System Design for 5G Converged Networks

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***Abstract*— This paper presents high level design concepts for the control plane (C-plane) of the upcoming 5G networks, in the framework of Fixed-Mobile Convergence (FMC). This control plane is enabled by SDN and NFV technologies in order to offer a very flexible environment able to optimally deploy network infrastructure(s) that will cope with multiple service provisions scenarios. Furthermore, our innovative control plane will be able to support fast deployment of novel services depending on the requirements from different use case and application scenarios and enabling the operators to provide fast answers to the society challenges ahead.**

Keywords—5G system concept, control plane, data plane, network services, fixed-mobile convergence, software defined networking.

I. INTRODUCTION

Software Defined Networking (SDN) and Network Function Virtualisation (NFV) [1] are concepts under development on networks to answer to the pressing requirements on improved flexibility – nobody knows what will be the next telecommunication success – and openness – the creation of an environment where such successes may be frequent. These technologies are helping on the telecommunication transition from vertical to horizontal approaches. In the current vertical orientation, network functions and services are delivered in a (mostly single vendor) stack that bundles purpose-built hardware, a platform-specific operating system, software, and management systems. In the upcoming horizontal approach, the hardware is deployed independently from the software that defines the network service(s). Each functional element is a separate independent layer in the network architecture. The key element that enables such a horizontal architecture is the SDN technology. SDN separates the Control and Data planes, and adds a virtualisation layer that connects the network control software to the existing hardware resources. With NFV, each functional element is represented as a virtualised network function, allowing network operators to use generic servers and switches instead of purpose-built hardware systems.

The 5G network will be able to provide the forthcoming fully connected society with improved communications, able to economically interconnect billions of devices (*100 times more devices than today*), able to provide large bandwidth everywhere (*1000 times larger than today*), faster response time (*5 times lower end-to-end latency*), faster service deployment (*100 times faster than* today) and services across every access technology (*a fully converged network, with a core agnostic to the access technology*). Some key performance indicators (KPIs) for 5G are discussed in [4].

SDN, in a generic sense, plays a key role in future 5G networks by offering a much higher level of programmability to change usage of network resources, as well as functions and protocols configuration. Programmability is achieved through the right level of abstraction and by software interfaces that enable a rapid development of network functions and services thus promoting innovation. SDN is also a tool to compose service chains [3] of value added services, such as parental control, firewalling, or media coding/adaptation/acceleration that are offered to customers in a dynamic and reconfigurable way.

This new way of deploying custom-made services is a stepping stone for the evolution to 5G networks. This deployment flexibility opens up new opportunities to extend the reach of carrier network capabilities and resources beyond traditional service delivery models, bringing innovation into the telecommunication market. In fact, these are a part of the requirements being set by the 5G community, such as the Next Generation Mobile Network alliance (NGMN) and other networking fora (GSM Association – GSMA, ETSI, etc.). The upcoming 5G networks should support fast service deployments, support current and future services as described by ETSI [2] in the context of SDN and NFV, and integrate a myriad of network technologies and devices. Furthermore, these networks should be economically viable, stopping the current unsustainable cost increase trend coming from deploying separate networks for each use.

This concept paper illustrates a vision and defines key concepts for an architecture of a common and access-agnostic control plane (C-plane), able to address 5G network requirements, in terms of technology heterogeneity – a full implementation of fixed-mobile convergence (FMC) not only in the data plane [6], also in the control and management plane –, performance indicators, expected costs, and service deployment flexibility. The proposed architecture re-uses existing infrastructure by developing a common 5G converged C-plane for last mile access networks of different characteristics. Our concept builds on the flexibility that NFV enables with dynamic deployment, adaptation, and exposure of network functions, by taking advantage of cloud computing, orchestration, and automation technologies. In addition, the approach will follow the idea of a toolbox with different building blocks and clear interfaces to support an easy handling and orchestration of the infrastructure set-up [9]. This flexible and configurable 5G C-plane will make it possible to create connectivity services for a multitude of use cases with the intent of supporting both existing and future use cases. Note that technology aspects of the data plane (D-plane) are not in scope of this architecture, as we expect that D-plane improvements will be dominated by hardware technology developments (seamless included in network by SDN concepts).

