From pipelines to clouds
Etisalat's playbook

Contents

Cloudification journey

Figure 1: Anual variation (CAGR) forecast for mobile networks from 2015 to 2020

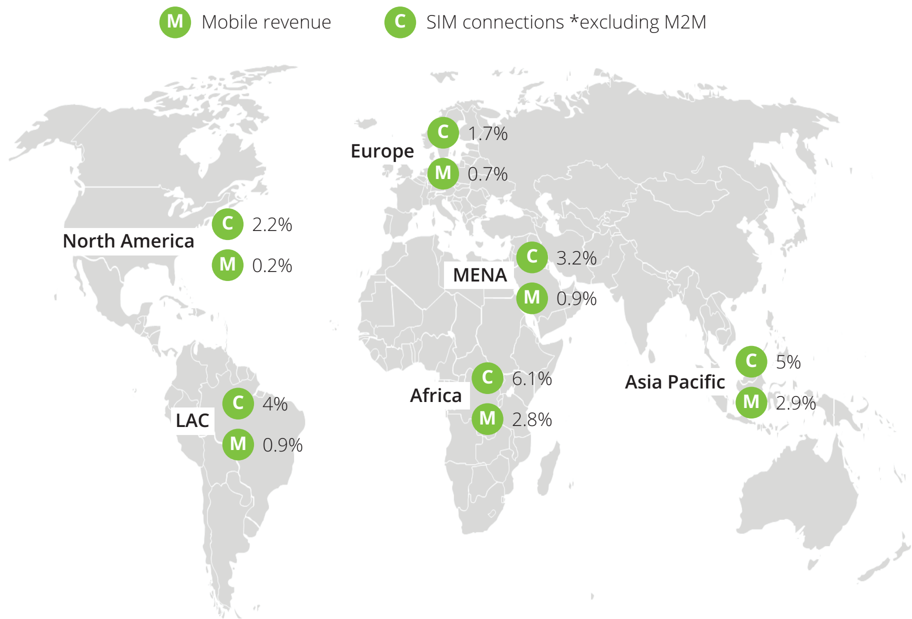
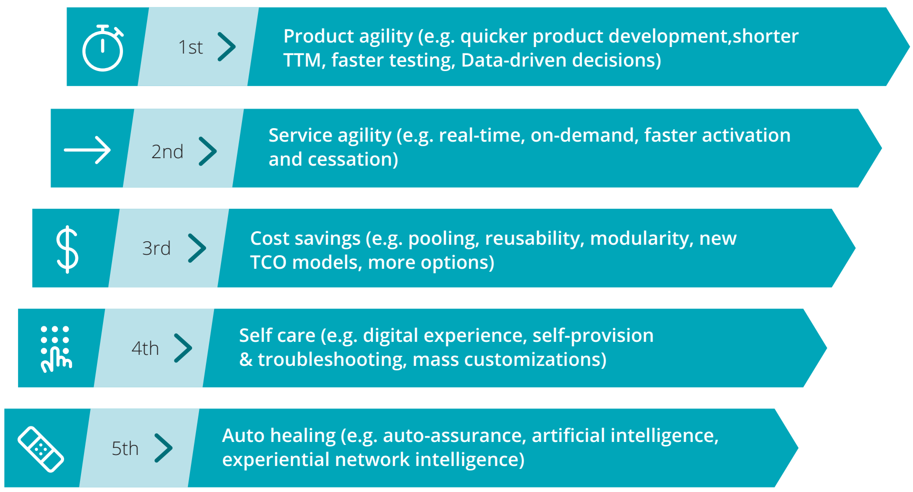


Figure 2: Main drivers for Etisalat's cloudification journey



Etisalat's considerations for the digital transformation

The telecommunication industry around the world is experiencing an exponential growth in the number of devices connected that ultimately impacts the infrastructure that needs to accommodate this data traffic growth. Hence, telcos are constantly investing in their network infrastructure so they can meet the market demand. However, this could lead to a profitability trap, since these investments do not necessarily mean revenue growth. Additionally, the strong competition among OTT providers is also impacting telcos' revenues, which are stagnating throughout the globe or not increasing at the same rate as the network's investments [1].

Furthermore, customers' behaviour is changing. Nowadays, they seek self-servicing, multi-channel offers, and demand to be always connected to the Internet. This situation is pushing telecommunications operators to evolve their business models from a typical communications service provider (CSP) to a digital service provider (DSP) in which they offer innovative value-added services (VAS) and improve quality of experience (QoE) while optimising their network infrastructure.

The adoption of a software-defined network (SDN) and network functions virtualization (NFV) are crucial parts of a telco's transformational journey. These technologies are enablers for telcos to stay competitive in today's market by reducing the Time-to-Market (TTM), increasing revenue, reducing cost of service and improving asset efficiency. For Etisalat, our main drivers to embark on this journey are listed as follows in Figure 2.

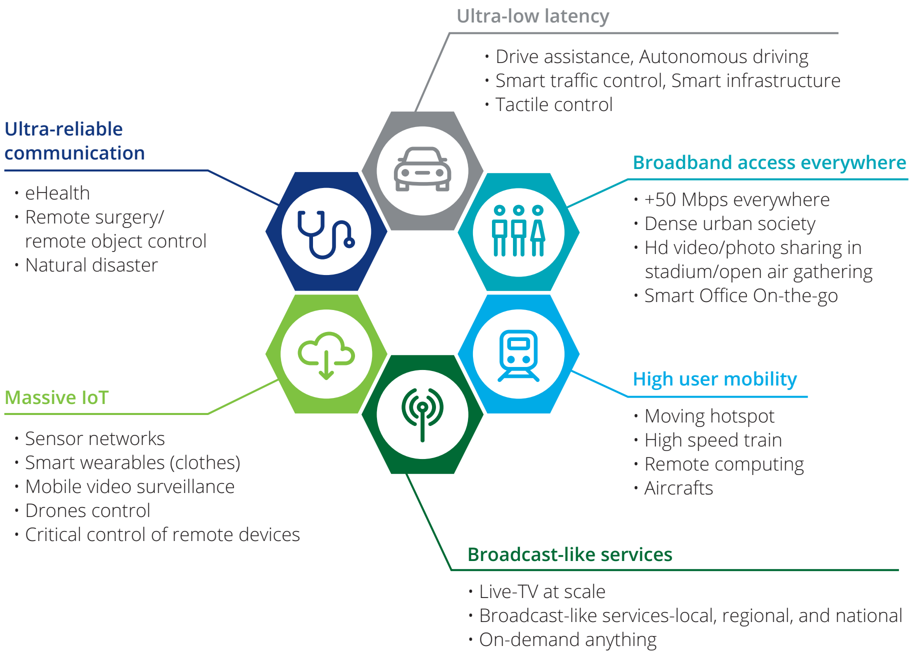
New services and user experience technological trends

Apart from the market drivers to embark on a transformational journey, telcos will need to unlock and explore new sources of revenue from digital services fulfilling the customers' digital experience expectations. Most of these value-added services require special capabilities that today's network infrastructure cannot provide. This is where telco's emerging technologies combined (SDN, NFV, cloud computing, 5G, MEC, IoT) will play an important role in enabling telcos and their customers to develop new products to be offered into the market as illustrated in Figure 3 (non-exhaustive).

Not only that, but we see that emerging telecom technologies will effectively unlock choices not available today to telcos when dealing with OTTs and other digitally-transformed organizations: to compete or to collaborate on a comparative footing.

The use cases illustrated in Figure 3 are potential business and new source of revenue for telcos. To exemplify, we can look at the drive assistance use case, which leverages technology to overcome human limitations. Let us assume that a person is driving at 100Km/h and suddenly a car crashes in front of their vehicle. The reaction to break happens in 1 second and, therefore, the car would move at least 27 meters more, enough to cause an accident.

