Fundamental Features of the Smart5Grid Platform Towards Realizing 5G Implementation

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Abstract. Based on the original framework of the Smart5Grid EU-funded project, the present paper examines some fundamental features of the related platform that can be able to affect 5G implementation as well as the intended NetApps. Thus we examine: (i) the specific context of smart energy grids, enhanced by the inclusion of ICT and also supported by 5G connectivity; (ii) the cloud native context, together with the example of the cloud native VNF modelling, and; (iii) the MEC context as a 5G enabler for integrating management, control and orchestration processes. Each one is assessed compared to the state of the design and the implementation of the Smart5Grid platform. As a step further, we propose a preliminary framework for the definition of the NetApps, following to the way how the previous essential features are specifically incorporated within the project processes.

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1 Smart Grids and Their Main Functionalities

The Smart5Grid project [1] constitutes a step forward in the integration of energy grids with the latest innovations in virtualization and communication technologies that 5G, the 5th Generation of mobile communications, brings. Smart5Grid is focused on boosting innovation for the highly critical and challenging energy vertical, by providing an open 5G enabled experimentation platform customized to support the smart grid vision. The Open Smart5Grid experimental platform aims to be an ecosystem where stakeholders in the energy vertical, ICT integrators, Network Applications (NetApps) developers, actors in the telecom industry and/or network service providers in general, could “come together” fostering collaboration and innovation. The final goal is to validate, both at the technical and business levels, the opportunities offered by 5G technology to the energy vertical, to be demonstrated in four meaningful use cases (UCs), relevant to real scenarios of use [2]. The use cases were specifically chosen to capture a wide range of operation scenarios for the power systems.

The present paper focuses on the description of the current state-of-the-art from the project’s perspective, providing insights on the latest advancements in areas such as smart grids (SGs), the cloud native paradigm as well as the impact of Multi-access Edge Computing (MEC) in 5G networks. Each one is assessed as of its relevance to the state of the Smart5Grid platform design and/or implementation.

The energy sector represents undoubtedly one of the most significant “test cases” for 5G enabling technologies. This is linked to the need of addressing a huge range of very diverse requirements to deal with across a variety of applications, like the stringent capacity for smart metering/Advanced Metering Infrastructure (AMI) that is used as a two-way channel for communications between meter and users, versus the latency for supervisory control and fault localization. Moreover, to effectively support energy utilities along their transition towards more decentralized renewable-oriented systems, there are different open issues to be fully solved as, for example, the need for 5G networks to enable the management of automation, security, resilience, scalability, and portability of the smart grid energy services.

The application of the virtualization and service-oriented principles in network design enables network systems to be realized based on cloud technologies and network services to be provisioned following the cloud service model [3]. This emerging trend is often referred to as cloud native network design, which is expected to be widely adopted in future networks, including the design of 5G/6G networks. Thus, cloud native is an approach to build and run applications that fully exploit the benefits of the cloud computing model. Such approach refers to the way applications are created and deployed, not where they are executed. It includes things like service architectures, infrastructure as a code, automation, continuous integration/delivery pipelines, observability/monitoring tools, etc. Cloud native apps are designed and built to exploit the scale, elasticity, resiliency and flexibility the cloud provides.

MEC makes no assumptions on the underlying radio infrastructure, which makes it a highly flexible element in the communications networks. As the delivery technology – together with the underlying hardware of the MEC platform – remains open, this enables new levels of adaptability to the chosen deployment scenario. Therefore, Service Providers (SPs) can use MEC as a revenue generator and application test bed (including service producing applications) without being forced to wait for full ratification/deployment of the 5G standard and the associated capital investment. This approach allows SPs to offer third parties a cost-effective way to trial their applications.

