SESAME

Challenges for Development in the 5G Era: The Innovative SESAME Model Approach

The 5G Infrastructure Public Private Partnership

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Infocom World 2016 _ Athens, Greece, Nov.02, 2016
SESAME-*based* Special Session

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Introduction

Introduction_(1)

- Internet and communication networks are "critical" tools for most areas and sectors of our modern societies & economies.
- They are radically transforming our world and do constitute fundamental "pillars" for any evolutionary process supporting effort for growth and development.

- **The communication networks** and the wider modern services/facilities environment *of the year 2020* **will be** *"enormously richer and much more complex than that of today".*

- The underlying (usually heterogeneous) network infrastructure **will be able of "*connecting everything*"** according to an extended multiplicity of application-*specific* requirements (*thus including users, equipment, things, goods, computing centres, content, knowledge, information and processes*), **in a purely flexible, mobile, and quite powerful way.**

Introduction_(2)

- **Modern innovative aspects <u>not only necessitate but also imply</u> for the proper establishment** and the **effective operation** of a relevant **novel kind of infrastructure**, ***able to provide network features and performance characteristics assuring progress and growth*** *in all corresponding domains* (*i.e., technical, business, financial, regulatory, social, etc.).*

- The **"inclusion" of modern features** *(such as of **virtualisation** and of **software-based network functionalities**)* in network communications infrastructures **will support the actual transitional process,**
  via further strengthening network flexibility and reactivity,
  - ***by providing a proper means for better network management***
  - ***and for the offering of new services***.

Introduction_(3)

- **Market "actors"** *(network operators and service providers, manufacturers, SMEs, end-users, etc.)* **are expected to be strongly involved in such processes.**
- **This will "redefine" existing value chains and reform roles and/or relationships between market "players", *whilst creating new and dynamic opportunities for novelty and investments.***

➡ **These changes will also take place within the forthcoming "fifth generation" *-or 5G-* of telecoms systems,** *that will be* ***the most critical building block of our "digital society" in the next decade.***

5G will not only be an evolution of mobile broadband networks, but

- will bring **new unique network** and **service capabilities**,
- will create a **sustainable and scalable technology,**
- will establish a **proper ecosystem for technical/business innovation**.

Challenges for the underlying Network Infrastructures

Challenges for the Network Infrastructures_(1)

- **The European economy has not only to "maintain" but also to "fortify" both its role and influence on the wider international environment**, ***strongly influenced by the fast Internet penetration.***
- **It is important to realize innovative actions and to expand knowledge** so that *"to keep a strong position in a strategically important market such as the one of the ICT sector".*

- ***The diversity of new (personal and professional) usages, leads to new requirements*** *on availability, latency, reliability, trustworthiness and security.*

- ***Appearance of new trends,*** *with the related features/functionalities much more closely "embedded" within the network applications.*
- ***Users gradually become more and more "demanding"*** *in terms of contents and service requirements.*
- ***Privacy and sustainability issues become of prime importance****, thus implying for resilient constraints on networks and service platforms.*

Challenges for the Network Infrastructures_(2)

ΟΜΙΛΟΣ ΕΤΑΙΡΕΙΩΝ

Appearance of a variety of major challenges:

- **"Handling" of the increased network traffic** together with the **provision of** all necessary **capacity and/or spectrum availability**, *so that to serve/fulfil all relevant requests coming from different services, devices and users.*
- **Accommodation of novel classes of services/facilities** *(e.g., covering attributes coming from the IoT, M2M communications or content-based applications, or by any other future "complex" environment that may potentially appear),* **while preserving a "low" *-or a kind of "reasonable"-* CAPEX and OPEX features**, **supporting economies of scale and avoidance of unnecessary investments.**
- **Strengthening Internet's penetration in all sectors of our lives and economies**, by making it an ***"indispensable means"*** for realizing an explicit, ubiquitous and dependable infrastructure in mobile, wireless and fixed communications.
  Internet "drivers" are all kind of services/applications from low (sensor and IoT) to high throughput rates (e.g. high quality video streaming) and from low to high latency.
- **Supporting of** all actions for providing a **guaranteed level of Quality of Service/Quality of Experience (QoS/QoE) together with enhancement of privacy and security over the Internet**, ***especially for professional uses and with the aim of offering optimal performance.***
- **Making the communication critical infrastructures "as resilient as required" by consumers of interconnected critical infrastructures (such as smart grid).**
- Supporting measures for realizing **reduced energy consumption.**