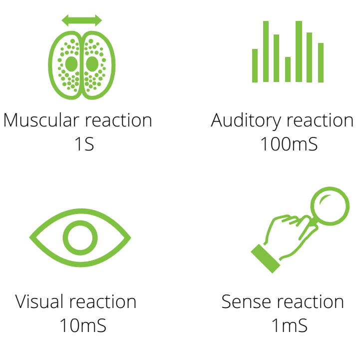
Figure 3: Use cases for value-added services with special network requirements



Source: Deloitte TMT predictions, 2017

A study conducted by Deloitte in the USA market predicts that safety will be one of the priorities of citizens in the future and that by 2020 a sixth of the cars will be equipped with automatic emergency breaks (AEB) that will contribute to a 16% reduction in motor vehicle deaths. The AEB is enabled by connected vehicles technologies (V2X – vehicle to everything) that requires either vehicle-based sensors or wifi /mobile (4.5/5G) communication [2]. The 5G mobile networks will overcome most of the sensors' limitations (for instance, range) [3] giving an opportunity for telcos to explore this market segment. Similarly to V2X, which requires a mobile network with ultra low latency, other use cases will also rely on special network parametrization. The IoT services, for instance, applied in smart cities, new video services (VR – virtual reality) and cloud B2B services (IaaS, SaaS) are some examples to be explored. Tapping into this blue ocean is neither economically feasible nor technically possible without telcos virtualising their infrastructure and digitally transforming in the process.

Figure 4: Order of magnitude of human reaction times



The digital transformation and its challenges to be addressed

In order to achieve the goals previously mentioned, telcos must launch a digital transformational programme which will impact multiple dimensions in their organizations. Based on TM Forum's digital framework [4], we believe that the gear to move the organization towards its digital vision is composed of five dimensions (represented in the core of the gear in Figure 5), encompassed by agile, recursive iterations that will keep the core in motion across the journey. The digital transformation will be challenging for telcos that will need to address multiple concerns related to their journey. We summarise all of them by grouping them into three main challenges as illustrated below. The "gear" is the mechanism to keep moving forward and also keep the five dimensions developing and synchronised throughout the journey.

At least three strong shifts will be faced in this important journey: 1) Internal cannibalization concerns, 2) Existing investments and skillsets, and 3) Traditional telecom vendors concerns. Although not directly tackled by this white paper, we believe the telco's over-arching transformational program must continuously alleviate them openly and reasonably as they embark on the Cloudification Journey.

It is important to highlight that the traditional, siloed operating model of telcos today has to gradually but surely die out, since it is probably the biggest soft bottleneck there is to this journey. Agility is not just speed—it is a philosophy with principles.

Even though all dimensions are important and provide a solid foundation for each other, for this specific paper Etisalat intends to deep dive into the infrastructure and systems dimension to explore what will be called the 'cloudification journey.

Figure 5: Digital transformation framework (Based on TMFORUM)

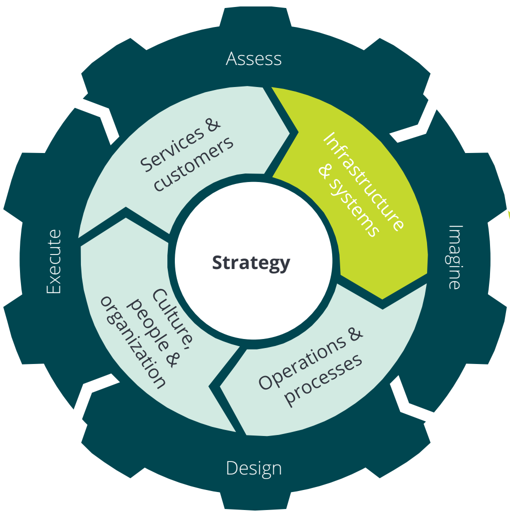
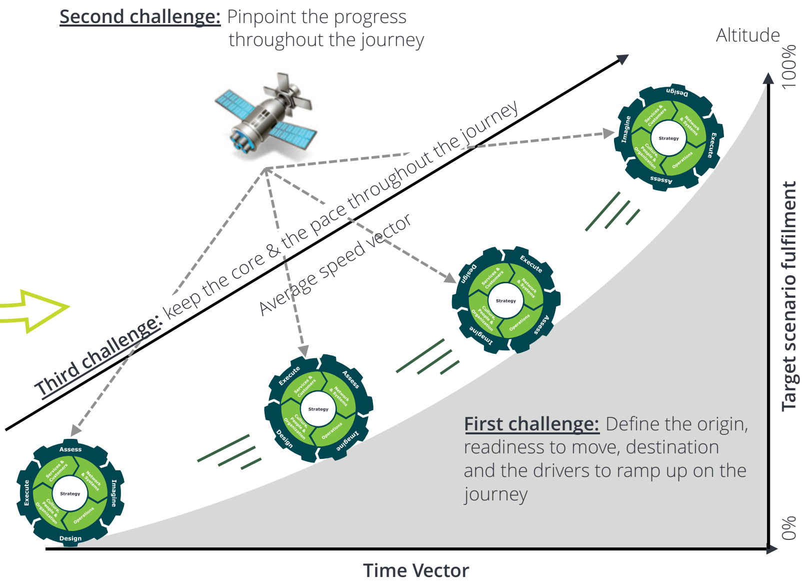


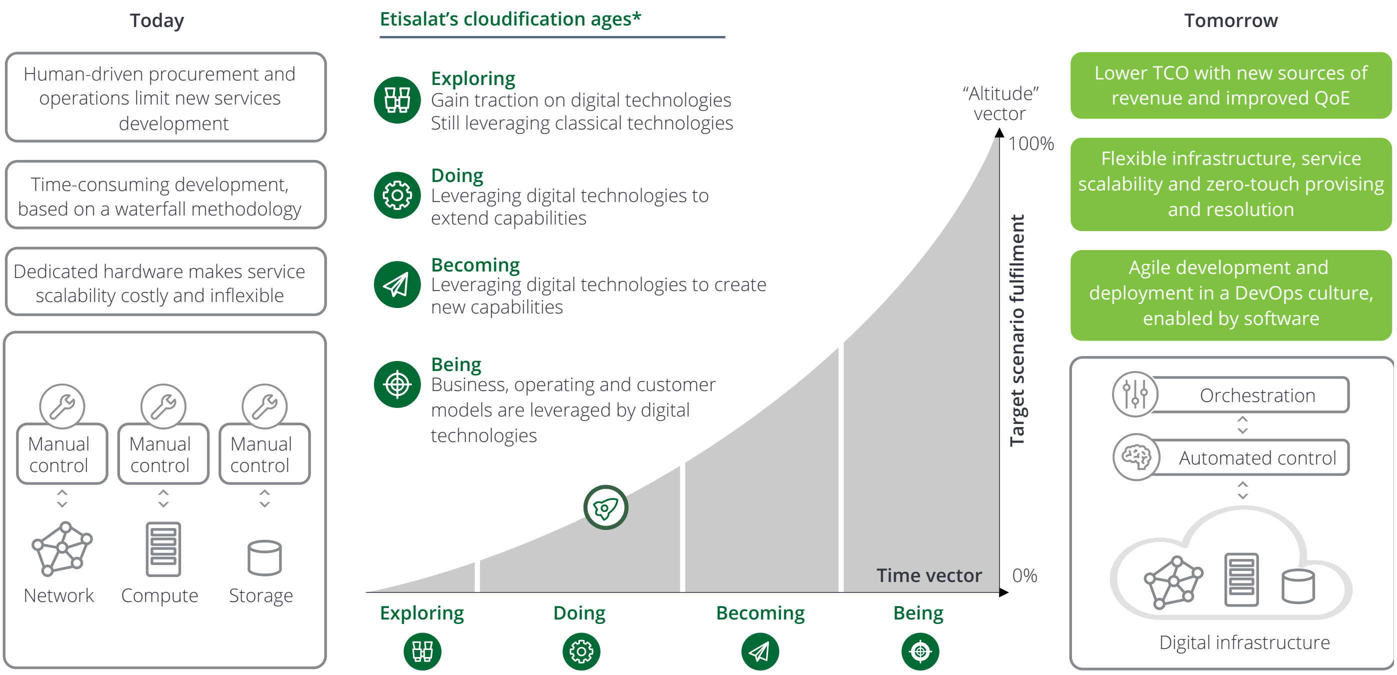
Figure 6: Illustration of the digital transformation journey and its challenges



The cloudification journey broken down into ages

Four main 'ages' are depicted to break down Etisalat's cloudification journey as a long-term transformational programme as described below.