Furthermore, in order to make 5G networks a fertile environment for innovation, at par with today's innovative environment of the Internet at large, the 5G C-plane shall be open for user/application service creation (exposed to developers' communities and third party providers). New possibilities to share access networks by having a common interface towards heterogeneous access network technologies (full FMC) will create new business opportunities both for network and service providers.

This work addresses a converged network architecture to meet the very versatile requirements of tomorrow's applications by a cognitive 5G C-plane for ubiquitous access technologies. The work builds on results of projects funded under the 7th EU Framework Programme for Research and Innovation such as METIS [5], COMBO [6], UNIFY [7], and other projects related to 5G or network convergence. Performance evaluation of the novel concepts disclosed in the paper is left to future works.

II. 5G Control Plane Challenges

Our vision is to develop the control architecture for a 5G network, able to support the integration of a ubiquitous access continuum composed of millions of fixed and heterogeneous wireless resources. 5G networks will have to cater for a large set of different deployments with multiple accesses in different environments, for example from traditional broadband deployments to on site tailor-made industrial applications. The vision is to provide functional convergence of network control to handle 5G access, 4G access, Wi-Fi, fixed access scenarios, and broadcast, with flexibility to efficiently support and deliver new types of applications for industrial Internet, vertical enterprise segments, vehicle traffic support services, Internet broadband, broadcast applications, and others.

Current cellular networks have been optimised for human driven communication, client-server Internet access for large volumes, and will not fit to scale to the number of devices with variable volume requirements. Fixed networks are being designed for large data volumes to individual devices e.g. Content Delivery Networks (CDN). Here, current convergence practice is twofold; (i) on the service level, with e.g. IP-Multimedia Subsystem (IMS) [8], and (ii) some sharing of infrastructures, through over-the-top service provisions and physical infrastructure sharing (e.g. cable ducts). Fig. 1 shows the interworking of cellular and fixed networks by the provision of access over a Wi-Fi link in the fixed network with the capability to simultaneously tunnel traffic from the cellular device to the mobile core, and diverting traffic towards the Broadband Network Gateway (BNG) in the fixed network. In practice, convergence has been only achieved in the scope of a service view. Real infrastructure convergence has been a secondary concern, and convergence by a common C-plane for ubiquitous access technologies is still lacking.

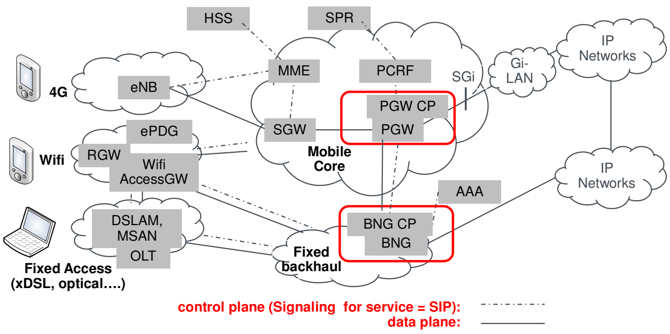


Fig. 1. Example of current practice for cellular and fixed interworking

In infrastructures where the operator has a mobile and a fixed network access service offer, the mobile core and the fixed core are split into logically and physically separate networks. The IP transformation of the operator environment drives the merge of the physical infrastructure (D-plane), but the logical split between mobile core and fixed core will not simply disappear. Reasons are the different network management and control systems, different AAA infrastructures, service differentiation for the different application (IPTV, VoIP …), Wi-Fi-hotspot management systems, etc. So, albeit the physical transport infrastructure(s) may be merging, the effective control (C-plane) of both networks remains different – as much as a consequence of this past legacy as a consequence of the typically distinct requirements to which each network cater. Furthermore, service deployment in such architectures becomes cumbersome, with complex code requirements for the multitude of control systems existing.