The work is organised as follows: The present Sect. 1 serves as an introduction where some essential features of the Smart5Grid project platform have been identified, able to affect 5G implementation. These are further discussed in more details in the subsequent sections, that is: Sect. 2 presents the context of smart energy grids with the consideration of ICT for smart metering and for better managing collected data; Sect. 3 discusses the cloud native context together with the example of the cloud native VNF modelling, that can strongly affect the intended Smart5Grid architecture. Then, Sect. 4 is structured to elucidate aspects from the MEC context, in particular as 5G enabler for effectively integrating 5G management, control and orchestration processes. Each one among the above platform architectural features is also correlated to the ongoing Smart5Grid approach, as actually performed in the process of the project. Following to the previous discussion, Sect. 5 is dedicated to the description of the intended NetApps. Finally, Sect. 6 summarizes the paper with several concluding remarks.

2 Smart Energy Grids

The profound transformation driven by deeper and faster decarbonisation is changing the energy world and is also creating new challenges, both on the supply side and on the demand side. In particular, the energy infrastructure needs to be enhanced and digitalized in order to cope with the deployment of renewable sources, increased decentralization, electrification of end-user and active customers, ensuring, at the same time, energy network stability, security, and resilience [4, 5]. The electric grids, which are essentially massive interconnected physical networks, are the infrastructure backbone for energy supply and use of today [6].

Electricity generated from renewable sources is predominantly variable in nature; in this respect, grids will be required to manage power flows more promptly and efficiently to support the integration of less predictable energy production, while maintaining the quality of supply. Nonetheless, supporting the boost of Renewable Energy Sources (RESs), smart grids will deliver substantial benefits in terms of resource-efficient economic growth, global and local pollution reduction [7, 8].

Grid interoperability with distributed resources is one of the fundamental pillars of grids' development [9]. Shifting from demand and supply patterns towards more decentralized generation (connected at medium and low voltage grids) raises the need to properly manage congestions and multidirectional energy flows. Moreover, connecting customers equipped with smart meters to the distribution system will allow their active participation to the energy market through the provision of flexibility services (e.g. via a "demand response" approach). Energy consumption patterns are also changing, due to the growth of new forms of energy demand in building, transport and industry sectors, with a high variability and high-power rating. The smart integration of electricity with final uses will significantly decrease both greenhouse gas emissions and energy demand, in order to deliver equivalent services with less energy input and resources.

In this multi-challenging framework, energy system operators will have to be empowered with more advanced instruments to provide reliable electricity supply and quality of service (QoS) in the increasing challenging energy system. The goal is to allow the grid system to work as efficiently as possible [10], minimizing operating costs and environmental impacts while maximizing system stability and security. This is a "key issue" to ensure more resilient supply of electricity, through the use of solutions that improve fault detection and allow self-healing of the energy distribution grid, without the intervention of technician. Smart grids accomplish the required optimization of energy networks by using digital and other advanced technologies [11]. They are necessary for the integration of growing amounts of variable RESs (like solar and wind power), and of new loads (such as energy storage and charging of electric vehicles), while maintaining stability and efficiency of the system. Furthermore, smart grids enable the utilization of flexibilities that are currently available or that will become available in the future, to better match needs on the grid with respect to generation and demand [12].

On this regard, the Smart5Grid platform is structured in a way to support the energy transition by providing the needed digital layer to ensure the availability of the communication infrastructure, whenever is needed.

Smart grids are complex systems [6–8]. They aim to intelligently integrate the behaviors and actions of all the stakeholders in the energy supply chain to efficiently deliver sustainable, economic, and secure electric energy, and ensure economical and environmentally sustainable use. Key to the success of SGs is the seamless integration and interaction of the power network infrastructure as the physical systems, and information sensing, processing, intelligence, and control as the cyber systems. With respect to power transmission and distribution networks, SGs integrate interconnected and geographically wide distributed components, both hardware and software, both on the demand and on the supply side, and "pool" their resources to create higher functionalities [13, 14] such as the following:

- *Advanced metering and monitoring*, for close to real-time (RT) transmitting and receiving data for information, monitoring and control purpose on what goes on the energy network, in order to acquire/provide feedback for the grid operation and enable consumers to better manage consumptions.
- *Active network management*, for the operational optimization through predictive maintenance, energy network remote reconfiguration and recovery schemes activation in almost real time.
- *Flexibility services,* from Distributed Energy Resources (DERs) such as distributed generation, energy storage assets and demand side response, leveraging on end-user's flexibility. A DER is a small-scale unit of power generation that operates locally and is connected to a larger power grid at the distribution level. DERs can include solar panels, small natural gas-fuelled generators, electric vehicles, and controllable loads,

such as HVAC (Heating, Ventilation and Air Conditioning) systems and electric water heaters
- *Smart charging services,* such as vehicle-to-grid (V2G) or vehicle-to-home (V2H) solutions (for battery electric and plug-in hybrid vehicles) and additional growth of electrification grade (i.e.: heating and cooling), increasing RESs grid hosting capability. (V2G is a technology that enables energy to be pushed back to the power grid from the battery of an electric car; a V2H system enables customers to store home generated renewable energy in their leaf battery or fill their battery when energy tariffs are low or even free).

In this context, the Smart5Grid project is structured so that to effectively support most of the above functionalities, offering dedicated services not only for the energy system operators, but also for DERs providers and aggregators who are assessed as "the new emerging actors" of the energy industry ecosystem.

The following responses are identified to the fundamental smart grids' functionalities, as the latter are actually developed by the Smart5Grid effort:

- Regarding *advanced monitoring*, an innovative cross-border frequency monitoring system will be implemented to support the regional Transmission System Operators (TSOs) to provide the system stability in the Greek-Bulgarian demo (*as discussed in the context of the respective use case 4, UC#4*).
- Besides this, in the Spanish demo (*as examined in the specific framework of use case 2, UC#2*), an innovative *safety system* for people working in high-voltage power stations will also be implemented and tested, since electricity still represents a danger for workers if not properly approached, keeping the due physical distance from the live parts.
- The most advanced *active grid management system*, developed by Enel Distribuzione Italia (EDI), will be supported by a NetApp to provide RT communication monitoring, preparing the ground for further implementation of edge-based computing (*as examined in the specific framework of use case 1, UC#1*).
- The real-time monitoring and control of DERs compose the basis for the provision of *flexibility services* to the energy system operators.

3 The Cloud Native Context

Within the Smart5Grid framework a core aim is to embrace and adopt, where possible, the cloud native paradigm [15]. The concept of cloud native, in a simple way, can be defined as related to applications that are born in the cloud – as opposed to applications that are born and raised on-premises [16]. However, this definition is quite simple and not representative of what cloud native truly means, so it is better to introduce the concept by means of different examples extracted from [17]. Based on this approach, cloud native applications have the following characteristics:

- *They often need to operate at global scale:* While a simple website can be accessed anywhere given that internet is not blocked, the concept of global implies that the application's data and services are replicated in local data centres so that interaction latencies are minimized, and the integrity of the application is clear to the final user.

- *They must scale well with thousands of concurrent users:* This is another dimension of parallelism that is orthogonal to the horizontal scaling of data required for global-scale distribution and it requires careful attention to synchronization and consistency in distributed systems.
- *They are built on the assumption that infrastructure is fluid and failure is constant* so even in the case the failure rate is extremely small, the law of large numbers guarantees that in a global scale even a low probability event can happen.
- *Cloud-native applications are designed* so that upgrade and test occur seamlessly without disrupting production.

The above characteristics perfectly "match" the requirements of a smart grid's communication and application layers, consequently entailing the need of adopting 5G. Due to the need of addressing a huge range of very diverse requirements to deal with across a variety of applications, an approach based on microservices [18] *and cloud nativeness is strongly needed with the consequent use of different techniques of virtualization, to help the power grid to truly become smart. Dedicated effort has been planned to realize this specific aim.*

The current specifications for realizing network virtualization and softwarization in 5G change how network functions are realized and deployed (as software instances hosted on Virtual Machines (VMs) and/or containers) but not with regards to how the functions are designed [19]. In fact, the state-of-the-art of NFV (Network Functions Virtualisation) implementations [20] often replace monolithic hardware-based network functions with their software VNF (Virtual Network Functions) counterparts. This approach naturally brings for any project based on software virtualization the creation of a certain number of common functionalities that are repeated across different VNFs, and which causes evident repetition and lack of flexibility in the network infrastructure. Moreover, NFV and Software-Defined Network (SDN) architectures both comprise a set of predefined function blocks that are interconnected via standardized reference points so, whenever a new function block is added into the architecture, these features bring a further "ossification" of the network infrastructure.