Figure 7: The cloudification journey's ages



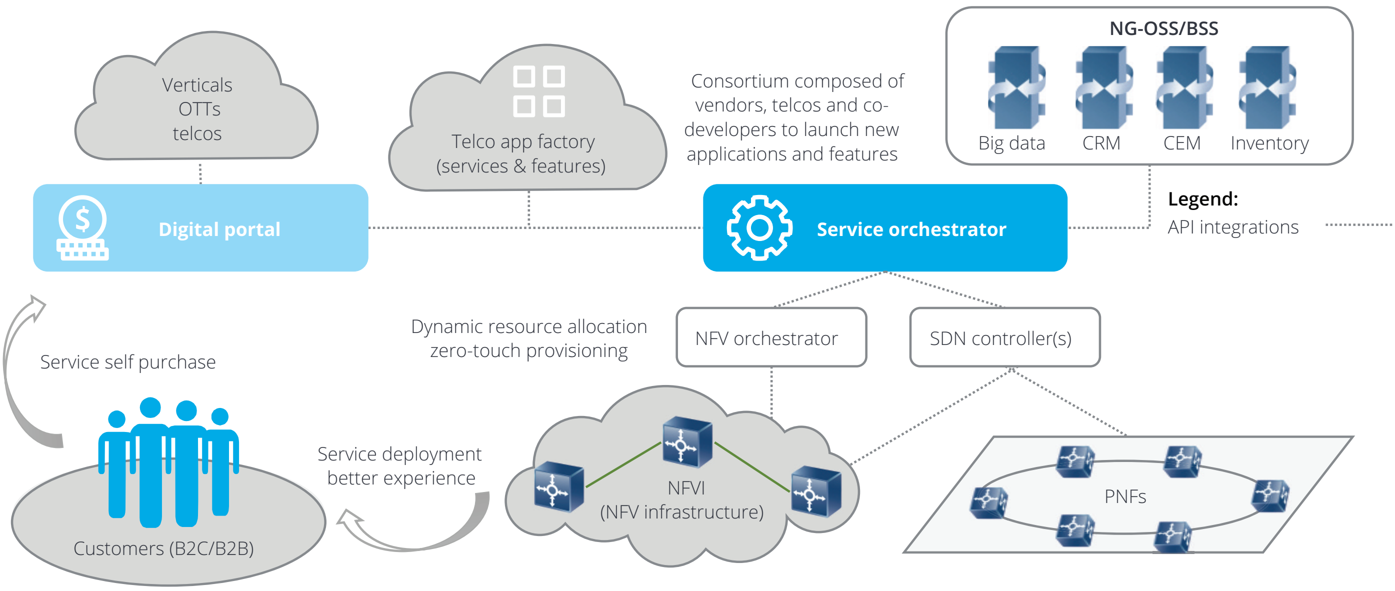
*Based on Deloitte's digital maturity assessment framework

A glimpse of the target scenario (Infrastructure & systems dimension)

Etisalat envisions the target scenario of the infrastructure to be simpler, more agile, more flexible and more software-based, with control centralised and intelligence pushed to the edge. Just as fibre-optics are indifferent to the kind of traffic or service running over it, Etisalat is evolving towards a network that is similarly transparent, enabling Etisalat to flexibly and freely launch any future service on this infrastructure. Service orchestration seems to be an extremely important component to achieve these goals. We believe that it is paramount that orchestration standardises faster and evolves more quickly to a reliably mature level in the coming years. One of Etisalat's initiatives is building a telco 'app marketplace', and wishes for similar marketplaces to rise in the industry, akin to the Apple Store or Google Play but for telecom services. This 'cloud factory' or 'telco app factory' can host new telco applications (software-based) that are easily upgradable and zero-touch provisioned in the new network by the service orchestrator to provide new services to consumers, businesses and the telco itself (e.g. for its OpCos). For Etisalat to enable this cloud factory, another important component is the NFV infrastructure. This layer must become a commodity (universal NFVI), shifting the responsibility of service resiliency from hardware to software (e.g. infrastructure as code), and from the network to the telco's applications. This, Etisalat learned, is also changing how networks will be designed and what redundancies will be implemented, and how upcoming telco services are built to be more empowered for more autonomous operation, rather than relying heavily on classical networking (e.g. auto capacity management and auto healing). Overall, the NFV infrastructure must be aligned and planned well (with the master plans) for increasing but harmonised distribution towards the edge (which may include other OpCos and geographies) to ultimately displace and replace legacy services. An exception to this smooth distribution towards the edge is the CPE, the virtualization of which can come very early in the journey, becoming a micro NFVI in the customer premises, and unlocking new opportunities for multi-service offerings with very low time-to-market (TTM).

The vision for our future architecture is a fluid micro-service-based infrastructure, leveraging modern APIs, and converging on a platform that will automate the end-to-end service lifecycle. The service orchestrator, big data and AI are at the heart of this future architecture.

Figure 8: High-level envisioned infrastructure and system scenario



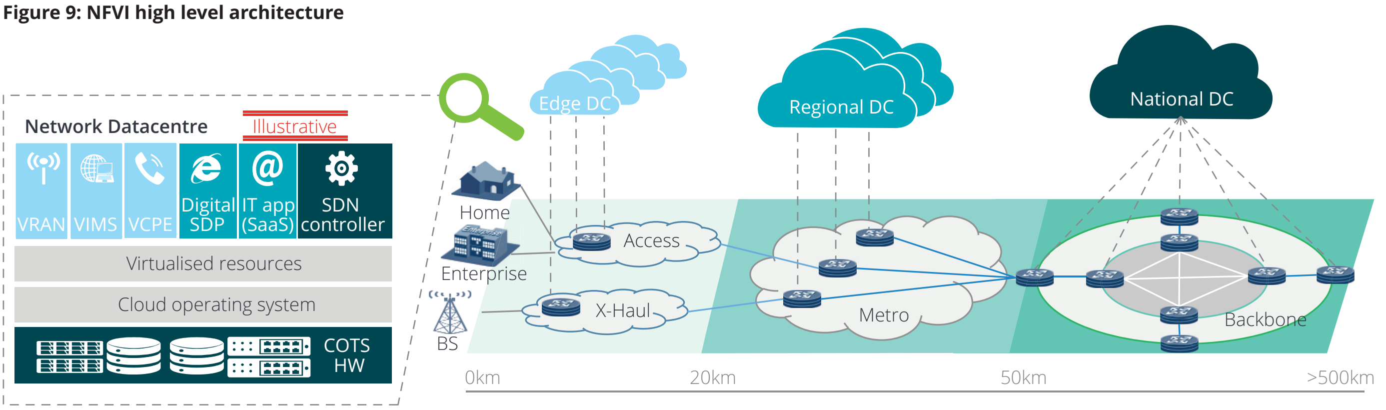
Exchanges and their re-architecture based on NFV/SDN

Telcos will have to develop a plan to implement a network datacentre layer that will be positioned in areas/regions closer to potential customers keen on consuming digital value-added services. The datacentres will be composed of COTS hardware managed and operated by a cloud operating system, and switches (or white boxes) controlled by an SDN controller. For instance, OpenStack, overseen by the OpenStack Foundation [5], provides a suite of open-source tools to build and manage cloud computing platforms. The virtualised functions and SDN controllers should be deployed as per the telco's roadmap, hosted at the network datacentre layer. Complemented by other technologies and reference solutions (like CORD and MEC), they will be the enablers to deploy the use cases that require lower latency and higher throughputs.

Additionally, IT workloads, content consumed by customers and immediate processing needs (e.g. edge analytics) can be served by the edge network datacentres, avoiding data unnecessarily clogging the core, especially in peak hours, and reducing latency and jitter.

It is important for telcos to decide which parts of their existing infrastructure (e.g. DWDM and GPON) can be leveraged. Moreover, in areas and markets of significant new growth, this network datacentre placement/connectivity and the master planning of sites/exchanges and cable routes must be aligned, identifying any changes required to comply with the future services requirements and building solid business cases for the new distributed digital infrastructure.