Challenges for Network Infrastructures_(3)

The forthcoming "*5G infrastructure*" will "face" most of the identified challenges and will offer reliable solutions!

5G will be much more that the next step beyond 4G: it is expected to be the "***core functional system of our modern digital society and economy***", thus generating a truly converged and tremendously "dense" communication infrastructure, integrating IT systems *(e.g., processing and storage)* with plentiful network resources.

5G is to become a sort of universal, highly flexible and ultra-low latency virtualized infrastructure,
capable of serving immense numbers *of smart terminals, devices, machines, things, sensors, cars, drones, etc.,*
with significant processing and storage capabilities *that may be exponentially increased, via relevant Cloud-based applications .*

The European Conceptual Approach

The European Conceptual Approach for 5G_(1)

5G networks will not only be based on transport and routing/switching technologies but will be more "*flexible and open*".

5G networks are expected to evolve more easily than today's networks and also to embed sensing, computing and storage resources in a converged and unified infrastructure, *able to "orchestrate" the delivery of services in a secure manner.*

5G networks will provide a significantly higher system capacity than today and solve any anticipated spectrum scarce.

5G networks should also promote *-to the extent possible-* a common network management for mobile and wireless, *in terms of*

- *constant performance optimisation,*
- *fast failure recovery,*
- *fast adaptations to changes in network loads, architecture, infrastructure and technology.*

The European Conceptual Approach for 5G_(2)

ΟΜΙΛΟΣ ΕΤΑΙΡΕΙΩΝ

Within the 5G-PPP framework, the following KPIs have been identified:

- Possibility for the **provision of 1000 times higher wireless area capacity** and of **more varied service capabilities**, *if compared to those of 2010.*
- **Saving up to 90% of energy per service provided**. *(Here, the main focus should be in mobile communication networks, where the dominating energy consumption comes from the radio access network).*
- **Reduction of the average service creation time cycle from 90 hours to 90 minutes**.
- Creation of a **sufficiently secure, reliable and dependable Internet, *with a "zero perceived" downtime for services provision.***
- Facilitating future **very "dense" deployments of wireless communication links *to connect over 7 trillion wireless devices serving over 7 billion people,*** thus realizing the option of "*connecting everything or everyone at any time at any place".*
- **Enabling advanced user controlled privacy**, to guarantee a proper level of protection of the facilities offered.

The European Conceptual Approach for 5G_(3)

The development of the forthcoming 5G systems will be based

on an **ecosystem of close cooperation**
between industry, SMEs and the research community

with the aim of

- *developing innovative -but applicable/viable- solutions*
- *guaranteeing the exploitation of such in global standards & markets*
- *ensuring interoperability and economies of scale, with affordable cost for system deployment and the end-users.*

Inclusion of Modern Features in 5G Networks

Inclusion of Modern Features in 5G Networks_(1)

- ***With 5G, future networks will be transformed into "intelligent orchestration platforms".***

- **The 5G architecture is assumed to integrate a broad range of use cases with innovative requirements, *particularly in terms of latency, resilience, coverage, and bandwidth*.**

- **5G is assessed to structure a stakeholder-*driven*, holistic ecosystem for technical and business innovation, integrating networking, computing and storage resources into *"one programmable and unified infrastructure"*.**