A promising way to tackle this problem with the current NFV and SDN architectures is to enable finer granularity for network functions and a common interface for loose-coupling interaction among them. The Service-Oriented Architecture [21] (SOA), with its latest development as the Micro-Service Architecture (MSA), offers an effective approach to achieve this objective. In the European Telecommunications Standards Institute (ETSI) NFV specifications, a network service refers to an ordered set of (virtual) Network Functions (NFs) specified by a service description (VNF forwarding graph [22]). In the SOA approach, this principle has been embraced by the NFV architecture in different level as NFVIaaS [23], VNFaaS [24], and NSaaS [25], which all adopt the SOA service concept, as specified in [26].

Cloud native is an approach to design, build and run applications/virtual functions that fully exploits the benefits of the cloud computing model. It refers to the way applications are created and deployed, not where they are executed, and it is based on the principle of decomposing an application into a set of microservices that can be developed and deployed independently to accelerate and optimize the DevOps strategies [27]. The microservices are packaged into light-weight containers which are scheduled to run on compute nodes by a container orchestrator. As regards data, we must underline that, to be properly classified as cloud native, microservices need to be "stateless", meaning that there must be a separation of the processing logic from the processed data and how it is stored in the cloud.

In framework of the actual Smart5Grid platform, the involved partners intend to embrace and adopt – where possible – the cloud native paradigm so that to "pave the way" towards the integration of the energy infrastructure and the 5G Core Network (CN) SBA (Service-Based Architecture). This 5G CN SBA will require several techniques being applied in unison, i.e., NFV and SDN that will require the deconstruction of VNFs into microservices. This effectively translates to the containerization of the 5G Core, and the gradual decoupling of network functions from VMs in support of containerized network functions. For this reason, the adoption in the early stage of a cloud native approach for the NetApp development will increase the compatibility between telco and vertical infrastructure.

For the purpose of cloud native VNF modelling and in order to understand the roadmap of the evolution of the VNFs towards a cloud native approach, we can rely on the 5G PPP "Cloud Native and 5G Verticals' services" White Paper [28], that conveys the point of view of the European Commission (EC) and the industry (as in Fig. 1). This figure shows the evolution from the classic solution based on VNF implemented to run inside VMs. It also depicts a possible evolution of the term VNF to CNF (Cloud Native Function) that is another way to indicate VNF but with strong emphasis on the cloud design. Observing the present phase, we can see that the classic solution is based on running VMs on top of bare metal/public cloud and on the use of hypervisors such as VMware [29] or VirtualBox [30]. At the same time, OpenStack [31] has been used as the *de facto* cloud computing platform. This architectural approach adopted in the Telecom sector follows the NFV MANO (Management and Orchestration) specification [32].

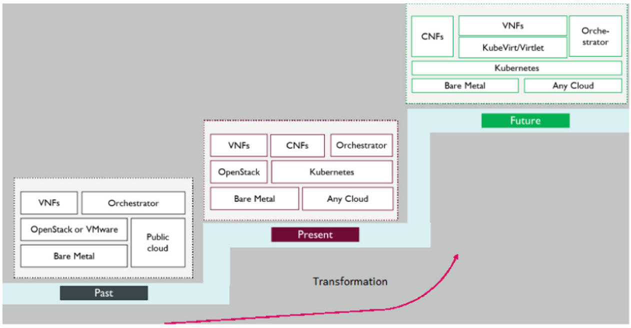

Fig. 1. Cloud native road path [26].