Figure 9: NFVI high level architecture

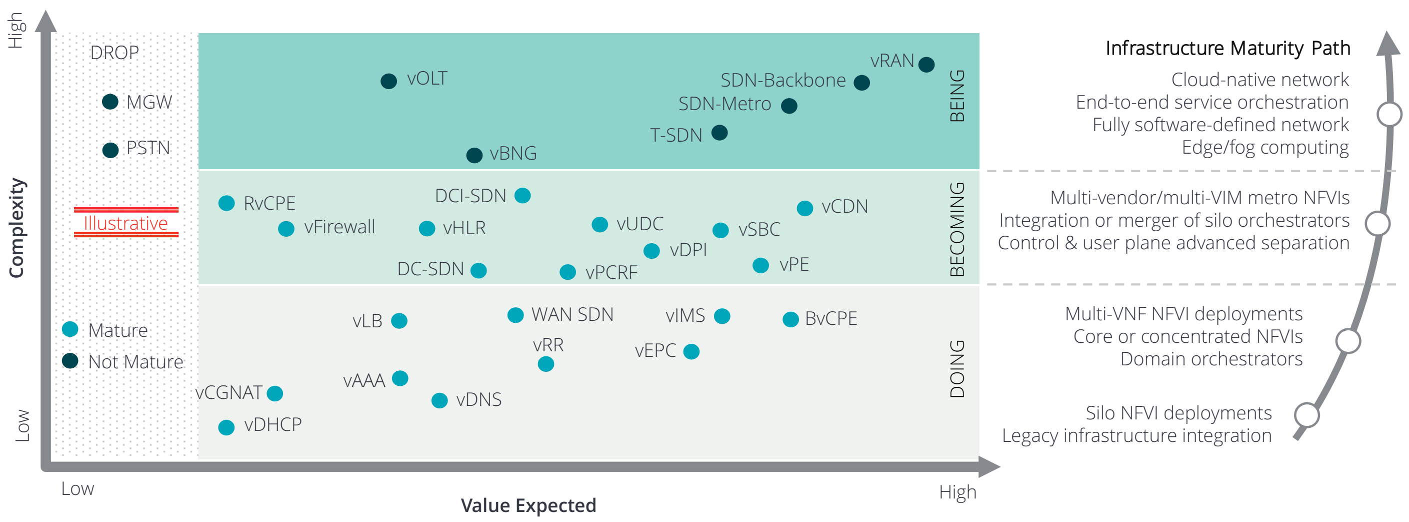


	Edge DC	Regional DC	National DC
Typical NW location	Access & backhaul	Backbone & metro	Backbone
Service latency	1ms < L< 10ms	10ms < L< 25ms	25ms < L < 40ms
Typical scenarios	Ultra low latency services	Real-time services & massive bandwidth	Non-real-time services & massive connections

Developing the transformational roadmap for the cloudification journey

To achieve the target scenario, a series of NFV and SDN use cases should be deployed according to a roadmap that needs to be defined by the telco. A methodology Etisalat used to develop the transformational roadmap consists of plotting in a chart the NFV & SDN functions or use cases to analyse their implementation and operation complexity and the anticipated value. The first axis, representing the complexity to implement and operate, will be composed of multiple factors weighted and scored. For example, integration levels required, changes on network infrastructure and systems, application readiness level, cloud resources required, impact on current services/customers and migration impact (offloading legacy services). The second axis, which represents the value expected, will also be composed of multiple weighted factors, such as enabling new services, enabling third-party integrations, increasing efficiency and automation, enhancing user experience and TCO reduction. Telcos who want to embark on this journey can develop a similar approach adapted according to their strategy and operating model. It is important to highlight that the roadmap might be regularly re-assessed and updated since technology is in constant evolution. It is certainly recommended to start deploying uses cases with lower complexity and higher value, but each telco is responsible for deciding its own roadmap, For instance, to skip virtualising an obsolete function or service, or launching a certain NFV/SDN use case as a vertical silo, such as SD-WAN. To illustrate the methodology that Etisalat used, the model was populated and linked back to three ages defined in our Cloudification journey.

Graphic 1: NFV/SDN functions maturity assessment



Description of the transformational roadmap according to the journey ages

After assessing all possible functions or use cases based on NFV and SDN technologies according to their analysed value and complexity, combined with the infrastructure maturity path, telcos will be able to define a feasible plan towards the target scenario. The cloudification journey is broken down into ages representing "waves of deployments", from low to high complexity, that will ultimately compose the roadmap towards being a cloud-native telco. Depending on the virtual solutions' maturity and the telco's virtualization maturity, ages can be skipped to speed up the journey. The ages are briefly described as follows:

1. The exploring age

The first age is composed of NFV and SDN components that can be set up and tested in non-production environments and can be used to gain traction with the technologies. Telcos could start this phase by assembling a team with an experimental mind-set and a lab environment in which they can create prototypical permutations before solution pilots and live trials. The lab infrastructure and stacks are recommended to be multi-vendor in different combinations to learn about integration and interoperability in NFV and SDN (perhaps as a precursor to the Telco's certification lab). Open source software (e.g. OPNFV and ODL/ONOS) and white boxes often satisfy this stage.

2. The doing age

The second age is composed of a group of NFV and SDN functions and use cases with strong business cases and/or proven commercial success worldwide. The recommended group for first deployments (usually SD-WAN, BvCPE, vEPC and vIMS) should have high value and low complexity that can be translated into quick wins and enhanced business cases to 'fund' the journey. For this phase, the implementation can be done for specific domains of the network most ripe for virtualization, with their own orchestrator (MANO) and infrastructure (NFVI). This age creates vertical deployments or silos for faster time-to-market, igniting the transformation early, ramping up experience in the new technologies and encouraging major vendors. With a stronger business case and sustained by the first wave of deployments, other low complexity and high value functions can be pursued, especially control functions (carrying non-live traffic) or those due for upgrade, expansion or write-off.

3. The becoming age

The third age focuses on the NFVI and aligning it with the telco's sites/exchanges master planning mentioned before. Telcos should deploy datacentres (nationally, regionally and in the metro/edge) according to their roadmap. By extending the digital infrastructure closer to where the customer is, new services that require very low latencies (in both networking, like in 5G, and processing, like in edge AI use cases) can be offered to the market. To interconnect all these datacentres and fully abstract the infrastructure layer as one telco cloud, telcos will need to deploy DCI-SDN and DCN-SDN technologies. Going further, telcos could harmonise existing silos by building an intermediary step—implementing an orchestrator of orchestrators for cross-domain services. Including the physical domain is strongly recommended, since purely virtual services (like mobile VPN) are rare and almost all virtual services will be hybrid. Also in this age, more use cases are added based on the telco's roadmap and this new infrastructure (e.g. vCDN, vSBC, vSMSC, vDPI, vUDC, vPCRF, vHLR, vFirewall, etc.).

4. The being age

The fourth age is when the end-to-end service orchestrator becomes mainstream, absorbs all existing silos and fully integrates with other systems. The network and functions become cloud-native, with the spread of containers, and perhaps even serverless computing. The next-generation OSS/BSS (NG-OSS/BSS) and a digital marketplace will be fully integrated with the service orchestrator based on APIs. Surrounding them, big data platforms, advanced analytics systems and AI will correlate and learn from multiple sources of data (internal and external, such as social media) yielding vital information to continuously improve the customer experience, eventually in an autonomous way. Based on the new NFVI (or telco cloud), and combined with edge/fog computing, digital services can be expanded to reach a wider geographic area and a higher number of customers to enjoy them. Scaling up the cloudification journey, telcos will by now be technologically, operationally and culturally mature enough to confidently deploy and operate any NFV/SDN use case, including high-complexity ones.