- **Software-*based* systems can offer the *flexibility* to adapt to new requirements and facilitate inclusion of innovation.**
  - *Flexibility in technical requirements and the system design is a **"key option"** to enable further modernization and to fulfill any unforeseen future service requirements.*
  - *From the long-term vision perspective, future systems are expected to offer high flexibility in data throughput, mobile ubiquity and to allow for very low latency and adaptability to new "schemes".*

Inclusion of Modern Features in 5G Networks_(2)

ΟΜΙΛΟΣ ΕΤΑΙΡΕΙΩΝ

Software Defined Networking (SDN) **allows**

- ***network control to be separated from the forwarding plane*** and
- ***a flexible management of the network resources****, thus* facilitating the design, delivery and operation of network services in a dynamic and scalable manner.

SDN is one of the networking computing paradigms that were proposed as *a way to revolutionize cellular network architectures, and so to move towards "more agile" and "cost-effective" network control solutions.*

Via SDN techniques, **network services can be implemented by programming -** ***instead of re-architecting-*** **the network;** *this implicates that* ***new network features can be introduced at significantly shorter time.***

Following to the actual "convergence" trends towards "close" integration between telecom and IT so that to "form" a common very high capacity ubiquitous infrastructure, ***SDN*** ***can lead to a "sort" of general purpose, programmable and specific high performance hardware, that will offer immense resources for transport, routing, storage and execution.***

Inclusion of Modern Features in 5G Networks_(3)

***Network functions virtualization (NFV)* permits virtualization of software-*based* network functions.**

- ***Instead of installing and managing dedicated hardware devices for such networking and servicing functions, these are realized as "software components"*** *and deployed on commodity or special hardware infrastructures.*
- ***Network elements are thus expected to become "computing equivalent" equipment,*** *that gathers programmable resources, interfaces and functions based on virtualisation technologies.*

The programmability also provides the ability to account for the usage of resources across the network, *thus enabling the envisioned flexible incentive alignment across several stakeholders.*

With ***resources*** *interpreted as that of* ***computing, storage, volatile memory*** *and* ***bandwidth,*** **the envisioned network programmability allows for optimization across all these resource dimensions**, *towards a single deployed solution.*

- **NFV is a new paradigm that prescribes virtualising network element functions**, which -in turn- means *translating individual virtual network functions (VNFs) into software processes.*
- **NFV aims to improve elasticity in provisioning network services** while, *at the same time*, improving scalability and reducing time to market.

Inclusion of Modern Features in 5G Networks_(4)

- ***Software-defined Network Clouds:*** **This implicates for cloudification of networking and servicing functions, which enables ubiquitous network access *to a shared services and shared pool of configurable computing, connectivity and storage resources.***

- ***It offers users and providers with various capabilities to process and store their data and services in data centers.***

- **It relies on sharing of resources to achieve coherence and economies of scale**, *similar to a "utility" over a network*.
- **It uses virtualization concepts** such as abstraction, pooling, and automation **to all of the connectivity, compute and storage to achieve network services**.

- **It can also take the kind of mobile edge computing (MEC) architecture *where cloud-computing capabilities and an IT service environment are available at the edge of the mobile network* that uses one or a collaborative multitude of end-user clients or near-user edge devices to execute a substantial amount of services** (*rather than in cloud data centers*), communication (rather than routed over the internet backbone), and control, configuration, measurement and management.

Inclusion of Modern Features in 5G Networks_(5)

- **The SDN approach, along with NFV, has accelerated the progress toward the concept of "*all-as-a-Service*".**

- As soon as the cellular network architecture shifts from its current view nearer to the users for providing edge services, ***a new holistic approach will cater for the necessary network redesign.***

- ***The combination of SDN, virtualisation and cloud technologies results into the concept of a network operating system that allows for unified orchestration of computing, storage, as well as networking resources in a programmable way.***

The SESAME 5G-PPP Project

The SESAME 5G-PPP Project_(1)

ΟΜΙΛΟΣ ΕΤΑΙΡΕΙΩΝ

➢ *SESAME targets innovations around three central elements in 5G:*

- **Placement of network intelligence and applications in the network edge** through Network Functions Virtualisation (NFV) and Edge Cloud Computing;
- **Substantial evolution of the Small Cell concept**, already mainstream in 4G but expected to deliver its full potential in the challenging high dense 5G scenarios;
- **Consolidation of multi-tenancy in communications infrastructures**, allowing several operators/service providers to engage in new sharing models of both access capacity and edge computing capabilities.

