine 2 Machine communication* • *IoT Virtual Network*
Source of the scenario	*IoT is well known scenario, experts estimate that the IoT will consist of almost 50 billion objects by 2020, the number of smart objects connected to the Internet will inflate the scale of the network up to two or three order of magnitudes and will bring a never seen pervasive interaction between humans, hosts, things in any kind of combination.*
Scenario description in a nutshell	*Superfluidity and interoperability in the IoT: the ability to instantiate IoT services on-the-fly (pub/sub brokers, gateway between different IoT networks), run them anywhere in the network edge (micro server) and shift them transparently to different locations, integrating vertical and/or proprietary platforms and devices.* *The ability to create on the fly a network (ad-hoc or/and infrastructured) composed by smart objects.* *The ability to use local communication (LTE Direct, BLE) instead of remote when needed: e.g. not all nodes can reach the internet, e.g. some nodes have to save energy.*
Extended description and examples	*The Internet of Things (IoT) is the "connection of physical things to the Internet", which makes it possible to access remote sensor data and to control the physical world from a distance. As regards, IoT services and vertical applications examples are endless and include sectors such as healthcare, security/surveillance, transport, factory (Industry 4.0), energy/grid, agriculture.* *Most of this examples can be categorized in two main categories based on how the IoT devices connects to the internet: i) Using a specialized protocol, e.g. ZigBee, BLE, BACnet ii) Integrating the device into the IP-world, e.g. 6LoWPAN, CoAP, MQTT.* *In both cases the IoT devices connects to the internet using a kind of "gateway" that provides the entry to the network (i) or that translate between protocols (ii, e.g. 6LoWPAN to IPv6, CoAP to HTTP). The functions, performed by these gateways, could be virtualised using SUPERFLUIDITY platform (e.g. on a microserver).* *As a concrete example we can think to a sensors network used for environmental/structural monitoring. Sensors can be deployed in a random topology, or the topology can vary due to moving sensors or environmental changes. In this case having ability to virtualise/move network functions is a fundamental property. For example: it will be*

		possible to keep the data aggregation functions near nodes that are actually producing more data or near nodes that needs to save energy, it will be easy to integrate new sensors and new protocols on the fly just upgrading a VM and to change routing depending on different metrics. .
Architecture and/or networking and/or technical challenges		*1) Scalability: support for dense crowds of devices, users* *2) Interoperability: efficiently working with the inherently heterogeneous mix of communication protocols and media* *3) Self-configuration and reconfiguration* *4) Support different network topologies: nodes can be deployed in deterministic or random topologies; in both cases, the network must adapt to the different topologies and adapt to changes (energy level of the nodes, unpredictable operating environment, different Data reporting model)* *5)Support to mixed scenarios with ad-hoc and infrastructured network* *6)Seamless combination of heterogeneous wireless accesses*
Benefits and innovation		*Today the IoT scene is composed by a set of different solutions: different hardware platforms, different radio interfaces, different communication protocols and different development platforms. All this has created a myriad of different IoT solutions, in case of both open and proprietary solutions the end user (user or developer) must actively build and manage the communication infrastructure between the different connected objects and between the different IoT systems. The coming of 5G networks with the development of a platform that can easily integrate and manage existing IoT networks could be a key aspect in the creation of an IoT ecosystem where the user, or the developer, do not have to worry about creating and manage the network, but they can simply use the device / service.* *The benefits of such platform are manifold:* - *easily exploit new network* - *partition/share an IoT network infrastructure* - *classification of data produced by IoT networks* - *easily aggregate and process data produced by IoT at the edge* - *hybrid IoT network*
ANALYSIS (rough)	**Foreseen components, functions, or primitives**	*- layer that abstract the different network types (wireless, BLE, LTE Direct, LoRa…)* *- dynamic configuration of connected objects* *- algorithms that build the network topology and/or position the network functions using different metrics (battery consumption, location, meteorological conditions, time of day ....)* *- service discovery* *- identify smart object and the conversation between them*

	Foreseen Requirements, Performance issues	*- handle a high number of connected devices* *- low energy consumption (computation/communication)* *- privacy & security*
Any other note or comment		

Name of the scenario or use case	***Context-adapted data delivery (CNIT-2)***
Rough Classification	**Main:** • *RAN-aware context-based content delivery and optimization* **Secondary classification labels:** • *Location based services* • *Monitoring and analytics* • *Adaptive media delivery*
Source of the scenario	*Traditional "application level" use case, heard many times, but which we believe we should pay attention to so as to identify "network level" functionalities to be taken out of the application itself.*
Scenario description in a nutshell	*Ability to adapt the delivery of content based on context information, including location but not restricting to it and including also an estimate of the user behaviour (e.g. user on the move, potential user interests, etc)*
Extended description and examples	*A user walking in a mall subscribes to a context/location based service (concretely, an app), where content relevant to the 'mall' context is pushed to the user terminal. Context is built not only based on location, but also user behaviour, such as user standing in front of a shop opposed to user walking/driving. The system should make sure that the right type of content type is pushed to the user: a walking/driving user is arguably not expected to be interested in full quality video opposed to a sitting/standing user.* .
Architecture and/or networking and/or technical challenges	*1) identification of basic (reusable) networking primitives underlying this application* *2) need for improved localization and context sensing primitives, including information gathered by user terminals (e.g. accelerometer)* *3) need for edge systems able to parse user information and match content with users* *4) need for context-aware scheduling and resource allocation strategies*
Benefits and innovation	*Today, applications of this kind must be developed "from scratch" in every environment, meaning that each mall or museum or venue has to develop its own application.* *We see an advantage in providing basic (and hopefully standardized or at least systematically addressed) "ambience" primitives which are offered to the "venue operator" (e.g. the mall) so as to rapidly deploy, provision, and customize the desired service.* *The expected market is for 5G operators to become "ambience service providers", so as to provide the wireless delivery primitives and tuning*

<table>
<tr><td colspan="2"></td><td>knobs that the “venue provider” can leverage to implement its own application, just focusing on the design of the application business logic itself, rather than being forced to deal with the underlying content adaptation and delivery details.</td></tr>
<tr><td rowspan="2">ANALYSIS (rough)</td><td>Foreseen components, functions, or primitives</td><td>- means to monitor, collect and analyse context information
- ability to gather sensing information from user terminals
- ability to process sensed data on the edge and classify “context”
- edge storage and processing of content for low latency delivery
- flexible and time-varying resource allocation
- xxx (to be expanded in next analysis)</td></tr>
<tr><td>Foreseen Requirements, Performance issues</td><td>- privacy issues
- resource allocation and scheduling must go beyond bandwidth/delay and include context information
- massive peak content downloads (e.g. HD video for “still” users)
- very low adaptation delay
- how to include user in the loop (interactivity, usability!)
- <u>all the above mentioned primitives should be provided as “cloud-like” to the venue provider</u>!</td></tr>
<tr><td colspan="2">Any other note or comment</td><td>Not clear whether this stems too much in the application domain and our project should not go “so high” in the stack.
Not clear whether this is truly characteristic for Superfluidity, or a rather more general use case valid for “any” 5G project, and hence it would be better to select other more distinguishing use cases at the end of the day.</td></tr>
</table>

Name of the scenario or use case	*Mobile Based Augmented Reality for User Experience Enhancement (Intel-1)*
Rough Classification	Main: • *Augmented Reality* Secondary classification labels: • *Enhanced Platform Awareness* • *Monitoring and analytics* • *Low Latency /High Throughput Applications* • *HIGH BANDWIDTH / HIGH PROCESSING CAPACITY*
Notes for discussion	• *CRITICAL vs. NON CRITICAL APPLICATIONS* • *"PUBLIC EDGE CLOUD" ??*
Source of the scenario	*The 'video game' generation has become accustomed to immersive environments which provide high level of engagement and stimulation. Also given the increasing mobility of the global population whether for holidays or business travel there is a growing need to navigate and interaction with unfamiliar environments than present challenges such as language barriers, navigation either by foot, by cars/public transport, or local knowledge of services such as food and drink. Augmented reality may have potential to improve human safety for example when driving a car. Augmented reality is a logical evolution for users which high expectations of immersive entertainment or users that want informed information retrieval over what is currently afforded by applications such as Google maps.*
Scenario description in a nutshell	*The ability to provide rich and dynamic information at very low latencies to support applications such as augmented reality dashboards for drivers, augmented reality glasses tendered to a 5G mobile handset to provide ambient intelligence to users such as tourists visiting a new city or providing multisensory stimulation to an on-line gamer interacting with their peers.*
Extended description and examples	*There is a growing interesting in using augmented reality to enhance user experience for both entertainment and practical purposes such as ambient environmental interactions. Examples include:* • Enhanced heads up display which overlay information on top of the windscreen to provide the drive information relating to safety such identifying objects in the dark which are obstructing a car's path, or providing the driver with navigation and road position information associated with a required road manoeuvre. • Augmented Reality (AR) applications running on 5G smart-phones or tablets can provide overlay augmented reality content onto objects viewed on the device camera. This has application such as Smart Cities to enhance the experience for visiting tourists. • Other scenarios include sporting event information, personalised advertisements etc.