The exploring age
Proof of concepts using industry standards

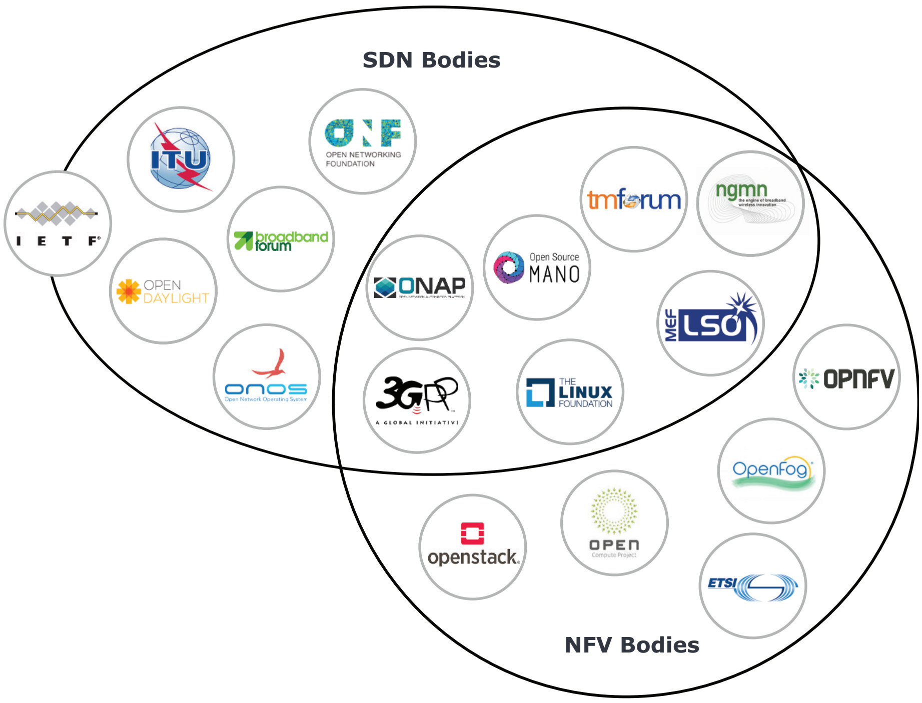
By design, the adoption of disruptive technologies deeply impacts telcos' infrastructures and systems, which may extend to their products and services. Hence, it is recommended to conduct Proof of Concepts (PoCs) in order to explore the technologies, test their technical feasibility and forecast their impact. To perform the PoCs, it is necessary to set up a lab environment with conditions identical to the telco's production network (i.e. with access to staging test beds and existing network labs). The PoCs are highly recommended to adopt standard NFV and SDN architectures and protocols (or at least popular ones by adoption and size of open source community), ensuring access to the widest variety of functions and use cases, as well as interoperability.

Standardization (via standards bodies, open source foundations/communities or even consortiums) is critical to the success of virtualization. If not joining, telcos should at least track the progress and updates of these organizations as input to their virtualization strategy and roadmaps, as well as to influence and partner with vendors to embrace these standards, open source software and open APIs.

Being software-based technologies, NFV and SDN standards are in constant evolution and telcos should always be updated about new releases that may affect their journey. For instance, in October 2010, ETSI released a document [6] presenting a set of PoCs and use cases related to a NFV and SDN combined architecture, before this specification both concepts could not be integrated. ETSI and IETF among other entities are trying to push these topics forward. One of the organizations is TM Forum, which launched a project called ZOOM [7] that intends to define the best practices to support both the technological and business aspects of the transformation. Recently, TM Forum established a partnership with MEF to collaborate on the standardization of lifecycle service orchestrator (LSO), a network architecture defined by MEF [8] in 2016 in which all the network is managed by an end-to-end orchestrator, similar to Etisalat's approach. Like any new and disruptive technology, individual non-mature or non-successful NFV/SDN endeavours may bring about skepticism but should not dictate the fate of the telco's transformation. Their evolution relies on a combined effort from standardization bodies, other telcos, vendors (telecom, IT and consultancies), and open source communities. Collaboration is key, and happens to be a core value of Etisalat.

Even though most vendors base their solutions on open-source software, they generally modify them extensively, some to the point where these platforms resemble proprietary solutions more than open source. Therefore, when selecting the partner(s), it is important to guarantee they are adherent to standards, software architecture principles and the respective telco's strategy in order to achieve the goals envisioned at the end of the journey.

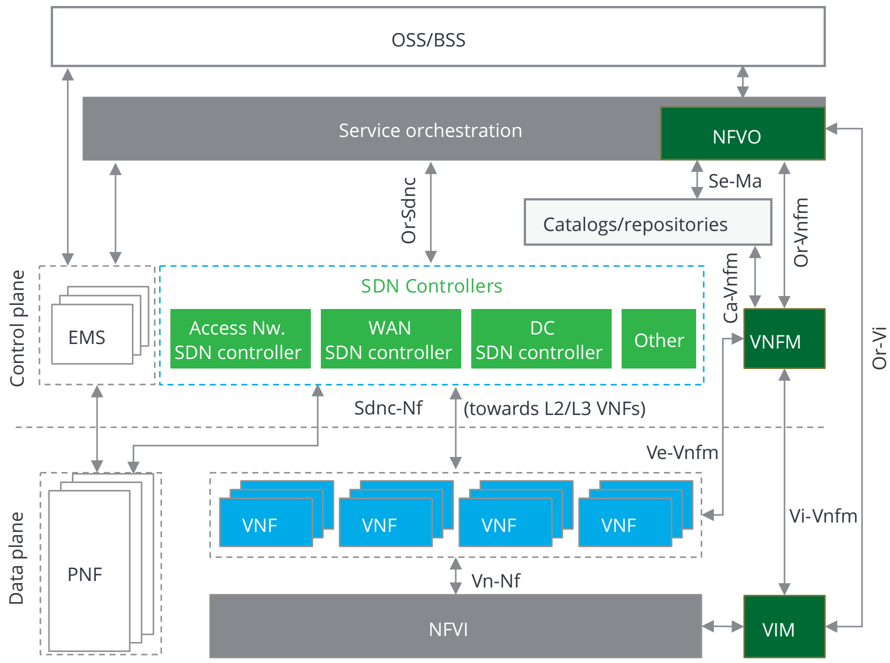
Figure 10: Worldwide standardization bodies and foundations landscape



Building a lab enviroment

Develop your cloudification roadmap, set up a multi-vendor lab environment, assess multi-vendor interoperability and building in-house experience and expertise

Figure 11: Lab environment with SDN and NFV combines architecture



White boxes and COTS hardware

Finding a cloud-native version of a physical telecom appliance or a network function is just one of the challenges of having a completely virtualised network. The other challenge is to ensure that the underlying infrastructure is composed of white boxes, which are, essentially, commercial off-the-shelf servers and commodity bare-metal equipment [9]. One of the biggest promises of NFV and SDN was precisely the use of commodity hardware (e.g. servers, switches, CPEs, transceivers) in the infrastructure, being relatively agnostic to the software running on them (e.g. multi-vendor hardware and software combinations), which will reduce costs and increase flexibility as it did for IT and major web companies. The white boxes are an important technological trend in networking, and one of the first vendors to enable this trend was Intel. The American company developed the Data Plane Development Kit (DPDK), a set of software libraries and drivers for fast packet processing that can run on any processor (e.g. Intel x86, ARM), giving commodity hardware the capacity to handle the majority of the packet loads of current networks [10].

Although there are no 'standards' defined for the design of these types of equipment, many vendors use the designs of the Open Compute Project (OCP), a project initiated by Facebook with the purpose of 'economising the datacentre'. For this initiative, Facebook already developed several systems and equipment such as FBOSS, Wedge and, more recently, Voyager, an optical switch released in November 2016. The four datacentres of Facebook that are 100% powered by OCP hardware and systems were 38% more energy efficient to build and 24% less expensive to run when compared with the social network giant's previous facilities [11]. Even though Facebook's achievements concerning the development of commodity hardware were impactful, some specialists state that the use of white box equipment did not really disrupt data centres. Instead, it mainly disrupted the server makers, lowering the prices of server components. Either way, telcos also reap the benefits [12]. Another project, also with Facebook's stamp on it, and perhaps more interesting, takes aim at telecom vendors and telcos. With the purpose of 'economising the telecom infrastructure' and modernising how it is built, the Telecom Infra Project (TIP) is worth following.

Nevertheless, the white boxes trend will deeply change the paradigms of hardware and software providers (vendors) that will need to shift from being network-oriented (or product-oriented) organizations to service-oriented organizations. Vendors have been incorporating professional services into their products, a transition that could be explained by an EBIT margin 3 to 7 times higher and a continuous revenue stream [13]. However, the digitalization (or the transition to being service-oriented) of vendors enters a new level with NFV/SDN technologies, since network equipment will no longer demand specialised or bespoke cutting-edge technologies, with the control and management separated and centralised in software-based controllers, and functions virtualised in software. The infrastructure layer will be based on commodity hardware, abstracted as the telco cloud, and the real service and value will sit with cloud-native applications and services that vendors and partners will co-develop together with telcos to generate new revenues, and yield operational and cost efficiencies. A gradual shift will be noticed in focus and spending away from telco's expensive hardware towards innovations in software.