This situation is not sustainable for 5G networks, because of the requirements on 5G networks and the associated costs. The new 5G architecture must provide a communications environment able to overcome the infrastructure shortcomings of today's networks, responding to the needs of new use cases utilising multiple core and access networks, in an economic efficient way. Data intensive (low data rates versus big data rates), nomadic mobility versus high speed mobility, and low latency critical application requirements must be fulfilled by this 5G C-plane architecture. Providing a converged core network with shared functions between different access networks is essential to keep costs low despite devices and traffic volumes increase. With a clear separation of C-plane, D-plane, and access network, the 5G network will provide new opportunities for different parts of the network to be operated by different legal entities. It can be envisioned that new access technologies will be deployed by new business entities that connect to one or several C-planes of different C-plane "operators", thus spurring competition for both, access and core network business.

As opposed to current implementations of Fixed-Mobile Convergence (FMC) focusing on internetworking and common interface definition – data plane convergence [6] –, the 5G C-plane will also bring control plane and management plane convergence. The 5G C-plane architecture will have to overcome the limitations for scalability in today's 4G cellular networks where state is held for each active session, signalling between multiple network functions is needed for bearer setup and user services are deployed in central data centre. This technology complexity has to be improved from the network side, while at the same time being able to provide a more seamless experience: the network will be "simply there", and the end-user will expect not only such pervasiveness of the network, but that it will provide the best service at each time. This will require a more holistic view of networks, where the provision of communications services is not only on a "best effort" or premium quality level, but it should be a responsive action depending of context information from the network as well as from the user requirements through user profiles and user roles, including proper selection of interface, communication service selection, and even service end-point redirection.

III. Architectural System View

The design of a 5G converged system starts from the assumption next generation networks will be built on physical infrastructures integrating a variety of fixed, wireless, and satellite access networks – full FMC as well as transport, networking and data centre technologies. Extending the SDN paradigm to 5G, centralised controllers will allow the configuration and management of physical resources, enabled by evolutions of current technologies (e.g. Openflow for the management of switches and routers, and Openstack for computational and storage resources). The SDN principle will consistently preserve the separation between C-plane and D-Plane. NFV and resource orchestration will allow the decomposition of network functions and their software implementation into the most suitable physical infrastructure, according to functional and performance requirements of 5G services and devices.

Within this technological framework, 5G networks shall provide fast, efficient and flexible service delivery, aiming at service, device and access convergence. *Service convergence* refers to the ability of 5G to provide a wide set of heterogeneous services, having challenging and possibly conflicting requirements, e.g. in terms of bandwidth, latency or reliability. *Device convergence* indicates next generation network will go beyond smartphones, and will provide connectivity to objects e.g. conceived for machine type communications, smart cities or industrial applications. Finally, *access convergence* focuses on the need to connect devices and provide services regardless of (or exploiting the most convenient) access technology.

The key concept to achieve convergence and flexibility, leveraging on the enabling technologies briefly described, is depriving 5G of the single and monolithic logical architecture, which characterised mobile and fixed broadband networks until today. Rather, 5G shall define a basic set of control functions allowing dynamic definition and instantiation of C-plane architectures, fulfilling service and application requirements. Different 5G use cases will have specific performance and functional requirements; hence, tailored C-plane architectures will be defined and instantiated combining subsets of the basic control functions. Functional requirements of each use case will affect the set of control functions composing the correspondent C-plane architecture. Those requirements might include the need to identify and authorise devices and subscribers over different access networks, the support of different types of mobility (from static and nomadic devices to the premium mobility of today's cellular systems), the support of several QoS classes, different security levels, etc. On the other hand, performance requirements (e.g. communication reliability, C-plane latency etc.) will affect the instantiation of the C-plane architecture, as functions might be implemented as virtual network functions in a network service chaining manner on general purpose hardware, high performance data centre, or on cloud edge points of presence – service execution close to the service consumption point.

Use case by use case, the C-plane will be composed by a set of Control functions, mutually interconnected by network function interfaces and connected to controllers via Network Function (NF)-Controller interfaces. Functions can be further distinguished between network access functions and network core functions. The same set of core functions is compatible with access functions of any access technology; this provides full FMC for device and access network.