Architecture and/or networking and/or technical challenges		*1) Delivery of significant data volumes with very low latency (~ms).* *2) Local caching of AR content to* minimise round trip time and maximize throughput for optimum quality of experience. *3) High availability for safety enhancement related applications.* *4) High reliability* *5) Scalable or elastic infrastructure to support transient peaks demands such as cultural or sporting events.* *6) Capture of mobile device, application, infrastructure platform and network metrics and fusing them into and efficient and meaningful manner which can be used to quantify the user experience and to drive Orchestration actions which maintain a desired level of experience.* *7) Successful and automatic differentiation of the landscape to support performant service deployment is necessary.*
Benefits and innovation		• Enhanced user experience which creates 'stickiness' for a location or event. • Drive new business innovations such as location or context aware services.
ANALYSIS (rough)	Foreseen components, functions, or primitives	*- Local VR Content Caches* *- Hardware Acceleration for content generation or rendering* *- Resource and platform aware Orchestration to intelligently manage VR applications to deliver the best available user experience.*
	Foreseen Requirements, Performance issues	*-How to include user experience in the loop.* *-High speed mobile cloud edge scale out or down in respond to spikes in utilisation and to minimise congestion.* *- Dynamic allocation of resources.* *- Dynamic network capacity* *-High reliability radio communications which support rapid location changes i.e. high mobility* *-Non-repudiation of information/content* -indoor & outdoor connectivity *- QoS for safety related applications*
Any other note or comment		*High potential use case given the number of possible devices that could utilise this form of technology.*

Name of the scenario or use case	***Performance Optimization for Distributed Multimedia Content Delivery (Intel-2)***
Rough Classification	Main: • *Application Aware Performance optimization* Secondary classification labels: • *Enhanced Platform Awareness* • *Monitoring and analytics* • *Adaptive media delivery* *GENERATION OF CONTENT BY THE USERS*
Source of the scenario	*The 'social networking generation' who consume and generate multimedia content on a continuous basis expect to access and share their content in a seamless and real-time fashion. The use of cloud computing resources to support flexible deployment of multimedia resources to deliver a high quality user experience. The advent of heterogeneous cloud computing environments with specialized co-processors affords new opportunities to improve use experience and to enhance business for targeted consumer services.*
Scenario description in a nutshell	*The ability to adapt the delivery of content or to upload and process content based on context information through the use of edge clouds. Orchestration of the applications such as vCDN and video transcoding services is platform aware which ensures workloads can be scaled on computing platforms that have appropriate platform features and capabilities to deliver the required level of user experience.*
Extended description and examples	*At large outdoor events users are generating large volumes of multimedia content and viewing multimedia content generated by members of their social network who are also attending the same event. The use of distributed caching technology can provide backhaul and transport savings and improved QoE. Content caching has the potential to reduce backhaul capacity requirements by up to 35%. Secondly the QoE can be improved by ensure video processing or delivery applications which are capable of utilizing platform features such as co-processing cards e.g. multi-integrated cores can be scheduled to run on these resources when available. Thirdly the Orchestrator is context aware and can schedule additional cloud resources which are in closest proximity to the event to minimise video stalling and increase browsing throughput.*
Architecture and/or networking and/or technical challenges	*1) Efficient match of workloads to heterogeneous resources (compute, storage and network). What is optimal allocation of quantities and types for a given application context?* *2) Capture of mobile device, application, infrastructure platform and network metrics and fusing them into and efficient and meaningful manner which can be used to drive system Orchestration.* *3) Elastic formation of cloud services to address transient increase in resource utilization.*

		4) Intelligent Orchestration to ensure that services and deployed and scaled on the most appropriate platform and consider the heterogeneity resources in the decision making process. *5) Use of offline and real-time in an interleaved manner to develop insights in to the interplay between services and platform resources allocations on a longitudinal basis and in point in time to optimize service placement decisions.* *6) Removing resource abstraction in cloud environments* *7) Successful and automatic differentiation of the resource infrastructure landscape to support performant service deployment is necessary e.g. feature, topology, location of resources etc.* *8) Successful and automatic differentiation of the landscape to support performant service deployment is necessary.*
Benefits and innovation		Heterogeneity in the clouds will continue to grow in the cloud. Platform features and capabilities have a significant impact on application performance such as multimedia and consequently user experience. By understanding the relationship between applications such as multimedia transcoding and the deployment infrastructure the user experience can optimized. Secondly the adoption of multimedia applications at the network edge will improve user experience both from a generation and consumption perspective e.g. local content caching to reduce backhaul. Improved application orchestration by exposing platform features which can benefit either the initial application instance of subsequent application scale out.
ANALYSIS (rough)	Foreseen components, functions, or primitives	*-Real-time and offline analytics* *-Real time telemetry* *-Mobile cloud edge for delivery/processing of user generated media and content.* *-Ability to gather application metrics from user mobile devices* *-Resource and service aware Orchestration*
	Foreseen Requirements, Performance issues	*-Resource allocation and scheduling that is both resource and state aware.* *-Modelling diverse data sources of varying quality and resources into an actionable representation of state and performance intent.* *-How to include user experience in the loop*
Any other note or comment		*Edge multimedia content use cases are already established however these are very generic and do not consider the platform and Orchestration aspects.*

Name of the scenario or use case	*Context Aware Smart Living (Intel-3)*
Rough Classification	Main: • *Intelligent Connected Devices to Support Smart Living Scenarios* Secondary classification labels: • *Context and Location based services* • *Autonomous intelligent services*
Source of the scenario	Exponential growth in the number and types of devices (sensors, actuators, mobile devices) that have a wide range of characteristics and infrastructure related demands. Potential growth to tens or hundreds of discrete or integrated devices for individual users. Currently users already have a number of personal devices such as a smartphone, tablet, laptop, Bluetooth-enabled devices e.g. activity tracking devices. This trend will continue and will evolve to include ambient devices which do not require direct interaction by the user but provide information and support services that are visible and invisible to the consumer. 5G needs to be designed to accommodate such growth in device numbers.
Scenario description in a nutshell	A key focus for the proliferation of IOT devices is realisation of a connected world where devices and sensors are connected in a seamless manner to support humans in the daily activities of living. The combination of sensor, actuators, mobile devices, ubiquitous high speed wireless connectivity and cloud infrastructures will the support the realisation of a smart society where intelligence is embedded into all aspects of daily life such as smart transport, smart home, smart health and wellness and so forth.
Extended description and examples	The term smart is being used to describe a dramatic evolution in the way we live our daily lives. It has led to the advent of concepts such as smart cities, smart homes, smart living, smart society based on dense wireless sensor networks with ubiquitous connectivity and data accessibility and context aware intelligence. Distributed networks of sensors together with personal sensors/devices will be used to support our daily activities. In homes, various ambient sensor and actuators such as temperature sensors, security devices, heating controllers, meters and home appliances will be connected wirelessly. While the majority of these sensors will be low data rate devices, devices such as HD security cameras will be high data rate and will need to be accessible from any location outside the home including different countries by the home owner on personal mobile devices. The task for 5G will be to integrate the management of these diverse connected devices. Examples of smart living scenarios include: • Smart clothing to support health and activity monitoring. It is expected that the use of wearables consisting of multiple types of connected devices and sensors will become more pervasive.

		Smart clothing with embedded ultra-light, low power, waterproof sensors particularly for sports and leisure activities are starting to emerge. These sensors can measure various environmental and biometric parameters such as temperature, heart rate, blood pressure, body temperature, breathing rate, blood oxygen levels, skin moisture, etc. Information from ambient sensing such as pollution monitoring can be used to inform the user area will provide them with the best air quality when exercising outdoors. A key challenge for this use case is the overall management of the number of devices as well as the data and applications associated with these devices. • *Wearables, smartphones, tablets, and other devices with sensors that are location and context aware will work together with apps and services that people use on a daily basis. For example a person is having a business meeting with a customer contact in their calendar. A few minutes prior to the meeting, their mobile device might share some data about that person by quickly sending content cached nearby in the cloud to help their preparation for the meeting while they are in transit to the meeting.*
Architecture and/or networking and/or technical challenges		1) *Smart aggregation devices which can support multiple radio protocols with different data bandwidths and QoS.* 2) *Improved localization and context sensing primitives combined with analytics to improve ambient intelligence and to provide user specific information and insights.* 3) *Data Aggregation and processing at edge systems.* 4) *Support for sensor network which are highly heterogeneous in nature from a wide variety of vendors.* 5) surge accommodation i.e. ability to handle scenario where a large number of devices attempt to access the network simultaneously
Benefits and innovation		• *IOT is expected to be a key driver for 5G. To achieve the vision of IOT which is a smart and hyper-connected internet of everything world requires the high bandwidth, low latency and ubiquitous connectivity. 5G will support the massive deployment of connectivity devices (sensors and actuators) to support a wide variety of scenarios. The expected level of embedded and ambient sensing coupled with 5G connectivity will support the development of new services value add services by catalysing new businesses. For example wearable device could connect to other devices and this could lead to new kinds of experiences which can be monetised into value add services for consumers.*
ANALY SIS	Foreseen components, functions, or	• *Cloud based radio access networks to support dynamic scalability* • *Ability to gather sensing information from user device e.g.*

	primitives	*smartphones, body worn sensors, smart clothing, ambient sensors etc.* • *Intelligent orchestration to support adaptable service delivery based on based on system wide context* • *means to monitor, collect and analyse context information* • *ability to gather sensing information from user terminals* • *ability to process sensed data on the edge and classify "context"* • *edge storage and processing of content for low latency delivery* • *flexible and time-varying resource allocation*
	Foreseen Requirements, Performance issues	• *Long life batteries 10+ years* • Smooth mobility between cells, layers and radio access technologies needs to be assured • high capacity and low latency backhaul • network need to be programmable, software driven and managed in an integrated way • support for any-to-any communication • reliability • security • performance (latency, throughput) • Varying payload size and frequency of transmission
Any other note or comment		*The IOT can be broken down into many specific use cases examples. Starting a general overarching scenario which may need to be broken down into more specific use case scenario's such as Smart Cities, Smart Home, Smart Health etc.*