It is important to highlight that the paradigm of a virtualised network as envisioned by ETSI can only be completely accomplished if telcos develop and/or procure cloud-native VNFs, and run them on a multi-tenant telco cloud, in turn running on top of COTS hardware. Traditional telecom vendors are increasingly adapting and adopting this trend more quickly, or they would risk shrinking their market shares and being confined to legacy pockets of the telecom infrastructure. Corroborating that, we observe that smaller 'software-first' telecom vendors, untied to network legacies and unburdened by entrenched value networks, have started encountering increasingly lower barriers of entry in the typically challenging telecom market.

The doing age
First set of deployments with proven business cases

The second age of the cloudification journey starts by deploying NFV and SDN use cases that stand out based on their value or proven success, thanks to the fact of being relatively well explored by the industry (like SD-WAN, vCPE, vEPC and vIMS). Implemented by Etisalat, the use cases have solid business cases and are offered by various vendors, big and small, old and new, in the market. Therefore, we will attempt to analyse them in more detail, not only highlighting a couple of their business case figures but also depicting how they could be deployed in this age.

Software-Defined WAN (SD-WAN): Software-defined WAN aims to simplify the management of multiple WAN links. It is used to create a software-defined overlay network independent from the carrier or physical infrastructure, reducing the time-to-market involved, easing the complexity of configuring and managing the customer's WAN and reducing the operational costs of all parties. For these reasons, many companies with branch offices across the globe have become quickly aware of this technology and are showing demand in adopting it, sometimes even without waiting for their local telcos to offer it, by either building it themselves with SD-WAN vendors or availing of the service from global telcos. Essentially, any Telco (or even vendor) may offer SD-WAN as a service anywhere on top of even a competing Telco's network, with new opportunities to provide cloud-based value-added and OTT services in a self-service fashion, such as application performance accelerators, voice services and virtual security functions, and unlocking an easier and faster stream of revenue.

In a network architecture that implements SD-WAN, there are three elements that must be present so the Telco can have a solid SD-WAN solution: the thin SDN-enabled CPE, the SD-WAN controller and the SD-WAN user interface (UI). The SDN CPE provides the capability of using WAN connections with application-based routing (among others). The SD-WAN controller is a centralised software platform that sets policies and management for all the SDN CPEs. Finally, signifying the self-care aspect of the service, the SD-WAN UI provides service management and visibility to the customer [24], often developed in an agile and DevOps fashion like in smartphone app development companies. The more conservative SD-WAN market prediction is from Gartner, which forecasts a growth from USD 129 million in 2016 to USD 1.24 billion in 2020 [25]. Trying to take their share, telcos have been working together with vendors to streamline WAN management. In fact, there are already many network operators providing SD-WAN as a managed service and the use cases already deployed have been successful, which makes SD-WAN an attractive service to sell to companies that want improved transport options, better network security, intelligent pathway control and automatic provisioning [26].

For enterprises, there are also significant resiliency benefits, such as substantial reductions in WAN trouble tickets and outages, as was shown in a Nemertes Research's study [27]. The enterprises that participated in that study declared that their sites still had link problems but that their users were not aware of these problems because the service was not disrupted.

Virtual customer premises equipment (vCPE): According to an SDxCentral report [14], SD-WAN and vCPE are the leading use cases in the NFV and SDN market. It is no surprise that, generally speaking, operators decided to start their journey by virtualising the CPE, as it is less risky to start at the edge of the network to mitigate the impact of outages on customers. By starting with the vCPE, it is possible to deploy the technology just for specific clients, allowing the operator to test it in a real environment scenario without compromising all the network.

In the traditional CPE, hardware appliances are required at the customer premises in order to provide a network boundary between the operator and the customer. The goal of vCPE is to reduce the amount and complexity of equipment needed by deploying a smaller number of platforms, either locally at the customer's premise or in a centralised datacentre so the operator (or customer) can remotely instantiate and manage a variety of functions. An important part of this solution is the vCPE (sometimes called the thick vCPE or the universal CPE), an often white box CPE acting as a micro-NFVI at the customer premises.

The business case for vCPE is quite appealing as shown in a study performed by Analysis Mason, in which it is stated that a Tier 1 operator in a developed market can generate USD 1.1bn net present value (NPV) over a five-year period if it is one of the first movers in enterprise vCPE (referred to sometimes as BvCPE). Moreover, the study indicated up to 47% BvCPE-related cost savings per site per year after the migration of all sites [15]. The same Analysis Mason study also states that residential vCPE migration in a developed market can lead to 82% of vCPE-related cost savings per year per household after the migration of all households to vCPE (usually referred to as RvCPE). It is important to mention that this value was obtained when considering a Tier 1 player with 17 million customer households over a five-year period. With such appealing business cases, it is normal that relevant operators around the world have been deploying vCPE, both enterprise and residential. Some examples of operators that already implemented vCPE are AT&T, NTT, Telefonica and Verizon [16] [17] [18] [19].

Virtual Evolved Packet Core (vEPC):
The EPC is the foundation of a mobile telecommunications operator's core network through which mobile services are created and delivered to customers [21]. Recently, with the exponential growth in mobile connections associated with new types of services (e.g. high-definition mobile video streaming) and new ways to deliver those services, telcos have been challenged to rethink their networks and to find new approaches to support such services and meet more demanding requirements that traditional EPC cannot fulfil. One of the solutions that came up was the virtualization of EPC. Many relevant operators around the world are virtualising their EPC, being motivated by business cases and studies such as the one performed by IDC in which it was stated that virtualising the entire set of EPC functions could enable the mobile network infrastructure to operate at a utilization rate of up to 87%, resulting in OpEx savings of up to 25% [22]. Furthermore, in the same study, IDC concluded that telcos can experience a 67% reduction in the TTM to launch new mobile services. Even though vEPC solutions are already mature, as has been proven by the announcements of major telcos like Etisalat that started to commercially virtualise their EPC [23], there are still some key challenges that must be overcome in order for telcos to have a successful virtual EPC deployment. First of all, they need to push their vEPC vendors (more than the NFVI) to exceed or, at least, maintain the demanding service availability and real-time performance requirements of current networks, guaranteeing that the migration process is transparent for end-users, and not impacting the 99.999% service availability requirements. As mentioned earlier, service availability in the virtual network shifts from being mainly hardware-centric to mainly software-centric resiliency.

Virtual IP Multimedia Subsystem (vIMS):
Like the EPC, the IMS has also been facing stringent requirements due to the growth of mobile Internet connections and the offerings of new services such as VoLTE and VoWiFi (Wi-Fi calling). Due to the need for programmable and scalable core networks, capable of answering the needs of different customer types and scenarios, telcos are turning their attention to virtual IMS solutions. One of the attractions of a truly virtualised IMS is the capability to support a multi-tenant model. Examples include enabling multinational telcos to host their operating companies (OpCos) on a centrally managed infrastructure or even the ability for a Telco to offer wholesale IMS services to other telcos. In addition to the capabilities aforementioned, there are also the benefits inherent to NFV solutions, such as CapEx and OpEx savings. Concerning this topic, Analysis Mason published an article presenting that vIMS for VoLTE services can lead to 45% CapEx savings and 10% OpEx savings when compared with a physical on premise IMS for VoLTE [20].

Other possible deployments:
By deploying vDNS, queries for the nameservers are sent to a datacentre, where they are checked in order to prove their legitimacy and to block malicious traffic. As it sits in front of the corporation's nameservers, vDNS shields the organizations by masking the origin IP address from the attackers and reroutes the traffic through the network. Specifically, DDoS attacks are prevented by masking the origin IP address with vDNS. Such attacks are a major concern, according to a Deloitte internal study which predicted a three-fold increase in attack size from 2015 to 2017 because of trends such as IoT and higher bandwidth speeds. Other benefits can also be generated such as increased availability and easier scalability.

The vFW is a VNF that enables telcos to offer Firewall as a service to customers. In addition, scalability is not a problem since it is not necessary to install new instances of firewall within the network. There are two ways a vFW can operate in the network: hypervisor and bridge mode. In the bridge mode, the vFW is normally deployed in a switch intercepting incoming traffic from other network segments. By operating in a hypervisor mode, it is deployed between the VMs and the vSwitch. This way, it protects the VMs not only from the incoming Internet traffic but also from other VMs traffic, working as a east-west protection.