➢ *Areas to be addressed*

- **Small Cells Context**: Proposition of the *Cloud-Enabled Small Cell (CESC)* concept for deploying Virtual Network Functions (VNFs) supporting of powerful "self-x" management & executing novel applications and services inside the access network infrastructure.
- **New network orchestration perspectives** in the 5G framework.
- **Network Functions Virtualisation for Multi-tenancy & NFV Management.**
- **"Self-x" Features** & **Software-defined Networking**.
- **Cloud technologies** & Hardware acceleration through non X86 processors.
- **Artificial Intelligence-based radio access management**.

Main impact

- **Ecosystem development to sustain network infrastructure openness** *through the development of CESCs for 5G* built on the pillars of network virtualization, mobile-edge computing capabilities and cognitive network management.
- **Multi-tenancy and flexible cloud-network integration**, with highly-predictable and flexible end-to-end performance characteristics.
- **Contribution to the 5G-architecture vision** **through the development of programmable mobile network infrastructures**, allowing for continuous innovation by means of key functionalities exposed to CSPs.
- **Decrease network management OPEX**, whilst increasing user perceived quality of service/experience and security.

The SESAME 5G-PPP Project_(3)

Motivation :

To address the previous needs and building upon the pillars of network functions virtualization, mobile-edge computing and cognitive management, SESAME's main goal is:

The development and demonstration of an innovative architecture, capable of providing Small Cell coverage to multiple operators, "as a Service".

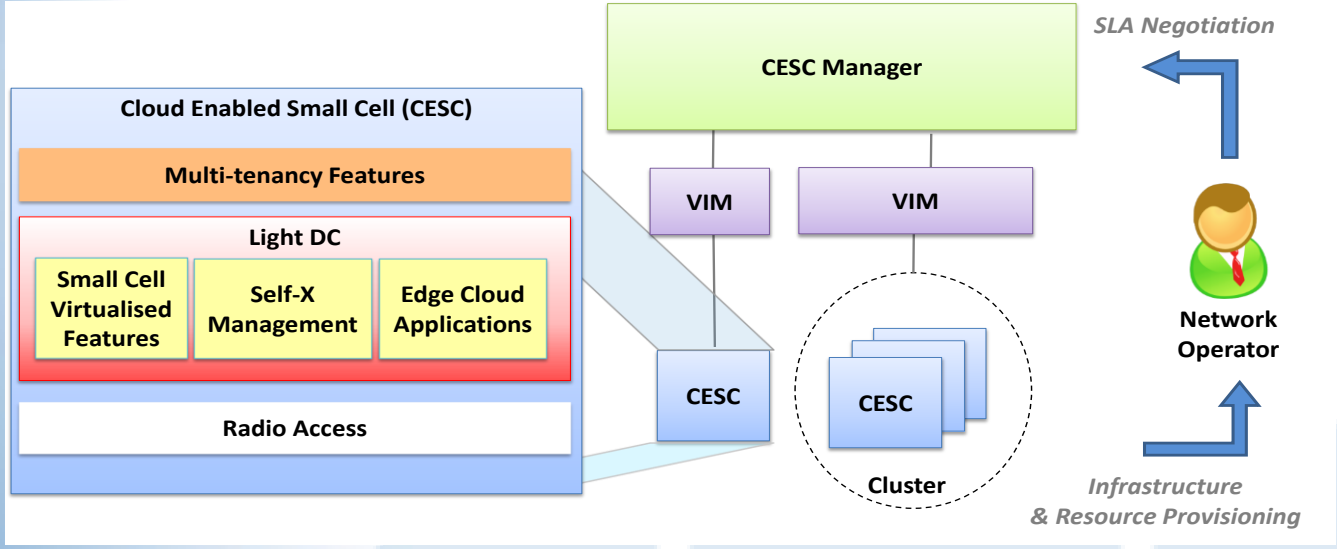
Features:

- **SESAME envisages the logical partitioning of the localized Small Cell network to multiple isolated slices,** *as well as their provision to several tenants.*
- **In addition to virtualizing and partitioning Small Cell capacity, SESAME supports enhanced multi-tenant edge cloud services** *by enriching Small Cells with micro servers.*
- **Apart from benefits offered to existing market players, the SESAME approach allows new stakeholders to dynamically enter the network value chain,** *such as Small Cell operators deploying such infrastructure in specific high traffic demanding areas, and acting as neutral host providers, offering to existing mobile operators access to "on-demand" Small Cell activation.*

- **This opportunity is "opened" *e.g.*, to real estate companies, municipalities, universities, *and virtually anyone who can install and run a local Small Cell network.***
- ***Although probably none of such entities would offer wide network coverage, many of them could foresee adequate profits generated locally, by exploiting the SESAME concept for leasing virtualized slices of their infrastructure.***

The SESAME 5G-PPP Project_(4)

SESAME High level architecture



SESAME High level architecture & CESC components

Novel concepts of virtualizing Small Cell networks ***by substantially evolving the Small Cell concept under the paradigms of a multi-operator (multi-tenancy) enabling framework and an edge-based, virtualized execution environment.***

- The CESC includes **a multi-tenancy platform able to provide the radio access** to support the required wireless capacity in a certain area.
- **Cloud-based computation resources are provided through a virtualised execution platform** (i.e. the "Light DC").
- This **execution platform** is used to support the required Virtualised Network Functions (VNFs) that implement the different features/capabilities of the Small Cells and the cognitive/self-x management operations, *as well as the computing support for the mobile edge applications of the end-users.*
- The **CESCM** is responsible for coordinating and supervising the use, the performance and the delivery of services.
- Depending on the actual virtualization capabilities, clusters will be assigned to one or more ***Virtual Infrastructure Managers-VIMs***
- The **Service Level Agreement (SLA) negotiation** is foreseen to interact through appropriate open software, *not yet defined*, with the existing support system of the telecom operator.

The SESAME 5G-PPP Project_(5)