The C-plane will be paired to a clean slate D-plane. Controlled by the C-plane, the D-plane will consist of forwarding paths configured in the SDN infrastructure (i.e. SDN routers and switches) allowing data to be routed from source to destination. According to service requirements, an augmented D-plane may also include additional tailored network functions (e.g. content caching, firewall etc.). The overall system concept is schematically illustrated in Fig. 2.

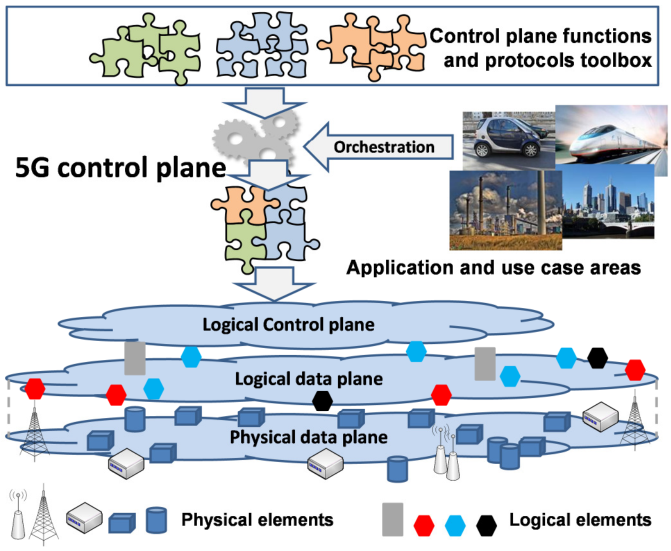


Fig. 2. 5G control and data plane system concept

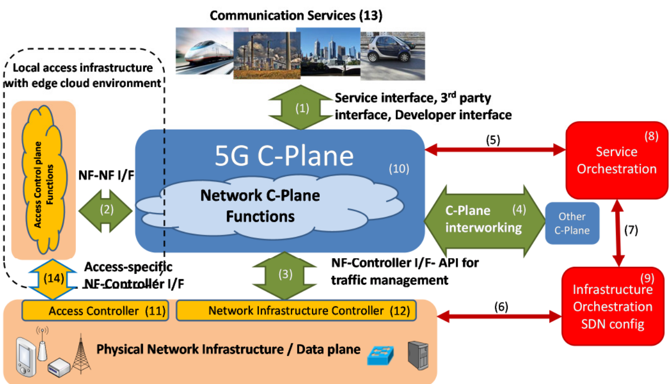
Besides identifying the required set of control functions, completing the C-plane design requires to specify *how to* provide connectivity services, i.e. defining C-plane procedures and protocols, necessary to accomplish all associated actions. The design must fully explore the freedom offered by SDN and NFV in placing network functions anywhere in the network and as decomposed abstract service functions. As such, it will require an intelligent orchestration and control system automating and hiding details, yet executing according to operators' and customers' policies. The 5G network functions are instantiated over the 5G network infrastructure via service and infrastructure orchestration mechanisms.

While enabling convergence, the architecture must maintain the low transmission cost per bit for the devices despite of requirements heterogeneity. This should be achieved by developing *Intelligent Connectivity*, capable of granting access, providing addresses, establishing QoS guarantees on forwarding traffic, re-locating services, while optimising resource usage and providing options for tailored services in the 5G system. Intelligent Connectivity will be provided by three building blocks:

- Basic Connectivity, including addressing, homing, session, and mobility management, intelligent interface selection;
- Quality of Service/assurance, service differentiation;
- Security, privacy, identity management including role management, AAA, Charging.

Additionally, a pervasive context framework will bind all these building blocks into a personalised orchestrated network.

Intelligent Connectivity will provide connectivity and packet transport to attached devices. Additional services can be added on demand based on context information, e.g. device type, subscription profile and user's role, location, or energy constraints. Such additional services include location tracking and handover, support for device dormancy and power saving, and enforcement of policies for traffic differentiation, security, privacy, and QoS provisioning. The converged network architecture will also allow for moving the service execution point considerably closer to the end-user, depending on use case requirements. For specific services it may also be possible to re-instantiate a network service function at a new service point of presence, as the end-user changes its point of attachment to the network.