Deploying a vDHCP as a VNF improves security, as it removes the possibility of a single point of failure since there is no longer a dedicated server for DHCP. Also, with vDHCP it is easier to scale the network and automatize routines. By virtualising CGNAT, performance is improved and telcos can quick expand their IPv4 networks. Since IPv6 adoption is slower than expected, and as more devices are daily inserted into the network, this VNFs is of great importance to the telco.

Overall, the benefits of these functions previous described can be translated in cost avoidance. As demand increases and the servers have a higher utilization rate, there is a better use of infrastructure resources because the need to acquire new servers can be delayed. When an instance of a VNF is about to reach its usage threshold, the server deploys another VM in opposition to the telco being required to buy another hardware to support the function.

Silo architecture for multiple domains

A very important step in the Doing Age is the implementation of a complete MANO (management & orchestration) stack, a platform to orchestrate both physical and software resources in a virtualised network. Together with the NFVI (and sometimes with their DC-SDN), they are popularly and collectively called the telco cloud. Defined by ETSI, the MANO is composed of three components: 1) the NFV orchestrator (NFVO), responsible for the on-boarding of new network services and VNF packages, for the lifecycle management of network services, for the global resource management and for the validation and authorization of NFVI resource requests; 2) the VNF Manager (VNFM), which has the role of guiding the lifecycle management of VNF instances and for the report of events between the NFVI and the EMSs; and 3) the virtualised infrastructure manager (VIM), responsible for the control and management of the virtualised physical resources (NFVI). A very important aspect of MANO integration is related to APIs. In order to work properly and effectively, the MANO must be integrated with open APIs in the existing systems. This fact not only affects vendors that intend to provide any part (or all parts) of a MANO solution, but also impacts OSS/BSS vendors who have been evolving their solutions to be more 'NFV friendly' in response to this, and opening up their platforms to be more modular, cloud-native and RestFul API driven.

It is critical to mention that apart from the production telco cloud (MANO and NFVI) environment, the telco should never miss to build at least one of the following MANO/NFVI environments: 1) a testing/prototyping environment, perhaps evolved from the lab built in the Exploring Age, and/or 2) a near-production staging environment, to ensure and automate the reliable and predictable deployment of VNFs and their updates.

Also, in this age, each domain (e.g. the vCPE solution and, optionally, its underlying classical network) will tend to have its own management and orchestration (MANO) platform and NFVI, and each one will communicate with the OSS/BSS systems individually, like new networks. The main goal of this 'initially-silo-but-controlled-architecture' is a faster time-to-market for lucrative NFV/SDN use cases, and ramping up experience and drive to transform the telco's OSS/BSS to the next-generation OSS/BSS. However, to limit and control the number of these MANO/NFVI combinations, the telco should start adding more VNFs per MANO platform in this age, which will also kick-start the multi-VNF cloud paradigm (trialing the DevOps approach), foster interoperability and add a level of healthy competition.

Figure 12: Silo architecture with integration between the MANO and the classical infrastructure per domain

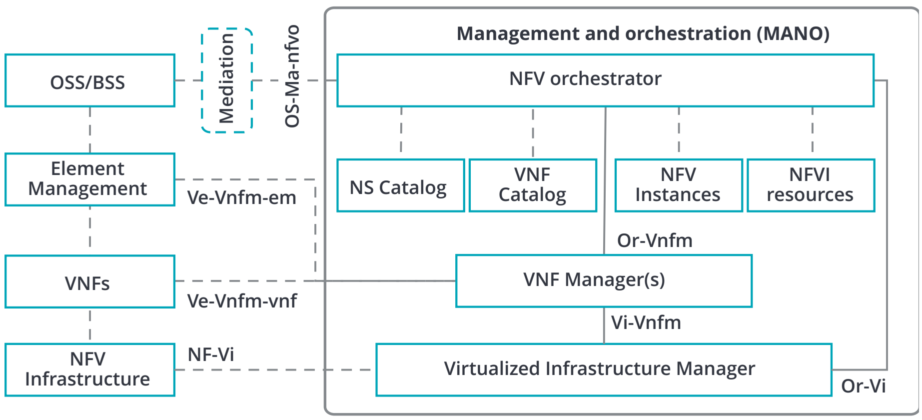
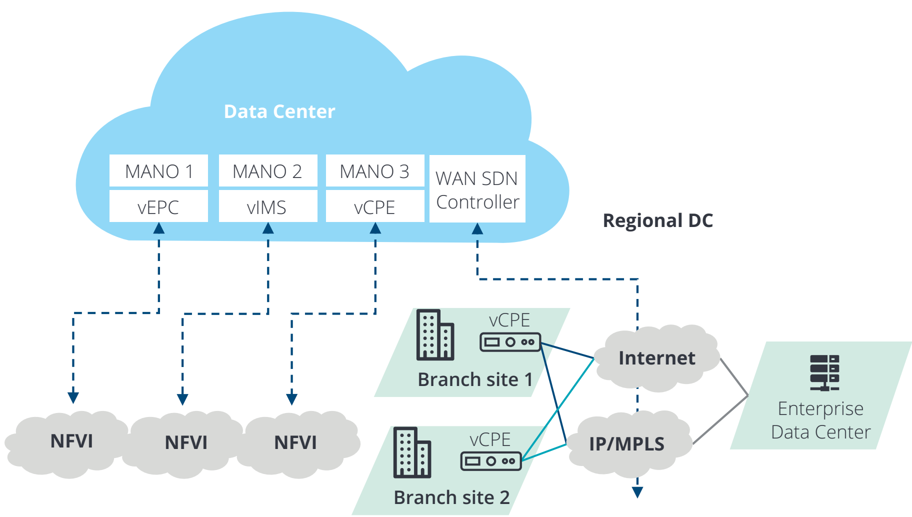


Figure 13: Siloed development of SDN and NFV use cases using existing infrastructure (DC)



The becoming age
Transforming telcos using cloud computing

The aim and spirit of the Becoming Age is two-fold: 1) Unleashing all the accumulated experiences, lessons learned and internal/external buy-ins; and 2) Moving from 'using digital technologies for extending existing capabilities' to 'using them to create new capabilities'.

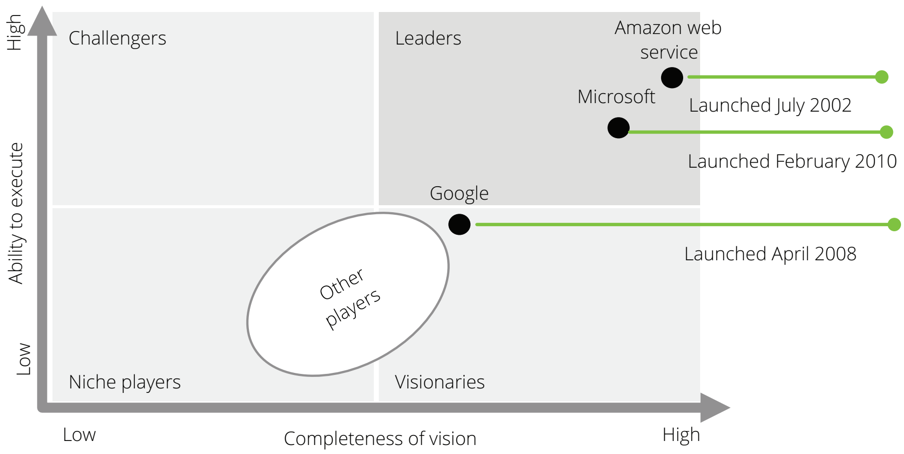
Cloud computing is not a new concept but is gaining footholds in telcos, sped up by NFV and SDN technologies, and playing an essential role in the cloudification journey. By having a cloud infrastructure (NFVI) closer to customers, telcos will be able to deploy new sets of NFV and SDN scenarios that enable new innovative services with special requirements (e.g. low latency and high throughput) that were complex or unfeasible before. However, in this age, Etisalat is learning that what can be more important than location are two intertwined cloud computing tenets: elasticity and resource pooling. A cloud is a waste if its resources cannot be virtually pooled, and it is not a cloud if it cannot be elastic within that pool. That is why homogeneity becomes key in the Becoming Age. In other words, the telco cloud graduates to becoming multi-tenant and agnostic to the VNFs. We had recommended earlier in the Doing Age to begin shifting the telco cloud to being multi-VNF (even if as a silo/vertical), in preparation for this. Now, the silos should start integrating or defragmenting, preferably in a multi-vendor supply arrangement. Strategically, it can also be multi-VIM (i.e. multi-cloud managers). With harmonising the NFVI, kick-starting the integration or merger of the silo orchestrators, as well, is now due.