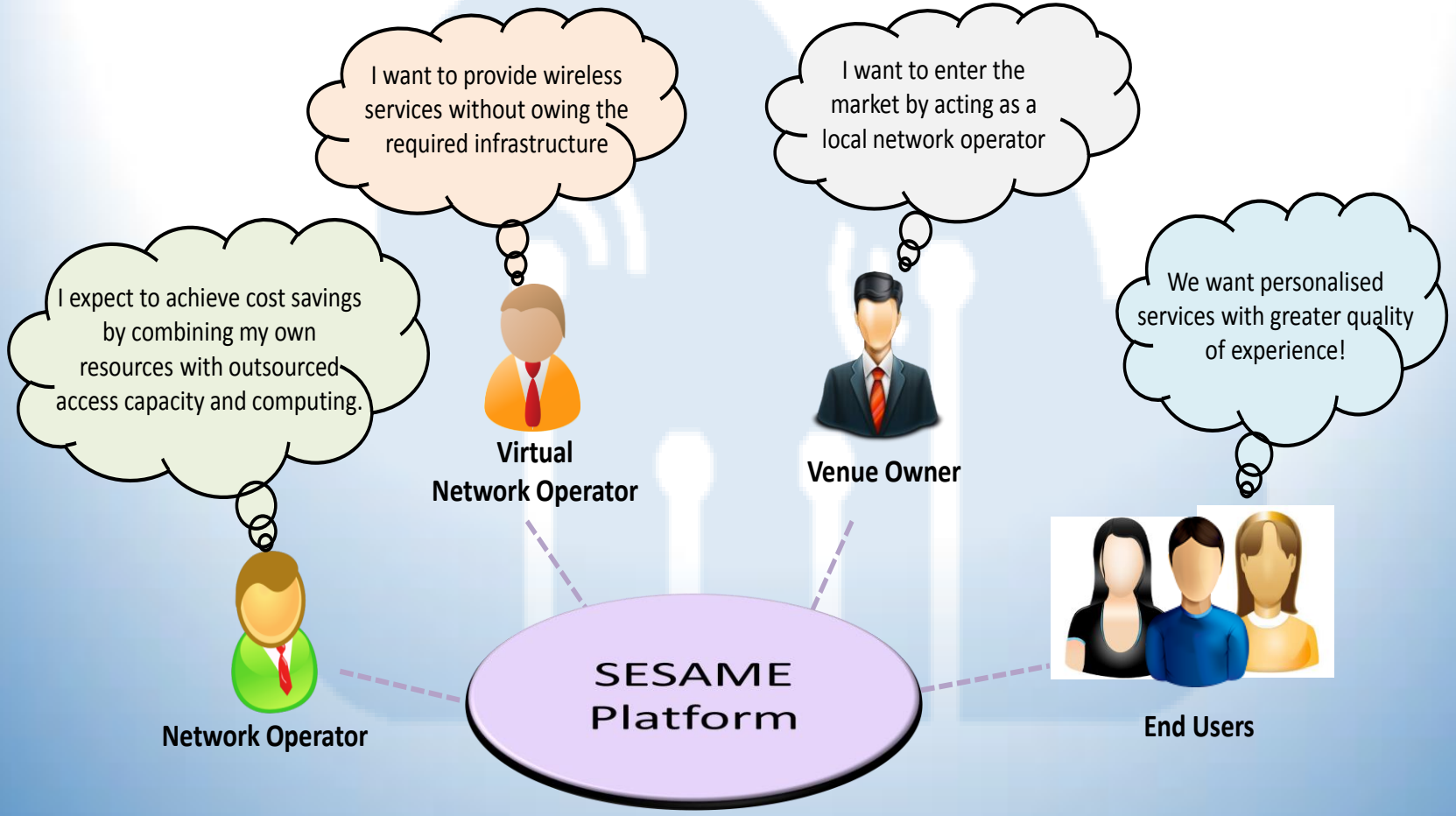
Areas to be addressed:

- **From the perspective of service provisioning, the proposed approach can be used to provide edge cloud capabilities and enable accelerated services, content and application *due to the increased network responsiveness*.**

- **Operators may provide the network's edge (i.e., the Light DC) to third party partners, *allowing the rapid deployment of cutting-edge services to users and enterprises, translating to added value and creating opportunities for vendors, service providers and operators by enabling them complementary and advantageous positions.***