NF: Network Function, I/F: Interface

Fig. 3. 5G System High Level Architecture

The concepts illustrated in the previous section, drive 5G networks design to the high level system architecture depicted in Fig. 3. The picture highlights the 5G C-plane, the key functional building blocks and the related interfaces (I/F).

The interface between the 5G C-Plane and 5G Communication Services (1) allows the transfer of use case specific information to the control platform, which will act upon all aspects relating to service invocation in the C-plane. Additionally, via I/F (1), C-plane specific information is provided to external users, service providers, application developers and customers.

NF-NF interface (2) between the 5G Access C-plane functions and the 5G Network C-plane functions is the key interface enabling access convergence, as it allows communication and interworking between 5G core network and access specific functions. Note the access network physical infrastructures are controlled by access specific control functions through the Access Controller (11), to which they are connected via Access Specific NF Controller Interface (I/F) (14).

Similarly, NF-Controller interface, connecting 5G C-plane to the Network Infrastructure Controller (3) is an SDN-type I/F, adapted to needs of the 5G C-plane and not bound to specific implementations of the D-plane. It allows network C-plane functions to control physical infrastructure through the Network Infrastructure Controller (12).

The high level architecture includes also I/F (4) to interconnect 5G C-plane to other application specific 5G C-planes, C-planes of cooperating network service providers, or legacy system C-planes (e.g. 2G, 3G, 4G, fixed networks C-plane, specific Wi-Fi/Hotspot C-plane, etc.). This interface can be optionally implemented and customised according to network operator's requirements.

The right side of the picture shows also the interaction between C-Plane and Service/Infrastructure Orchestration entities. The Service Orchestration module (8) is in charge of defining instantiations of the C-plane (according to service and device requirements) and to implement them on the physical infrastructure via the related interface (5). Similarly, the Infrastructure Orchestration/SDN Configuration module (9) orchestrates and defines resources configuration for D-plane, which are instantiated via the related interface (6). Both modules (8) and (9) can be implemented separately or can be merged into one module. In this case the I/F (7) will disappear.

The 5G C-plane block (10) includes multiple instantiations of logical C-planes, which can be seen as a network slice, composed by sets of control functions, mutually interconnected by network function interfaces. Functions instantiation can be either centralised or distributed on edge data centres, as defined by the Service Orchestration module (8).

Management and orchestration of virtual entities, both at service and infrastructure level, will be performed according to "network-functions-to-infrastructure" decoupling principles, information elements, and interfaces specified in [10]. The Network Functions Virtualisation Management and Orchestration (NFV-MANO) architectural framework specified by ETSI has the role to manage the infrastructure and orchestrate the allocation of resources needed by the supported network services and by the virtualised network functions, including instantiation, lifecycle, fault, and performance management.

The Access Controller (11) is the entity controlling (i.e. configuring and managing) access specific physical resources, both for 5G or legacy systems. Along the same line, Network Infrastructure Controller is the entity controlling (i.e. configuring and managing) core network physical resources.

IV. IMPLEMENTATION EXAMPLES

The definition of each 5G C-plane procedure includes:

- Identifying the involved 5G network functions;
- Defining the required information exchange among involved 5G network functions;
- Defining the required information exchange among involved 5G network functions and converged network infrastructure controllers.

The involved Network Functions (NFs), and the information exchange on related Interfaces (I/Fs), depends on device types and communication services.

Fig. 4 zooms into the C-plane and logical D-plane of the reference model and illustrates an example set of 5G core network functions required to provide connectivity services, such as (i) Authentication and authorisation; (ii) Addressing; (iii) Forwarding Path management; (iv) Mobility management; (v) Context Aware engine; (vi) Optimisation function.