Name of the scenario or use case	*Mobile services offloading (NEC-1)*
Rough Classification	Main: • *Cloud based mobile services* Secondary classification labels: • *Location based services* • *User following services* • *Cloud offloading* *MIGRATING SERVICES FROM MOBILE DEVICES TO MOBILE EDGE*
Source of the scenario	*This is one of the basic use cases enabled by the Superfluid Cloud concept that NEC is developing for some time. It enables operators to sell new and innovative valued-added services to their customers.*
Scenario description in a nutshell	*Applications currently running in users' mobile devices (e.g. parental control, ad removal) can be offloaded to the edge of the network, for improved security and reduced battery usage.*
Extended description and examples	*Taking advantage of the Superfluid Cloud properties, ISPs can offload many of the services that currently run on users' mobile devices to the cloud, providing extra security and reduced battery usage, while keeping a near local user experience.* *Given the small footprint envisioned for the Superfluid Cloud guests, services can be deployed in a VM per user fashion, providing extreme personalization and unmatched security and privacy. The small footprint together with the mobility properties of the Superfluid Cloud, enable the processing units to follow the user around. Deployed in the edge, from the home gateway to the closest BTS, and therefore eliminating all sorts of overheads associated with centralized approaches, for a user experience that matches a local application.* *Examples:* 1. *Parental control* *By offloading parental control to the cloud, parents have extra assurance that their children cannot tamper with the service, but are still monitored independently of their location, being it at home through the Wi-Fi connection or outside, using 3G/LTE, and even independently of the device their using.* 2. *Ad removal* *Ad removal is an important part of web surfing these days, that the users want available in all their devices. By using the Superfluid Cloud operators could provide personalized ad removal on the cloud, eliminating all of the browser extensions and mobile apps, and reaching new devices, like Smart TVs that start to have integrated browsers but no add removal functionality.*
Architecture and/or	*The use case depends directly on the properties provided by the*

networking and/or technical challenges	*Superfluid Cloud, and therefore depends on the development of such technology. The following are some of the research topics especially interesting in this context.* 1. *There are all sorts of new "lightweight virtualisation technologies" that can be used to provide small footprint guests for the Superfluid Cloud, ranging from containers to Unikernels or minimalistic Linux deployments. However, porting applications to these technologies with low effort is one of the biggest road blockers at this point in time and needs to be addressed.* 2. *A management framework for the Superfluid Cloud is another open issue. The proposed system quickly scales to thousands or hundreds of thousands of guests, deployed over a wide area and in constant movement. These characteristics put a special burden on a Superfluid Management Framework, that will need to address two particular requirements for this use case:* • *Extreme scalability: the framework should be able to manage hundreds of thousands of guests;* • *Low footprint: the software must run on a wide variety of devices, from powerful datacenter servers, to low power single board computers deployed at the edge.* 3. *For the successful deployment of such a system platform operators need to open the system to 3rd parties who will develop some of the applications. Therefore, the development of APIs through which 3rd parties can use the system is another essential topic. These APIs should also provide the means through which users will be able to request services.* 4. *Security and privacy of the users and users' data in such a system is essential. Users need to be provided with means enabling them to choose the type of data (network traffic) each of the applications have access to.*
Benefits and innovation	*Current services are either local (in terms of the device) or centralized (in the cloud). By moving cloud services closer to the user operators can provide the advantages of cloud services with the user experience of a local application.* *Benefits:* • *For the user:* o *Longer battery life on their mobile devices* o *Extra security* o *Device independent services* • *For the operator:* o *Provide value-added services*
A N Foreseen	• *Superfluid Cloud porting tool*

	components, functions, or primitives	• *Virtualisation infrastructure* • *Management framework*
	Foreseen Requirements, Performance issues	• *Extremely fast times for instantiation, tear-down and migration of appliances* • *Extremely scalable management*
Any other note or comment		

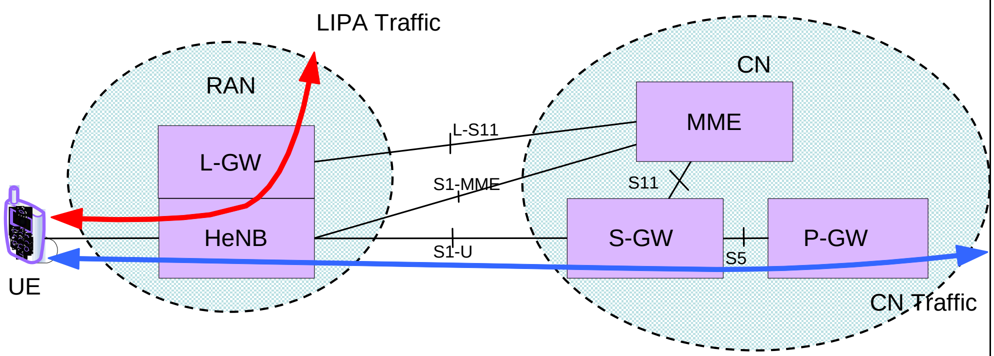
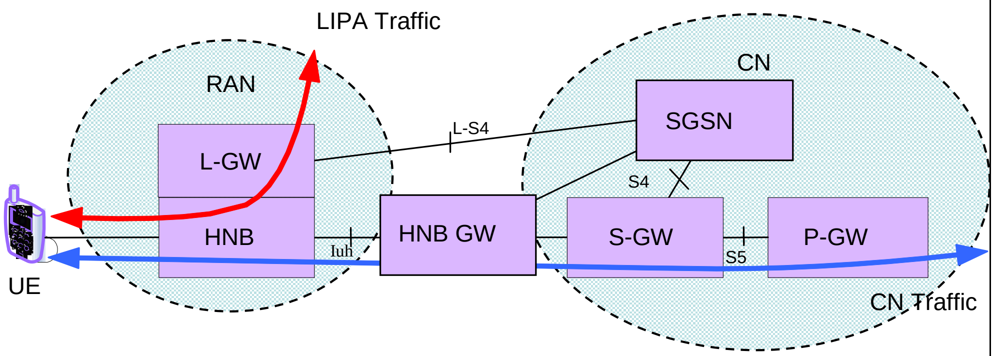
Name of the scenario or use case	*Transparent web service acceleration (ONAPP-1)*
Rough Classification	**Main:** • *Use a specialized accelerator VM instance to convert static content to use a CDN* **Secondary classification labels:** • *Transparent CDN* • *Re-routing of network traffic* • *Service chaining*
Source of the scenario	*OnApp Accelerator program is going to be released in beta form 'imminently'. More information can be found at the following link.(http://onapp.com/files/brochures/2015/onapp-accelerator-datasheet-170715-web.pdf) It is a way of more easily using Federation that was developed over the course of the Trilogy2-FP7 EC Project. It is very much in OnApp's interest to have more users wanting to adopt Federation. Many hosting providers are happy to sell under-utilised resources, but buying has been a more difficult prospect.*
Scenario description in a nutshell	*Benefit from CDN acceleration without explicitly re-writing web services and content.*
Extended description and examples	*Web hosting providers (who are OnApp's primary market) can currently use the OnApp CDN platform to differentiate from other solutions. The difficult though is that their customers, the end-users, may be web-developers that don't have much experience with CDN platforms. To expose this, a transparent web content accelerator VM is placed in the same network as the VM instances and can instantly benefit from having multiple connected locations..*
Architecture and/or networking and/or technical challenges	*1) Analyse static content that is available from a web server* *2) Compress the content so it is easy to mirror across CDN sites / within the Federation* *3) Re-write local routings to utilize the CDN platform* *4) Integrate with existing edge-services* *5) Re-route traffic to utilize a closer edge provider*
Benefits and innovation	*For a large number of end-users CDN platforms are a step beyond their technical knowledge and have a barrier to entry. To reduce this barrier and allow more people to benefit from CDN and Federation technology the complexity is being passed to the accelerator application. This allows the 'smarts' of the CDN logic to be kept from the web-developers and instead handled by the service provider which is a clear differentiator. Also as there are no changes to the original content, it can be combined with any other technologies that need the unmodified HTTP content.*
ANALYSIS (rough) — Foreseen components, functions, or	*1) Accelerator VM to be created in the same network* *2) Re-routing rules to work with the CDN platform.* *3) Static content analysis*

	primitives	4) *Compression system* 5) *CDN replication engine integration*
	Foreseen Requirements, Performance issues	*The accelerator will need to schedule the conversion of content for new web-sites.* *The information should be cached and when changes are made only the parts that are changed should be re-analysed to avoid over contention of the accelerator* *Difficult to transport secure 'session' based traffic e.g. https. Dynamic content will also need to be provided by the main origin until there can be a consistent view across any of the edge-providers.*
Any other note or comment		*This is quite high in the stack. It is relevant and has clear commercial benefits from a company perspective. It will likely be continued from a business perspective so is likely to have good exploitation and dissemination.* *Some of the original work was done outside of Superfluidity but not against any other EC Projects. Transparent CDN has not been discussed in the context of Trilogy 2 but VM mobility has.*