This early-stage approach brought several problems. For example, in multi-domain orchestration environments, as the ones used commonly in 5G services, the management of several Virtual Infrastructure Managers (VIM) (e.g.: OpenStack) in a multi-cloud environment is a complex and hard task not easy to solve. Another problem is that it is difficult to manage multiple VNFs in a consistent way because we are facing the hard dependency between the hardware and element management systems that exist in the real environments. Finally, at implementation level, it is also hard to combine different blocks from different vendors. These concerns can be solved if we move forward into a cloud native solution given their foundation principles.

By summarizing, we can extract four key ingredients that have to guide Smart5Grid project towards the development of cloud native applications. Consequently we shall need:

1) *Small, stateless microservices architecture, running in containers*, which are faster to get deployed and upgraded with the use of few cloud resources, with the purpose of deploying just what is needed instead of the entire network function.
2) *Open architecture and Application Programming Interfaces (APIs) so it is possible to continuously onboard innovation.* For example, the 5G Core uses an SBA with well-defined APIs for network functions to offer services or call on each other. This, merged with the cloud-native service mesh, enables rapid manipulation of the 5G Core, allowing the integration of new network functions, or rapidly scaling & deploying different slices.
3) *Cloud agnostic and infrastructure agnostic*, to eliminate the hardware dependencies.
4) *DevOps for automation and fast time to market*.

4 Multi-access Edge Computing as "Enabler" to 5G Adoption

Using an "edge cloud", SPs can host applications in a virtual retail space, test the revenue return and scale-up or remove as appropriate. So, starting out as a 4G edge test bed with limited deployments at first, MEC allows a smooth transition into the 5G network rollout, removing the need for major upgrades when the expected time for transition arrives [33, 34]. Another focus area for transitioning to the 5G networks is about re-using the existing deployed systems in the process. Due to the MEC's virtualised characteristics, it is very easy to monitor performance and resource needs of an application which, in turn, enables more accurate pricing for operators towards application providers for hosting the applications [35, 36].

The common feature set of providing much-improved capabilities at the edge of the network, improved intelligence about resources needed at the edge and the ability to charge for service delivered by cycles, memory, storage, and bandwidth delivered, makes it "quite attractive" to start the deployment in (early) 5G test sites. Taking into account the above considerations, MEC compatibility towards 5G networks may be about:

- Integrating the MEC data plane with the 5G system's one for routing traffic to the local data network and steering to an application.
- An Application Function (AF) interacting with 5G Control Plane Functions (CPFs) to influence traffic routing and steering, acquire 5G network capability information, and support application instance mobility.

- The possibility of reusing the edge computing resources and managing/orchestrating applications and/or 5G network functions, while MEC still orchestrates the application services (chaining).

MEC, as it is deployed in the 4^{th} generation LTE (Long-Term Evolution) networks, is connected to the user plane. With LTE networks already having been deployed for a number of years, it was necessary to design the MEC solution as an add-on to a 4G network in order to offer services in the edge. Consequently, the MEC system – as defined in ETSI GS MEC 003 [37] and in the related interface specifications – is to a large extent self-contained, covering everything from management and orchestration down to interactions with the data plane for steering specific traffic flows. With 5G, the starting point is different, as edge computing is identified as one of the key technologies required to support low latency together with mission critical and future IoT (Internet of Things) services and to enable enhanced performance and quality of experience. The design approach taken by the 3GPP allowed the mapping of MEC onto AFs (Application Functions) that can use the services and information offered by other 3GPP network functions based on the configured policies [37, 38]. Several enabling functionalities can provide flexible support for different MEC deployments.

There is a growing consensus that in the long term, 5G deployments will increasingly integrate fixed-mobile networks infrastructures with cloud computing and MEC [39]. In these scenarios, the borders between cloud and MEC virtual resources will not be explicit, thus paving the way towards a sort of "continuum" of logical resources and functions, offering flexibility and programmability through global automated operations. This will require that the orchestration capabilities, which are already a key element for exploiting cloud computing capabilities, become an essential part of the operation of future 5G infrastructure.