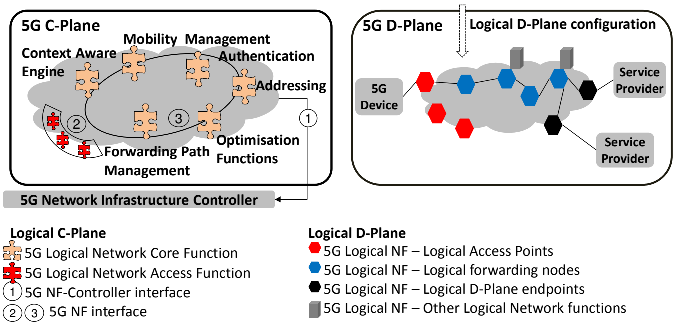


Fig. 4. Examples of 5G core network functions

The *authentication and authorisation function* performs the identification and authentication of the entity (user/device) requesting an application service, and the validation of the service request type. The *addressing function* performs the allocation and management of addresses and IDs for entities. The *forwarding path management function* defines and manages the D-plane for each attached entity, including the allocation of logical D-Plane endpoints, allocation of logical NFs, and allocation of forwarding paths to route data generated from or directed to the attached entity. The *mobility management function* keeps track of entity's location and allows the forwarding path to be dynamically managed. It includes providing entity's reachability, tracking area lists management, handover management etc. The *context aware engine* collects context information for the attached entities, and interacts with other C-plane logical NFs, and already tailored logical NFs (5G control sub-systems) to optimise and tailor the network service according to the available context information. The *optimisation function* interacts with the 5G control sub-systems, consulting them when triggered by user devices, the access network, services, or other networking procedures. This function evaluates how to react to that trigger and provides an optimised connectivity action to be taken by the network.

Fig. 5 and Fig. 6 illustrate two instantiations of the C-plane and its ability to tailor the D-plane for two use cases.

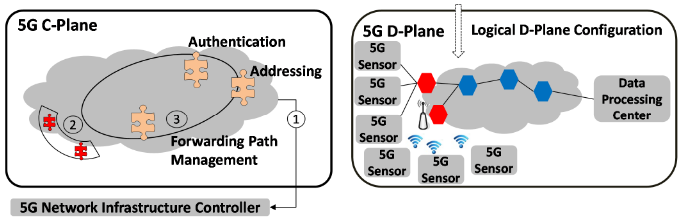


Fig. 5. 5G C/D-Plane for Static/Nomadic Sensors Network Use Case

Fig. 5 considers a Static/Nomadic wired and wireless sensors network application. In this case data communication is sporadic and requires low data rates. Hence, the logical C-plane does not require a mobility function, an optimisation function, or context aware engine. Two logical network access functions are required, to manage both the wireless and the wired connections. The logical D-plane consists of logical access nodes and logical forwarding nodes only, building forwarding paths from the devices to a data processing centre.

A typical scenario is a manufacturing hall, where different sensors are connected to control and manage the production process. Fixed sensors are installed along the production line. Wireless sensors are installed on the components and intermediate materials, which arrive at the manufacturing plant and connect to the local wireless network to exchange location and production specific context information. This scenario requires the support of a nomadic access protocol without mobility support. Mobility can be handled on lower layers within the local address domain.

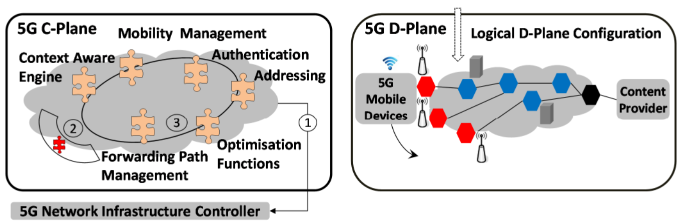


Fig. 6. 5G C/D-Plane for Mobile Broadband Use Case

Fig. 6 considers a mobile multimedia broadband service. The device changes its location and environment at high speed and the data communication requires high throughput. Hence, the logical C-Plane must be composed by the full set of logical network functions. In this case, only the logical wireless network access function is required. On the logical D-plane, additional logical network functions such as content caches and mobility association points are required.

The automotive and transportation sectors will rely on remote processing to ease vehicle maintenance and to offer services to customers with very short time-to-market. This requires robust communication links in V2X scenarios with very low latencies and availabilities close to 100% at speeds up to 350 km/h. In particular the challenge is to establish communication links across different network operator networks with the same requirements on latency and service guarantee as within a single operator network [5]. This requires a bigger set of network functions as the example before.