Name of the scenario or use case	***Rapid and massively-scalable instantiation of high performance (virtual) application instances (ONAPP-2)***
Rough Classification	**Main:** • *To utilize an adapted version of the Integrated Storage platform on heterogeneous, low-power microservers* **Secondary classification labels:** • *Low resource overhead hypervisor* • *Massive consolidation of VMs* • *Communication and shared resources across hypervisor instances*
Source of the scenario	*Utilising a lean and highly-efficient Hypervisor platform, named MicroVisor developed as part of Euroserver-FP7 Project; in Superfluidity we will look at profiling the performance of various platforms and determine the I/O performance improvements enabled by the MicroVisor over the current state-of-the-art. The platform development and initial idea are out of scope of Superfluidity but algorithms for optimal resource placement along with orchestrators and improving the I/O performance of fluid VM instances across the platform will be investigated.*
Scenario description in a nutshell	*Investigate how the new MicroVisor platform can be leveraged for fulfilling the objectives of Superfluidity on heterogeneous hardware architectures.*
Extended description and examples	*There is a sea change coming for x86 server systems. Current deployments rely on cache-coherence and this is becoming more limited with NUMA and some novel high-speed interconnects being used to extend the use of cache-coherent systems. Eventually there will be a time where cache coherency can no longer be maintained. This is the motivation behind the MicroVisor. In this project we will look at how to leverage liquidity of resources across heterogeneous hardware platforms including ARM and x86..*
Architecture and/or networking and/or technical challenges	*1) MicroVisor platform that is brought in as binary form (no source code).* *2) Investigate the interaction between ARM and x86 systems and see how performance can be improved when interacting between the platforms* *3) Understand the workloads and look to move resources to best take advantage of x86 or ARM hardware in-line with global objectives and policies set by configurations and the orchestration system.* *4) Investigate how to maintain network communications and fluidity across heterogeneous resources*
Benefits and innovation	*OnApp are working on several potential business cases relative to the MicroVisor not limited to utilizing low power micro-servers that are coming to the market. The innovation comes from the generation of*

		fluid VMs that can move across MicroVisor based platforms. For some workloads, utilizing a VM may not be the best way of migrating resources and maintaining fluidity. We will investigate when it might be appropriate to utilize virtualised resources and/or containers and also potentially look into VM / container / chroot exporting and importing.
ANALYSIS (rough)	Foreseen components, functions, or primitives	*1) Hypervisor platform* *2) Storage, Network I/O resources* *3) ARM / x86 systems* *4) Interaction with SDN / networking resources*
	Foreseen Requirements, Performance issues	*We will need to continue the profiling as per the activities of I5.2. Beyond this we will need to look at improving the platform performance to allow for many 10s of 1000s of VMs to be instantiated that are light-weight, via MiniOS or other similar light-weight VM designs.* *Working on improving scheduling systems and see how it will integrate with orchestration systems such as OpenStack*
Any other note or comment		*There are quite a few areas of work related to the platform research and development that have synergy with the overall objectives of Superfluidity.*

Name of the scenario or use case	***Local Breakout (LBO) (PTIN-1)***
Rough Classification	**Main:** • *Network Forwarding Efficiency* **Secondary classification labels:** • *Local Network Connectivity* • *Corporate/Campus Connectivity* • *Big Events (Crowd) Connectivity* • *Tactile Communication Services* *MOVING TRAFFIC TO LOCAL NETWORK AVOIDING GOING TO THE CORE*
Source of the scenario	*This use case addresses a very well-known concept on 3GPP networks, in order to avoid Internet traffic to go through the Home Network when a user is roaming out. In this case, the same concept is applied, but to a more restricted area (the edge). This use case will help to flatten the network and make it more efficient.*
Scenario description in a nutshell	*Local Breakout intends to avoid user traffic to be sent to the mobile network core, when communication parties are on the same edge network (e.g. eNB). On 3GPP networks, by default, all traffic is terminated on the mobile core (PDP/PDN). However, in many cases, knowing that users are attached on the same edge, communications can be shortcutted, making the connectivity more efficient. A similar concept may also be applied to fixed networks.*
Extended description and examples	*The Local Breakout use case may apply to many situations where communication parties are attached to the same edge of the network. In this case, it is desirable that the traffic can flow between them directly, not going to the mobile core, which is today the default behaviour.* *Use cases that may take special advantage of that scenario are: some big events (sport, concerts, etc.) and corporate services, among others.* *In the case of big events, the operator can deploy services, like event video streams from multiple cameras, statistics, virtual reality, augmented reality (e.g. overlay player names), etc. on the edge, benefiting from the significant backhaul traffic reduction, increasing the bandwidth and reducing the latency available for users, resulting in an improved quality of experience.* *Corporate connectivity services can also benefit from the Local Breakout scenario. In this case, corporate and other big customers (like universities and schools) users, use to generate large amounts of traffic to access to local corporate services or other corporate users. Using Local Breakout, operators may save a lot of resources, increasing the overall quality experienced by the user (bandwidth, latency, etc.).*
Architecture and/or networking and/or	*In order to implement the Local Breakout behaviour, the mobile network has to change the default forwarding behaviour, which sends all traffic to*

technical challenges	*the core. In the last Releases, 3GPP has been working on several technologies that can support the technical requirements needed for this use case. For example, [TR23.829] describes multiple options of local/offloading communication that can fit the requirements, namely making an RNC/eNB breakout.* *The following Figures depict some of the architectures proposed (LIPA, SIPTO).*   *Note: This capability to take out the traffic on the edge (e.g. eNB) is common to almost all Edge Computing use cases, in order to provider services from there.* *This use case will bring some technical challenges also from the point of view of OSS/BSS systems since overall consumption, core usage and service provisioning will vary.*
Benefits and innovation	*This model brings multiple advantages to operators and users.* • *Performing local breakout, the operator can save resources on backhaul links, since part of the traffic is forwarded locally.* • *As the traffic is not forwarded through the core, users have more bandwidth available for local traffic, e.g. corporate, event-related, etc.* • *As the traffic is not forwarded through the core, users have lower latencies, benefiting especially some delay-sensitive applications,*

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such as voice/video calls, gaming, virtual reality or augmented reality.
This model allows operators to easily set up local services for temporary events, without a significant backhaul capacity, decreasing deployment times and reducing deployment costs. These costs reduction can also be reflected to the customer

The main innovation of this use case is the operator capability to change the forwarding model, decentralizing the routing process and making it more efficient, especially for some particular scenarios. Operators increase user satisfaction and reduce costs; users get a better quality of experience (tactile communications).
These use case complements and fosters Edge Computing.</td></tr>
<tr><td rowspan="2">ANALYSIS (rough)</td><td>Foreseen components, functions, or primitives</td><td>Some foreseen components are:
Mobile Local/Offloading (LIPA/SIPTO features)
Edge Forwarding Services</td></tr>
<tr><td>Foreseen Requirements, Performance issues</td><td>Some requirements are:
3GPP Local/Offloading (LIPA/SIPTO) capabilities
Edge Forwarding Capabilities</td></tr>
<tr><td colspan="2">Any other note or comment</td><td></td></tr>
</table>