The integration of 5G management, control & orchestration processes is expected to facilitate applications/services development by providing controlled access to high-level abstractions of 5G resources (e.g., abstractions of computing, memory/storage, and networking) thus enabling any vertical application. Moreover, as a real operating system, it should provide automated resource management, scheduling process placement, facilitating inter-process communication and simplifying installation and management of distributed functions/services, spanning from cloud computing to MEC. A shared data structure will to support multi-vendor systems and applications.

In the specific Smart5Grid framework, the core aim is to focus on the deployment of four selected UCs of strong market relevance for revolutionising the energy vertical industry, in parallel with the introduction of an open 5G experimental facility to support integration, testing and validation of existing and new 5G services and NetApps from third parties. MEC reduces latency to milliseconds and allows for constant connectivity. Plus, when the edge network experiences high traffic, the edge may offload data to the cloud to maintain a quick and reliable connection. MEC shall provide a multiplicity of explicit benefits for the provision of the related services to any participating market actor – especially to network operators – and also to support the effective transition towards a reliable 5G implementation.

5 Smart5Grid NetApps

This section presents the Smart5Grid NetApp which is proposed as a solution to the needs of Smart5Grid project and its UCs. In fact, the Smart5Grid NetApp provides a means for developers to define vertical applications by interconnecting together new and/or existing pieces of software in the form of VNFs. By splitting the functionality of the NetApp into decoupled VNFs, the reutilization of software functions is encouraged. This, however, is not something that the NetApp brings as a new concept. The ETSI NFV framework [32] describes the reference architecture, information models and tools required to manage this kind of applications. However, when introducing advanced networking such as 5G, this framework on its own requires a high level of expertise from developers, not only from the relevant field of the specific vertical application that is being developed, but also from the field of telecommunications if the building of End-to-End (E2E) application is the purpose. With this in mind, the Smart5Grid NetApp concept intends to provide a solution to this problem by abstracting the complexities of network deployment and configuration from the developers of vertical applications.

A Smart5Grid proposed NetApp is a cloud native application. Thus, it is made up of VNFs based on OS (Operating System) containers' technology. Consequently, a corresponding NetApp contains the necessary components to offer a service as a software (SaaS) application for the energy vertical (i.e., it is a complete and standalone (SA) vertical application). However, this does not imply that the service provided by this vertical application cannot be consumed by other external or legacy applications, e.g., from a north-facing API. Also, as shown in Fig. 2, a NetApp may directly expose other user interfaces, such as dashboards, open to design decisions made by the developer.

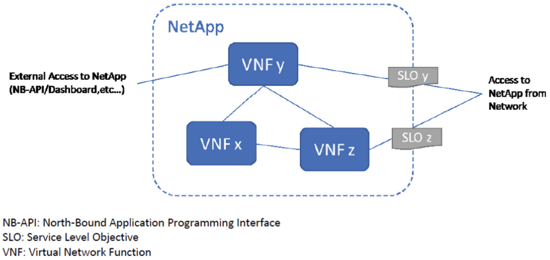

Fig. 2. Basic NetApp representation.

As already mentioned, NetApp components can be deployed as container-based VNFs. A NetApp can contain one or more VNFs. By splitting these components whenever possible in the implementation, the NetApp brings the opportunity to take advantage of the cloud/edge infrastructure. An example of this could be, in the case of a NetApp composed by two components (cf. Fig. 3), that the NetApp function that require low latency input or responses could be placed at the edge of the computing infrastructure, while the other function that may be resource-intensive, not suitable for an edge deployment and not requiring its benefits, should be placed in a cloud data centre where resources are not constrained.

Each NetApp is formally defined in a NetApp descriptor which will include the necessary information regarding the services that compose it, its topology and also the performance requirements of each component; this implicates that the infrastructure over which it is instantiated, can perform their intended functions, such as MEC offloading, VNF scaling, and traffic policy enforcement via its management and orchestration (M&O) systems. This information allows the M&O systems to create end-to-end slices that fulfil these requirements, allowing developers to design applications with strict performance demands and without needing the expertise to implement the networks that support them.