The above examples give a good overview as to how the communication services will influence the manifestation of the C-plane and its research and development, starting from the use case and application areas.

V. Conclusions

Next generation networks are expected to become one of the key building blocks of the forthcoming digital society, enabling a variety of different sector/vertical services, supporting new applications and connecting next generation devices. Flexibility will be the keyword for 5G network, as it will be required to integrate heterogeneous access technologies and network infrastructure, as well as to fulfil performance and functional requirements of a multitude of different services. Additionally, network operators cost reduction (both OPEX and CAPEX), ease of service deployment and support of new business models will be drivers for 5G design.

This paper discusses system concepts and devises a high level architecture, aiming at identifying key design principles for a converged 5G network. In the proposed view, 5G requirements will be achieved via the definition of an access agnostic reconfigurable control plane (C-plane), fully decoupled from a SDN driven data plane (D-plane), and instantiated on physical infrastructure according to SDN paradigm and leveraging on NFV technology. Built upon a basic set of network control functions, the C-plane will be tailored, instantiated, and operated according to device, service, and application functional requirements and performance targets. The C-plane will also have interfaces towards Network Infrastructure Controllers (allowing interaction with network physical resources) and will expose configuration APIs to third parties, service providers, and application developers, easing communication service deployment, operation, and management.

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VII. References

[1] Manzalini, A.; Saracco, R., "Software Networks at the Edge: A Shift of Paradigm," *Future Networks and Services (SDN4FNS), 2013 IEEE SDN for* , vol., no., pp.1,6, 11-13 Nov. 2013.

[2] Network Functions Virtualisation (NFV) – Network Operator Perspectives on Industry Progress; ETSI NFV paper, http://portal.etsi.org/NFV/NFV_White_Paper2.pdf

[3] IETF working group: "Service Function Chaining (sfc)", https://datatracker.ietf.org/wg/sfc/charter/.

[4] Technical Annex to the Contractual Arrangement setting up the PPP in the area of advanced 5G network infrastructure for the future Internet http://5g-ppp.eu/wp-content/uploads/2014/02/Advanced-5G-Network-Infrastructure-PPP-in-H2020_Final_November-2013.pdf.

[5] Osseiran, A.; Braun, V.; Hidekazu, T.; Marsch, P.; Schotten, H.; Tullberg, H.; Uusitalo, M.A.; Schellman, M., "The Foundation of the Mobile and Wireless Communications System for 2020 and Beyond: Challenges, Enablers and Technology Solutions," Vehicular Technology Conference (VTC Spring), 2013 IEEE 77th , vol., no., pp.1,5, 2-5 June 2013

[6] Breuer, D.; Weis, E.; Gosselin, S.; Mamouni, T.; Torrijos, J., "Unified access and aggregation network allowing fixed and mobile networks to converge," Optical Fiber Communication Conference and Exposition and the National Fiber Optic Engineers Conference (OFC/NFOEC), 2013 , vol., no., pp.1,3, 17-21 March 2013

[7] John, W.; Pentikousis, K.; Agapiou, G.; Jacob, E.; Kind, M.; Manzalini, A.; Risso, F.; Staessens, D.; Steinert, R.; Meirosu, C., "Research Directions in Network Service Chaining," Future Networks and Services (SDN4FNS), 2013 IEEE SDN for , vol., no., pp.1,7, 11-13 Nov. 2013.

[8] A. Cuevas, J. Moreno, P. Vidales, H. Einsiedler, "The IMS Service Platform: A Solution for Next-Generation Network Operators to Be More than Bit Pipes", IEEE Communications Magazine, August 2006, Vol. 44, No. 8.

[9] H. J. Einsiedler, R. L. Aguiar, A. Gavras, H. D. Schotten, "A new meta-model for Future Internet architectures", Future Network & Mobile Summit 2013, 3-5 July 2013, Lisbon, Portugal, Conference Proceeding ISBN: 978-1-905824-36-6, IEEE published.

[10] ETSI GS NFV-MAN 001, "Network Function Virtualisation (NFV); Management and Orchestration", v1.1.1, Dec 2014.