Name of the scenario or use case	*virtual Convergent Services (vCS) (PTIN-2)*
Rough Classification	Main: • *Home Gateway Services* • *Set-Top-Box Services* • *Mobile Services* Secondary classification labels: • *Location Based Services* • *Caching Services* • *Functions Orchestration*
Source of the scenario	*The concept is similar to the vHGW (virtual HomeGateWay), which is a well-known NFV/SDN use case for fixed networks. With the evolution of the vHGW to individually deal with the multiple persons inhabiting the home (e.g. different URL filtering rules), this model can be applied to mobile scenarios, building a convergent service, which can be used from different access technologies. Due to potential low-delay requirements, this use case may take advantage of edge deployments. This subject is of interest to PT/PTIN and other vendors and operators.*
Scenario description in a nutshell	*The vHGW use case intends to move traditional functions (e.g. firewall, parental control, NAT, etc.) residing on the customers' home to a virtual HGW (vHGW) in the cloud. In a convergent scenario, these services apply both to fixed and mobile environments, providing a convergent desired behaviour, either when the user is at home or using a mobile device.* *The vSTB component complements the use case, extending the usage of a virtual STB to a multi-screen scenario, simplifying the convergent environment, reducing operator investment and making easier the upgrade and deployment of new services, being accessible to the user from any terminal.*
Extended description and examples	*The vCS use case is built on top of a generic platform composed by a chaining engine and a set of functions, which can be dynamically sequenced as desired per person/user. The traffic generated by the user will be driven according to defined chaining rules and this sequence will determine the treatment the traffic will receive, e.g. crossing firewalls, parental control, NAT, etc.* *In a convergent scenario, users take advantage of the operator capability to provide the same behaviour on fixed and mobile environments. This is the value-added that this vCS use case brings to users.* *With this model, operators can create a separation between the access network and services. For the users, service configurations apply, no matter the access network they are using.* *The deployment of vHGWs on the data center, make operators free to deploy new services, or upgrade them without changing anything on customers equipment. This provides independence from smartphones/HGWs and*

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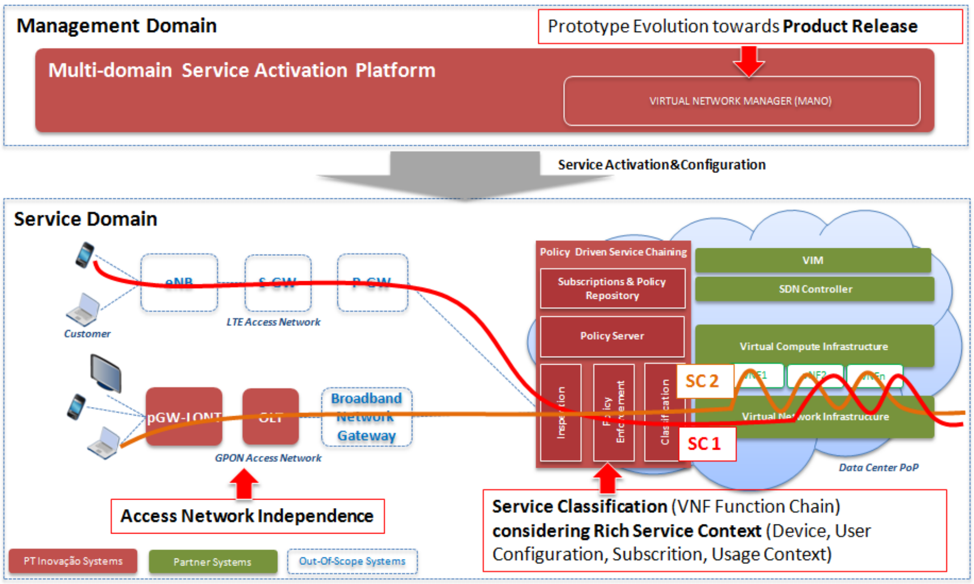
<td>flexibility to manage services, lowering operational costs (no intervention is needed with the customer).
This kind of services largely benefits customers when deployed on the edge of the network, since they can get low delay and high bandwidth, to do, in the network, what today use to be done locally at customers’ home or terminal.
Taking advantage of this generic platform, operators can deploy other services than traditional functions. Good examples of this are CDN features, which increase the overall quality of experience of customers and reduce the required bandwidth on the operator’s core and backhaul network.

</td>
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<tr>
<td>Architecture and/or networking and/or technical challenges</td>
<td>To implement the vCS use case, the architectures of multiple SDOs must be combined, in particular:
• TMForum (OSS/BSS issues)
• ETSI NFV (NFV issues)
• ONF (SDN issues)
• IETF SFC (Chaining issues)
The following picture intends to provide an overall architecture.
Note: This combination is the main challenge of this use case.</td>
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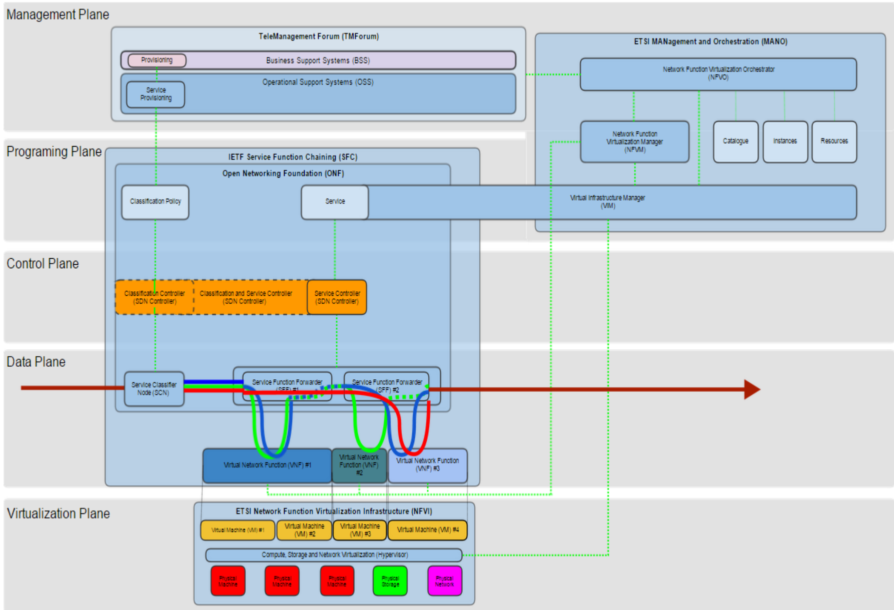
<tr><td colspan="2"></td><td>
</td></tr>
<tr><td colspan="2">Benefits and innovation</td><td>The migration of services from the customer home/terminal to the cloud has the following advantages

On fixed networks, it allows operators to deploy simple and cheaper equipment on customers’ home (L2 HGW); due to the high number of customers, this usually represents a significant cost saving for operators. On mobile networks, it allows customers to save computing power and battery on their terminals.
It brings agility to operators to manage services (add, upgrade, swap), without requiring any change on the customers’ home. Many times, new features require significant upgrades or even equipment replacement, which results in huge costs for operators. On the other hand, operators are no longer “on the hands” of the functions vendors.
For fixed networks, it allows a more flexible management of functions, not requiring the displacement of a technician to the customers’ home to upgrade/replace the HGW.
Other functions can be added to the function chains, such as CDNs, improving the quality experienced by customers, making a more efficient use of the network resources and reducing costs.

In short, the main innovations have to do with the agility of functions management and the convergence between fixed and mobile functions available. This brand new paradigm.</td></tr>
<tr><td>ANALYSIS (rough)</td><td>Foreseen components, functions, or primitives</td><td>According to the architecture depicted above:

OSS/BSS Service Provisioning
VIM, NFVI, NFVM, NFVO, Catalogue DBs
MANO & Chaining features (Classification Policy, Service Provisioning, SDN Controller, Classification Controller, Service Classifier, Service Function Forwarder/OVS, etc.)
HGW/STB Functions and VNFs (Firewall, Parental control, NAT, DHCP,
</td></tr>
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		Broadcast Video Delivery, VoD Delivery.
	Foreseen Requirements, Performance issues	*Some high level requirements.* • *VNF management and orchestration capabilities* • *Service chaining capabilities* • *Service provisioning capabilities*
Any other note or comment		

Name of the scenario or use case	*Video Orchestration and Optimization (PTIN-3)*
Rough Classification	Main: • *Video Orchestration* • *Video Optimization* Secondary classification labels: • *Location Based Services* • *Advertisement*
Source of the scenario	*This use case addresses a very well-known concept of today, regarding the delivery of customized video contents to the users, considering their location (advertisements), as well as the optimization of the video according to the access conditions.* *As OTT TV provider (MEO Go), PTP/PTIN is interested on this use case, in order to better provide advanced video features for their customers.*
Scenario description in a nutshell	*Video Orchestration intends to orchestrate the video contents sent to users, in advanced scenarios like multi-camera events (e.g. football match), where the user may choose the camera he wants to see. This may include advertisement videos.* *Video Optimization intends to increase the quality experienced by the user, considering the current access conditions. The quality of the video is adapted to the receivers.*
Extended description and examples	*The Video Orchestration and Optimizations intends to orchestrate the video to be delivered to the user with the most appropriate quality, according to the user's access conditions.* *In the case of content orchestration, it intends to perform the required orchestration of the video, according to the user selection, especially in situations when there are multiple sources, e.g. in multi-camera football matches, when the user can see the match from different angles. This orchestration may include advertisement videos, in case the operation and/or content provider business model includes that option. The video orchestration may be different from region to region, considering a local customization of contents, e.g. regional sport news. Caching mechanisms may be also involved.* *In the case of video optimization, the user must be provided with the more suitable video quality, depending on the access conditions at each moment. This means that if the user is crossing an area with lower coverage, the content must be reduced in quality to accommodate that limitation. The need for adaptation may be supported by local monitoring systems that provide metrics about the user's quality of the link..*
Architecture and/or networking and/or technical challenges	*In order to implement the Video Delivery and Optimization features, it is required an architecture that is able to deliver video to users on the edge of the network according to the MEC architecture. For that, the traffic*