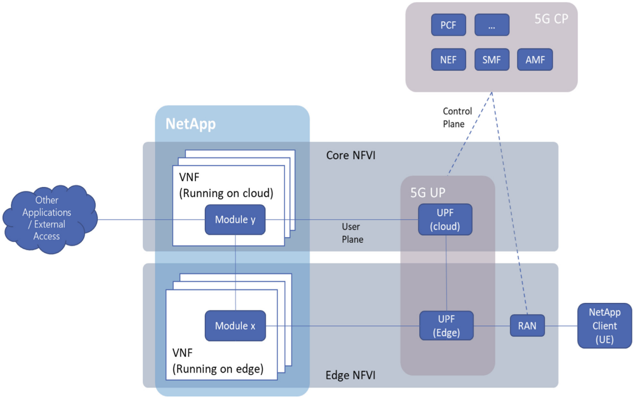

Fig. 3. NetApp deployment over a 5G network.

6 Concluding Remarks

5G networks are assessed as a vital element for the expansion of smart grid technologies, allowing the grid to adapt better to the dynamics of renewable energy and distributed generation. In fact, 5G allows an efficient integration of hitherto unconnected devices to smart grids with the aim of precise monitoring and improved forecasting of their energy needs. Managing energy demand can thus become more efficient, requiring less investments, as the smart grid has the ability to balance easier the energy load, reduce electricity peaks and, ultimately, reduce energy costs.

In this scope, the EU-funded Smart5Grid project intends to complement contemporary energy distribution grids with access to 5G network resources through an open experimentation 5G platform and innovative Network Applications (NetApps), focusing upon four meaningful use cases for the energy vertical ecosystem and aiming to demonstrate efficiency, resilience and elasticity provided by the 5G networks. In particular, the project proposes an innovative architecture [40, 41] and creates a dedicated platform to fulfill its innovative objectives, which is characterised by several essential features. In the present work we have discussed relevance to smart grid, correlation to the cloud native context and options for including – and promoting – MEC.

Smart5Grid foresees to deliver a more secure, reliable, efficient, and real-time communication framework for the modern smart grids. The project platform supports the current energy sector stakeholders to adopt smart grids so that to: (i) Easily and effectively create advanced energy services; (ii) interact in a dynamic and efficient way with their environment; and; (iii) automate and optimise the planning and operation of their power and energy services.

The Smart5Grid virtualisation framework is also based on cloud native applications that have been architected as a set of microservices running in Docker containers. This enhances the Smart5Grid platform with the ability to support applications designed specifically for cloud infrastructures that consist of loosely-coupled microservices and enabling zero-touch orchestration and agile DevOps practices, whereas each microservice will remain self-contained and will encapsulate its own code, data, and dependencies. Most importantly, the cloud native approach takes full advantage of the scalability and resiliency features found in modern serverless platforms.

Smart5Grid also “paves the way” for applying the key features of Multi-Access Edge Computing (MEC). The main target will be to push computation, storage, and network resources closer to the devices that consist the power grid to solve the resource limitation problem and to offload NetApps directly to edge servers. This will allow a significant reduction of latency for devices to access the network and to reduce energy consumption. MEC is also going to ensure data security and integrity by enabling ubiquitous last-mile service access to the smart grid devices, while at the same time, it will offer deployment of network slices within minutes, coupled with value-added capabilities for the smart grid NetApps, such as bandwidth assurance, life cycles management of network services, and overall balancing of service loads.

Following to the above, we have also presented the Smart5Grid NetApp intended scope which is actually proposed as a sort of solution to the needs of Smart5Grid project and its specific UCs. NetApps’ main purpose is to hide the complexity of the 5G telco network to the energy application developers so that they can develop an application not having to deal with the underlying network. Smart5Grid will support most of smart grid´s functionalities by enabling an environment in which cloud-native NetApps can realize the integration between the energy vertical and 5G networks, with a special focus on deployments that leverage edge infrastructure.

Smart5Grid leverages on the concepts of 5G MEC, 5G SBA, network slicing, and ETSI MANO network management, in order to enable the vision of “5G empowering the energy sector” and to allow the roll-out of extended and highly demanding NetApps on top of a 5G mobile network infrastructure.

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