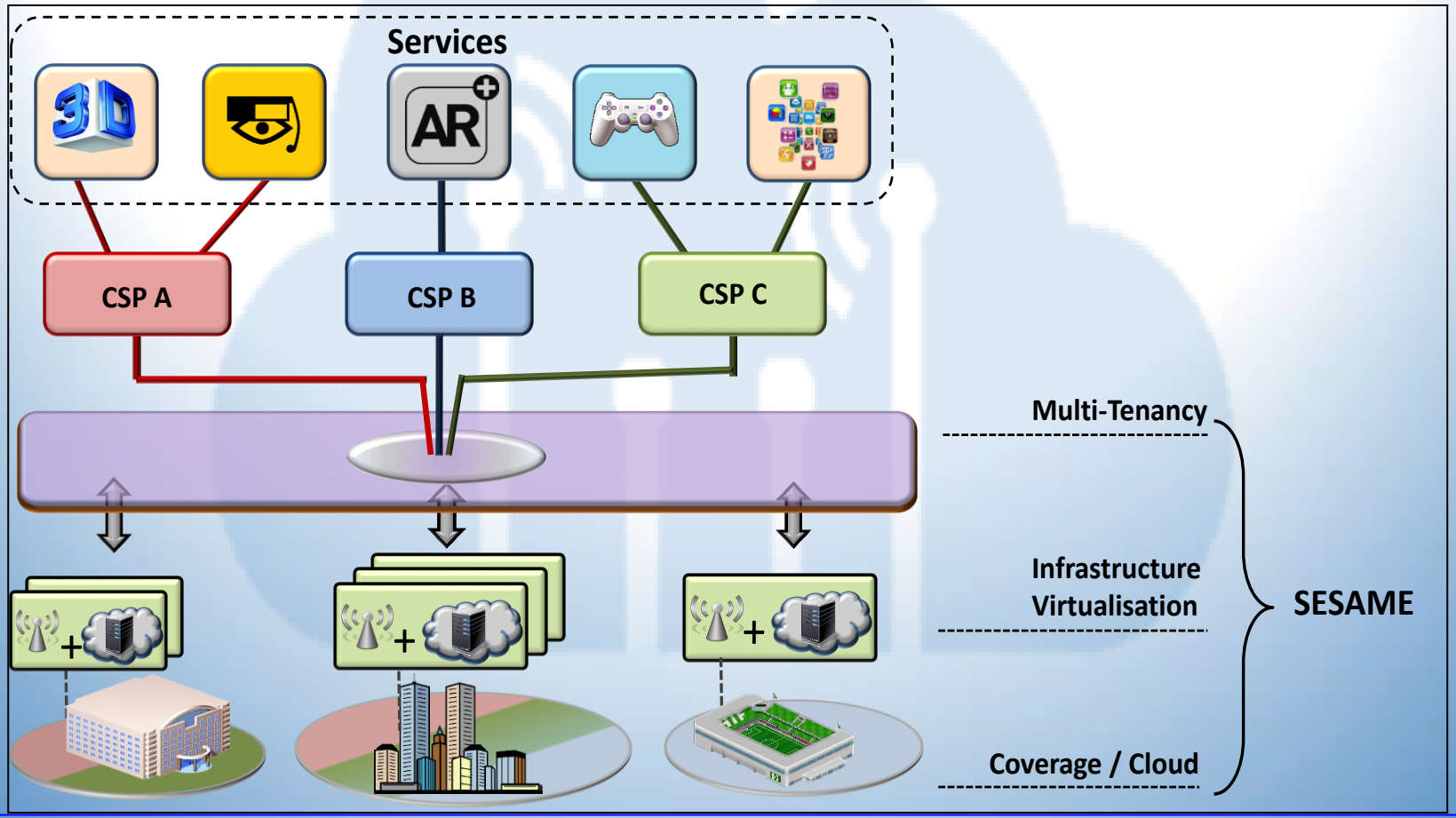
- **The Light DC will enable the rapid on-demand deployment of cutting-edge network services in the form of Virtual Network Functions (VNFs) – *such as data processors, security appliances, proxies, media transcoders, M2M gateways etc., close to the mobile nodes.***
  Locating virtual service processing nodes closer to users reduces latency, improves throughput, and reduces traffic in the network core.

The SESAME 5G-PPP Project_(6)



The SESAME 5G-PPP Project_(7)

SESAME applicability:



Concluding Remarks

- *Identification of* ***Actual Challenges for Network Infrastructures***
- *Correlation to* ***European Conceptual Approach for 5G***
- *Identification of* ***Modern Features for 5G Networks****:* ***SDN, NFV, SDN-Cloud, NEC***
- ***Small Cells can play an important role within the 5G Era***
- *The* ***SESAME 5G-PPP Project****: Identification of* ***Innovative Features***

Thank you for your attention!

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