		must be offloaded in the edge, not going to the mobile core.
Benefits and innovation		*This model brings multiple advantages to operators and users.* • *The video orchestration on the edge of the network benefits the operators, saving bandwidth on the backhaul, increasing the quality of experience and reducing costs.* • *The video orchestration on the edge of the network benefits the users, increasing the available bandwidth and reducing latency.* • *By using the context information (MEC), a more effective quality adaptation can be performed, delivering the most appropriate video quality.* • *By using the context information (MEC), a more focused advertisement can be performed, delivering sponsored videos e.g. based on the current location of the user (shopping mall).* *The main innovation of this use case is the operator capability to orchestrate and optimize video contents on the edge, taking advantage of context knowledge, high bandwidth and low latency.*
ANALYSIS (rough)	Foreseen components, functions, or primitives	*Some foreseen components are:* • *Video orchestration server* • *Video optimization server/gateway* • *Advertisement logic* • *Advertisement video database*
	Foreseen Requirements, Performance issues	*Some high level requirements:* • *Video orchestration capabilities* • *Video optimization capabilities* • *Video server capabilities* • *Advertisement logic capabilities* • *Monitoring QoS/QoE capabilities*
Any other note or comment		

Name of the scenario or use case	*Virtual CDN for TV contents distribution (PTIN-4)*
Rough Classification	Main: • *Content distribution optimization* Secondary classification labels: • *Private Virtualised CDN* • *TV contents*
Source of the scenario	*Use case identified internally, already under analysis in the scope of internal projects.* *It is of PTIN's business interest, based in the fact that PT Group provides 3P services, with multi-screen TV. Selected due to the required storage optimization at PT's data centers and user experience optimization.*
Scenario description in a nutshell	This scenario addresses content caches deployment, close to network edge, running own rules, based in behaviour analysis and consumptions' forecasts. This may be associated to virtualised CDN, allowing several players to deploy their own CDN, according to their rules and needs. Current Internet contents distribution CDNs are based in traditional content caching algorithms, based in observed contents popularity and the distribution rules are similar for all contents and producers. However, other type of services require different rules to cache contents closer to users' location, like TV. Contents are stored in the edge repository but only become available after their scheduled transmission time. After that, they stay available in the edge for a defined period of time; after that, they become available only from a central data center, freeing storage space for other contents. This may be associated to mobility, with contents following potential consumers, while they change attachment points to the network, creating a more demanding use case, closer to Superfluidity objectives.
Extended description and examples	Current CDN are based in the distribution of contents, based in observed popularity. This is effective for Internet, where contents become increasingly seen as their popularity growths. This is not the case for TV contents, which follow a different behaviour. In this case, it is possible to forecast visualizations of certain contents based in the past observed popularity of similar ones (e.g. football matches and reality shows) or for periodically broadcasted programs (e.g. series and recorded news). In addition, in many of those scenarios, those contents remain popular for 2 or 3 days, being of no interest to maintain them at edge caches after that period. In that context, for instance, popular TV series may be cached some minutes/hours before scheduled emission time and be kept there for one or two days. In addition first seconds/minutes of all movies may also be cached in order to allow a faster visualization while users are browsing contents or to download to the edge the complete movie. In this context, it is of interest for operators to have access to CDN

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Even though CDN are more related with content distribution, rather than processing, still require processing to select and deliver contents to consumers. This may also be associated with other functions like content adaptation and mobility.
Work in Superfluidity should not focus in specific rules for TV contents distribution optimization but look into CDN in general in the context of 5G. Contributions to MEC may be foreseen.</td></tr>
<tr><td colspan="2">Architecture and/or networking and/or technical challenges</td><td>1) Content caching at the edge
2) Content mobility
3) Content adaptation</td></tr>
<tr><td colspan="2">Benefits and innovation</td><td>Better storage resources usage.
Faster and better service delivery to customers.
Service scalability.
Service functions composition benefits.</td></tr>
<tr><td rowspan="2">ANALYSIS (rough)</td><td>Foreseen components, functions, or primitives</td><td>- Virtual storage at network edges and along the data path from central data centers
- Decision algorithms, taking into consideration the existence or the need to deploy contents at and from network edges</td></tr>
<tr><td>Foreseen Requirements, Performance issues</td><td>- Fast setup/migration/teardown of VM at the edge with high storage capacity
- Capacity to rapidly move contents between edge and core, and between edge points</td></tr>
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Name of the scenario or use case	***Business Communication Services (TPIN-5)***
Rough Classification	**Main:** • Business communication services at the edge **Secondary classification labels:** • Small Cells • Mobile Edge Computing • Services platforms • Edge breakout • Enterprise/operator converged services • Community services
Source of the scenario	Internal discussion, new idea. Similar use case is presented by MEC[1]. This use case presents a possible evolution of currently provided business services like ipCentrex. PTIN has already products (IMS/ipCentrex) on convergent communications areas and this use case is the natural evolution of it.
Scenario description in a nutshell	Enterprises and operators with installed small cells may take advantage of traffic breakout at the edge, allowing an efficient communication at their premises without requiring the traffic to go to the core of the network. This is valid for data exchange but also for other type of communication services, like voice and Unified Communications[2]. In particular, the applications to support the unified communications can be deployed at the edge, become even mobile, following the user when outside the enterprise, reducing the backhaul resources consumption and increasing the network responsiveness (low delay). Context: • Smartphones, tablets, etc. (mobile terminals), replace traditional fixed terminals at the enterprises • The 'office' moves to the terminal, using services provided by the operator, in both cases possibly hosted in a Cloud • Mobile networks replace private traditional enterprise networks • Small cells being installed at companies to increase capacity • The operator network is used as additional, distributed, enterprise resources
Extended description and examples	The Unified Communications concept puts in the mobile terminals the traditional enterprise services, serving as a single platform for the user

[1] ETSI GS MEC 002 V0.4.2(2015-07)
[2] http://www.scf.io/en/documents/081_-_Enterprise_unified_communications_services_with_small_cells.php

	to have unified access to all sort of messaging, voice, collaborative and other services, being them provided by the enterprise or by the operator. The deployment of Small Cells, besides improving QoE regarding traditional operator services, may also integrate with Wi-Fi accesses and may provide breakout features to access local enterprise services. The adoption of the virtualisation technology, also under analysis to be applicable in the small cells context[3], may represent a step forward in the evolution of both aspects, making possible to deploy dynamically, at the right place, the required functions, from network to service functions. MEC, as presented in the previously referred ETSI use case, can also be added, inclusively as a platform being present in future small cells' solutions. MEC will provide the platform for applications deployment at the edge that may be, in fact, inside enterprises environment. MEC can also be used to host the virtualised part of Small Cells. Thus, the merging of unified communications, small cells, virtualisation and mobile edge computing can be exploited to provide better, more flexible services to business customers. There are several advantages with this approach: (i) for the enterprise, reducing the cost of acquisition and maintenance of the enterprise network and services; (ii) for the users, making their life easier; (iii) for the operator, additional business. Edge computing resources can be used to deploy localised services to serve a community served by a geographically close set of 5G cells (videoconferencing, content caching, etc.). Service mobility is also improved, since when the user is away from its enterprise environment, the (unified communication) environment follows him. From his mobile terminal, the user runs traditional services hosted at the enterprise and/or at the operator's platforms. When the user is away, services may be run at their traditional servers (enterprise or operator) or at the closest edge. When the user terminal is under his company's small cell, some services traffic is exchanged directly with the enterprise's services platforms.

[3] Small Cells Forum, "Virtualisation for small cells: Overview", document number SCF106

		The use case scope can be further extended to other type of communities, beyond business, which are geographically dense and require a specific communication service.
Architecture and/or networking and/or technical challenges		1) Service platforms have to be developed considering the possibility to be deployed at the enterprise, operator data center or at the edge. 2) Move communication service platforms while communications are ongoing 3) Virtualisation of Small Cells 4) Usage of MEC inside the enterprise environment
Benefits and innovation		Operator - New business model - Optimal network resources usage (local breakout) - Reduced traffic on backhaul network Users - Reduced latency times - Increasing bandwidth - Network/Service follows the user Enterprises - CAPEX reduction on network/services acquisition - OPEX reduction to manage and maintain enterprise networks and services
ANALYSIS (rough)	**Foreseen components, functions, or primitives**	- Service components (voice, conferencing, storage, etc.) - Small Cell components - Traffic offload mechanisms - MEC platform
	Foreseen Requirements, Performance issues	- Service state being transferred between edge service platforms, on the run - Local breakout feature for unified traffic
Any other note or comment		

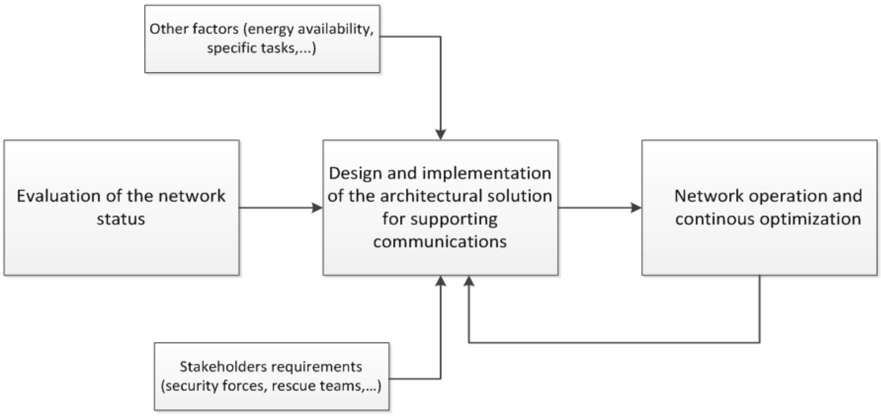
Name of the scenario or use case		*Anti NDP Spoofing software implementation (Telcaria-1)*
Rough Classification		Main: • *Implementation of virtual functions to prevent NDP Spoofing* Secondary classification labels: • *Security* • *Software Defined Networking* • *Network Functions Virtualisation* • *Hardware Accelerators*
Source of the scenario		*NDP Spoofing is analogous to the ARP one, but since IPv6 is not as extended as v4, some companies ignore this security threat due to the relation between solution cost and risk.*
Scenario description in a nutshell		*Implementation of a defence against NDP-Spoofing, for example SEND protocol, via Software.*
Extended description and examples		*The exchanges of NDP messages in datacenters is a matter of time, as IPv6 is destined to replace v4. For that reason, it is imperative to implement a solution to a potential spoofing in the Local Area Network, as it has been done with ARP.* *The inclusion of a defence against the mentioned threat, such as virtual implementation of the Secure Neighbour Discovery protocol in a superfluid network would be a great addition for the near future, furthermore, if hardware accelerators allow to speed up some of the functions of the protocol.*
Architecture and/or networking and/or technical challenges		*1) ensure security in LANs that use Neighbour Discovery Protocol* *2) solution should have lower costs than current ones in order to achieve a better acceptation among companies*
Benefits and innovation		*Today, this kind of application is not considered a priority but as IPv6 continues to grow, anti NPD-Spoofing will become necessary.* *An early superfluid development offers a strategic opportunity for the distribution of a product that will become essential in the near future, while there is almost no competence.*
ANALYSIS (rough)	Foreseen components, functions, or primitives	*- virtualised NDP functions* *- anti spoofing mechanisms* *- potential hardware accelerators of the previous mechanisms*
	Foreseen Requirements, Performance issues	*- effective defence against spoofing and impersonation* *- lower costs than previous solutions* *- potential higher speed than previous solutions*
Any other note or comment		*This proposal might be too specific for a use case.* *Also, the router companies offer solutions to this particular problem since a few years ago, so costs are not as high as they used to be and will*

	become lower as time passes. *Despite these cons, 'Superfluidity' should be compatible with IPv6 security as it seems the future of the internet.*

Name of the scenario or use case	*Protection against DDoS (Telcaria-2)*
Rough Classification	Main: • *Defence against DoS attacks* Secondary classification labels: • *Security* • *Cloud architecture* • *Software defined networking* • *Network function virtualisation* *CYBER SECURITY …* *NFV & SUPERFLUIDITY : HELP TO SECURE OR IS A VULNERABILITY* *Other partners interested CNIT, BGU, ONAPP* *Links to other projects dealing with security (ENSURE)*
Source of the scenario	*Several small companies have suffered Denial of Service attacks in recent times. The attackers are hard to stop because of the distributed nature of the attack and the companies tend to succumb to blackmail.* *For this reason defences against DDoS attacks become more proficient over time and use every new useful technology, including parts of Superfluidity such as Cloud Architecture and Software Defined Networking.*
Scenario description in a nutshell	*Exploit of the elements that compose Superfluidity, to design defences against the increasing number of DDoS attacks.*
Extended description and examples	*Distributed Denial of Service attacks are currently hard to deal with.* *There are efficient defences against them but not infallible, nor universally extended.* *Technologies included in Superfluidity such as cloud architecture and software defined networking have been proposed as a defence against these attacks.* *Start-ups could use in their data centers, a defence already implemented in the network with a minor cost.*
Architecture and/or networking and/or technical challenges	*1) identification of possible defences against DDoS attacks* *2) determine which are implantable in superfluid networks* *3) propose the implementation of the most efficient of the studied defences*
Benefits and innovation	*Cybersecurity is a field in constant flow, as attacks evolve so must defences.* *Distributed Denial of Service attacks, although being relatively simple, are troublesome for start-ups with data centers but insufficient defence.* *A defence against DDoS attacks already implemented in the network means an added value to the Superfluidity project.* *A defence which implementation also includes other network functions could probably have an overall lesser cost than an isolated functions.*

		This offers a business opportunity to sell the DDoS superfluid defence as low cost, especially among recent and small companies.
ANALYSIS (rough)	Foreseen components, functions, or primitives	*- means to identify DoS attackers* *- drop traffic from attackers* *- determine if former attackers are no longer infected and restore traffic flow if they're not* *-potential use of hardware accelerators to speed up the performance of the defensive mechanisms*
	Foreseen Requirements, Performance issues	*- security issues* *- solution shouldn't slow the network* *-minimise the effect of the defence in traffic coming from non-attackers* *- economic issues* *- solution should be open for future improvements and updates*
Any other note or comment		*Security may not be a priority for the development of superfluid networks, but it eventually becomes an essential part of every network. For this reason, early attempts of implementing security in 'Superfluidity' should at least be taken into consideration.*

Name of the scenario or use case	*Emergency communications (TID-1)*
Rough Classification	Main: • *Network auto-configuration* Secondary classification labels: • *Location based services* • *Monitoring and analytics* • *Adaptive media delivery* • *Content centric networking* • *Enhanced group communications* • *Intrinsic security mechanisms*
Source of the scenario	*Emergency communications is one the classic use cases considered for 5G (e.g., NGMN, METIS). 3GPP is also working to improve for capabilities specifically aimed at critical communications requirements. It even has created a new specification group, SA6, Mission-critical applications, which is responsible for the definition, evolution and maintenance of technical specification(s) for application layer functional elements and interfaces supporting critical communications (e.g. Mission Critical Push To Talk). Other bodies are also considering this kind of services and the systems supporting them, like the TETRA Critical Communications Association (TCCA)*
Scenario description in a nutshell	*Capability of the network to repurpose itself after a disaster for providing specific services based on the remaining infrastructure available, including user devices and other networks. Support of specific services for specific groups (police, firefighters, rescue teams,…), including the capability to locate specific devices, broadcast messages and form device supported extensions to the network.*
Extended description and examples	*A natural disaster (earthquake, tsunami,…) or man produced one (terrorist attack, industrial accident,…) results in the loss of part of the communications network infrastructure. The existing operating infrastructure should reconfigure itself in order to provide a set of basic services* • *Support of emergency teams' communications.* • *Support of the broadcast of alert messages with enough flexibility in terms of selecting areas or user groups where location-specific alert information can be directed* • *Control of the operating mode of the devices connected (e.g., forcing reduced energy consumption operational modes, like half duplex)* • *Support of safety related functionalities, like the location of devices for rescue purposes.* • *Access control to the network in order to avoid it being saturated by lower priority traffic.* *The network should be able to integrate new elements once they become*

	available. It should be able to integrate with broadcast and satellite systems.
Architecture and/or networking and/or technical challenges	*1) The network should be able to evaluate its own status in order to determine which is the best configuration feasible for providing the functions expected* *2) The network should be able to learn from its own operation in order to optimize the configuration and the use of resources*  *3) The network should be able to incorporate new elements and nodes as they become available.* *4) The network should be able to prioritize the communication services for certain groups, like rescue teams. At the same time, it should be possible to block users to prevent that they make the network unusable* *5) It should be possible to configure the network in order to support specific tasks, e.g., the location of victims in collapsed buildings.* *6) It should be possible to seize resources (e.g., frequency channels) from other operators or systems to support the operation.* *7) It should be possible for the network to activate the safety capabilities of devices without the users' intervention.* *8) The network should be able to provide intrinsic security if the centralized security infrastructure (e.g., HSS/AuC, MME in LTE) is not accessible*
Benefits and innovation	*Today, specific communications networks (TETRA 1,TETRAPOL and P25) should be deployed for supporting emergency/mission critical communications. However, these services can be more effectively supported commercial networks infrastructure.* *Two main sets of innovations are required for providing future mobile networks with the necessary capabilities to support this kind of communications::* • *The capacity to configure a new network from the infrastructure that is available, possibly using resources (spectrum, processing and networking resources) from other systems and networks.* • *The capacity for supporting specific services and operational*

		modes required for safety procedures. *These innovations may be reused for supporting other commercial mobile wireless services.*
ANALYSIS (rough)	Foreseen components, functions, or primitives	*- Means to monitor, collect and analyse context information.* *- Capability for deriving the topology of D2D supported subnetworks* *- Ability to gather sensing information from user terminals* *- Network elements supporting content centric networking capabilities*
	Foreseen Requirements, Performance issues	*Several KPIs can be defined, assuming a minimum infrastructure available:* *- Time needed by the network to set up the "emergency mode" and make the service available shall not exceed* *- Capacity to support a minimum number of simultaneous connections* *- Capacity to locate specific devices within a given time frame* *- Capacity for operating without energy supply for a certain period of time*
Any other note or comment		

Name of the scenario or use case	*Late transmuxing (USTR-1)*
Rough Classification	Main: • *Audio/Video streaming* Secondary classification labels: • *Cloud* • *Caching* • *Video delivery optimization*
Source of the scenario	*Optimizing video delivery and caching for CDN like setups*
Scenario description in a nutshell	*Instead of using the network only as cache, the network (edge) nodes may be used to create requested formats when needed, saving bandwidth and storage within the network.*
Extended description and examples	*With the growth of the internet, usage has shifted from sending textual messages to streaming video. Lots of the different devices and players are used to watch these video streams. However, not all of those support the same streaming formats and that is why multiple different streaming formats are used to view the same video. Many known server setups already try to tackle the problem of serving these different formats fast and resource efficient. Most make use of proxy servers (edges) to reduce the load on the storage back end. Some use these edges as a caching layer or a content delivery network (CDN), some others use them for on the fly conversion. None of the setups however, utilise the power of caching and on the fly conversion on the same server.* *Example 1. Edge* *The CDN edge could use more of its CPU and less of its local storage when content is muxed as late as possible. User experience will benefit as startup times are reduced.* *Example 2. Home Gateway* *An STB or gateway may be equipped with LTM to fetch only a mezzanine set of samples from and origin (or maybe provided with off-hours download in regions where there is low-bandwidth generally) to then mux the content on request to the device (iOS, Android – etc) in the home.*
Architecture and/or networking and/or technical challenges	*The setup should be able to add and remove edges based on need, so cloud based autoscaling. Locations upstream origins (to fetch samples once for on-the-fly-conversion) should be configurable when an edge starts. A tiered layout allowing for multiple upstreams (local, remote, far) can be envisioned as part of the architecture.*
Benefits and innovation	*Creating a setup that combines caching and on-the-fly leads to a setup*

<table>
<tr><td colspan="2"></td><td>where videos can be muxed directly from the edge. Compared to other setups this lowers internal traffic and reduces load on the origin. All of which results in faster, cheaper and more efficient video streaming.</td></tr>
<tr><td rowspan="2">ANALYSIS (rough)</td><td>Foreseen components, functions, or primitives</td><td>Lightweight edge with muxing and caching capabilities.
Origin providing mezzanine samples.
Location service for edges to get configuration.</td></tr>
<tr><td>Foreseen Requirements, Performance issues</td><td>Latency between origin and edge should be low enough (but cache priming or 'prefetch' may be deployed as well).</td></tr>
<tr><td colspan="2">Any other note or comment</td><td></td></tr>
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Name of the scenario or use case	*Remix (USTR-2)*
Rough Classification	Main: • *Video orchestration* Secondary classification labels: • *Advertisement* • *Targeting* • *Location based services*
Source of the scenario	*Personalization of content, per individual or by group, rule or recommendation based*
Scenario description in a nutshell	*The ability to personalize video streams for instance in the form of targeted ads to individuals or to a group based on some ruleset not only represents value in the advertisement space but also is of value to for instance broadcasters who are bound to geolocation restrictions for their content or would like to add a 'bumper'. Letting the network resolve this based on an upstream selector lessens content owners need for their own individual technology setups.*
Extended description and examples	*Remix in essence resolves a playlist to a video format's appropriate timeline representation (which differs in each specification: from MPEG-DASH to HLS to HDS or Smooth each define a different manner of doing this, in some cases there are even multiple possibilities).* *Actual playlist creation* *Examples;* *1. Server side stitching* *A viewer presenting it's token is provided with an individualized stream based on what the recommendation is for that particular token, the server does the negotiation, and creates the playlist/timeline/stream. The viewer (player) receives a single stream, no need for specialized app development to* *2. Ad blocker circumvention* *Having the origin create the full stream (a mix of various locations) will provide a single timeline to the player: player based ad blockers will not work nor will there be need for platform specific app development.* *3. Blanking* *A rule based approach will allow to create a targeted stream for viewers in a certain location, which is useful when for instance content may not be viewed in a certain region due to license restrictions.*

		4. Bumpers *The same rule based approach will allow to insert a general bumper or leader to all viewers, for instance stating this is not a live event and phone nrs shown should not be called.*
Architecture and/or networking and/or technical challenges		*Availability of content (Advertisement) repositories with matching ABR (adaptive bitrate) content* *Ability to on-fly-transform content to match requests* *In the case of ads, appropriate statistics following the various standards*
Benefits and innovation		
ANALYSIS (rough)	Foreseen components, functions, or primitives	*Playlist creator* *Recommendation proxy* *Transcoding service*
	Foreseen Requirements, Performance issues	*Sufficient speed when transforming content real-time* *Fully individualized streams are at odds with CDN strategies that strive to cache once for all*
Any other note or comment		

Name of the scenario or use case	*Backend Storage Caching (USTR-3)*
Rough Classification	Main: • *Audio/Video streaming optimization* Secondary classification labels: • *Cloud* • *Origin caching* • *Video delivery optimization*
Source of the scenario	*Optimizing origin video delivery by local caching*
Scenario description in a nutshell	*Local caching by the origin of HTTP ranges fetched allows for chunk creation from such cached content, this will improve response rates from the origin, but still maintaining the caching external.*
Extended description and examples	*In a typical cloud setup, for instance EC2 with a webserver as origin and all source content (mp4's) in S3 the origin will go to S3 for every requests, fetching index and samples needed each time, even if the exact same mp4 is requested but to different protocols.* *If the origin could reuse samples fetched from a previous call it would save on nr of requests needed thus optimizing performance in latency and response times*
Architecture and/or networking and/or technical challenges	*Origin with local caching (on the origin itself) where the optimal amount of in-use caching and invalidation times are unknown and either should be preconfigurable or self-optimising.*
Benefits and innovation	***Improved origin behaviour in cloud based environments***
ANALYSIS (rough) – Foreseen components, functions, or primitives	*Dynamic webserver configuration, automated reconfiguration based on use metrics, cache invalidation.*
ANALYSIS (rough) – Foreseen Requirements, Performance issues	*Cache invalidation of the local cache needs to be setup properly, either by understanding which timeout should be used for automated invalidation or a pure API could be needed.*
Any other note or comment	

Name of the scenario or use case	*Third-party network processing in operator clouds (UPB-1)*
Rough Classification	Main: • *In network processing for third-parties* Secondary classification labels: • *Cloud architecture* • *Network function virtualisation as a service*
Source of the scenario	*Content providers are keen to place their content and processing close to users, and mobile apps want to leverage nearby processing for quick and cheap offloading. Until now, only major providers such as Google of Microsoft could afford to do this (e.g. the Google Global Cache).*
Scenario description in a nutshell	*Mobile operators are deploying racks of machines already for NFV and this trend will intensify in the future with in 5G. Superfluidity will add processing capabilities to all parts of the network.* *Such capabilities could be rented out to third parties that would run processing there. The key challenge is to ensure scalability and security in this content: third-party processing should not attack the operator's network or other tenants.*
Extended description and examples	*How can we enable the following functionality:* - *A mobile app wants to batch incoming messages to save mobile device energy and to get them through the firewall of the operator.* - *A client wishes to filter traffic by renting processing close to the source (e.g. DDos filtering)* - *A content provider wishes to quickly create a dynamic cache close to users in an operator's network.*
Architecture and/or networking and/or technical challenges	*1) How to ensure third party processing is safe for the operator in a cheap way.* *2) How to ensure scalability to many tenants per box* *3) How to ensure we can use different types of commodity hardware to ensure performance while giving isolation.*
Benefits and innovation	*This use case can democratize in-network processing and allow anyone in the Internet to innovate, not just the major players. This will unleash creativity and will evolve the network in an organic way.*
ANALYSIS (rough): Foreseen components, functions, or primitives	*- language that enables in-network processing that can be checked statically for security* *- Implementation based on single-function VMs (e.g. ClickOS)* *- Ability to run on different types of hardware.*
ANALYSIS (rough): Foreseen Requirements, Performance	- *tradeoff between expressiveness of language and the ability to statically analyse it* - *tradeoff between using sandboxing (runtime cost) vs. static analysis (pre-processing cost)*

	issues	
Any other note or comment		*An initial implementation is available in our Eurosys 2015 paper called "InNet: in-network processing for the masses" . This use case is taking the same idea and applying it in the context of Superfluidity.*

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