Telcos already host their IT applications, enterprise applications and support systems that are positioned in central facilities capable of providing infrastructure with optimal cost, performance and uptime as per Tier (I-IV) specifications. The network or telco datacentres, on the other hand, are distributed to host network or telecom VNFs and SDN controllers that provide services closer to the customers. Hence, they should spring up in areas with potential business and subscriber growth. So, unlike IT datacentres and IT clouds, a different strategy should be followed when building telco datacentres and telco clouds.

In any case, the lessons learned by now become confidently more specific. For example, in most of Etisalat's NFVI deployments, rack-mounted servers were found to be more flexible than blade servers—despite the opposite being true for IT clouds. Another lesson was that deploying the VIM (e.g. OpenStack) in a disaggregated, centralised architecture is more suitable to distributed NFV than the hyper-converged, distributed architecture.

Moreover, by embarking on the cloudification journey, telcos can leverage lessons learned from other industries that have been generating value from digital technologies. When it comes to cloud computing, Amazon Web Services (Graph 2) is by far the market leader, perhaps as big as the next 10+ cloud providers combined. Most analyses to understand the root cause of Amazon's predominance strongly indicate that it is simply because they were early adopters. That is, their accumulated experiences, lessons learned and internal/external buy-ins, which Amazon had started accumulating earlier than anybody, gave them the significant edge. We therefore expect the telco cloud, being a new and niche cloud, to similarly reward the early adopters (i.e. telcos and vendors).

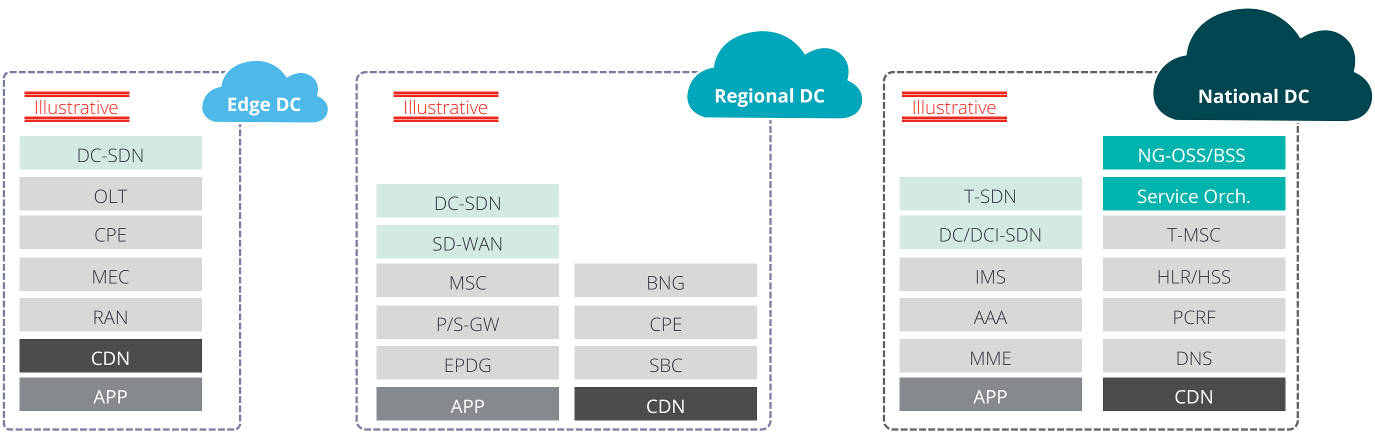
Graph 2: Gartner's IaaS magic quadrant representation released in June 2017



Spreading the telco cloud towards the customer

The distributed infrastructure will enable telcos to separate the control plane from the user plane in order to provide better customer experience and unlock new service possibilities as emphasised earlier. In this age, in addition to the national datacentre (that should have been built in the Doing Age), telcos should start deploying regional datacentres as per the master planning strategy, driven by solid business cases. Based on this distributed NFVI, telcos can continue deploying NFV and SDN use cases as per their up-to-date roadmap initiated in the Exploring Age (vCDN, vSBC, vDPI, vUDC, vPCRF, DC-SDN, DCI-SDN, vHLR, vFirewall). It now becomes important to address the rules to select which hierarchy is better for each deployment. Some functions and use cases prefer to stay centralised, some others require further distribution, while others fit into a multi-tier deployment of national, regional and edge DCs. The choice of a two-tiered, three-tiered or x-tiered distribution of DCs depends on the telco's strategy and its physical presence, but it has to be decided in the master planning, and communicated to the entire telco's engineering and architecture cadre. The figure below illustrates an end-game example within a national geography (global or international DCs may be considered, or collapsed onto the national DCs). For instance, the national datacentres might host telecom signalling functions, service orchestration and non-latency-sensitive functions, applications and systems that are storage and/or processing hungry, benefitting from highly centralised pooling, like historical analytics/machine learning, master controllers and digital service platforms. The national DCs need to be able to stand by for one another. Note that even if one national DC is planned, a DR site and plan must be included. Depending on the measured latencies, the regional DC would cater to functions and applications that carry the data plane (customer-transmitted data) that requires lower latency (e.g. less than 25ms), plus high-throughput functions (e.g. vPGW, vCDN, BNG). With the edge DCs, it is necessary to highlight that latency is not only related to the network but also associated with the data processing. Functions requiring extremely low network latency (10ms or faster) and/or extremely low processing latency (for real-time actions) will need to be at the edge, avoiding the processing latency incurred when transmitting all data unnecessarily to central DCs and burdening them with hard-to-prioritise processing. Cloud RAN, 5G, IoT, augmented reality, V2X, healthcare, and safety-related applications would be in dire need of the edge DCs. An additional side benefit of edge DCs is the further distribution of functions, enabling a more granular, on-demand and forecastable capacity planning per edge DC, reducing software overprovisioning buffers (e.g. licences) and increasing the telco's agility (e.g. granular expansion or shrinking, with zero human touch being possible).

Figure 14: The NFV and SDN functions and use cases hosted by distributed, hierarchical datacenters



The becoming age

Abstracting the NFVI into a single cloud infrastructure

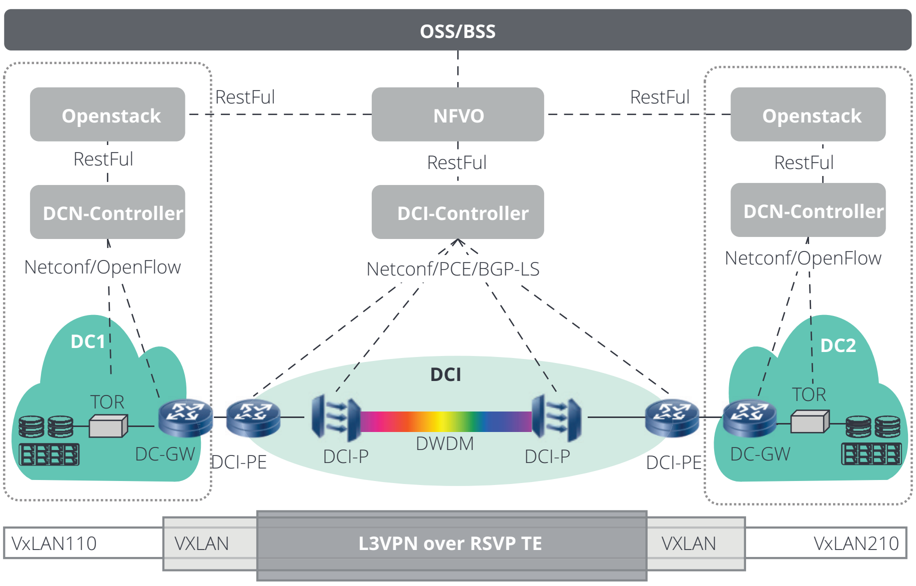
With the spreading of the cloudification of the network, new concerns arise. A series of distributed datacentres are now hosting pieces of the "network intelligence" and therefore need to be synchronised by an entity that ultimately will abstract the whole underlay (e.g. optical transport) as a single virtual network. The datacentres need to be efficiently interconnected so that balancing of service workloads between facilities can be completely managed, optimised and eventually automated.

The challenge is to make several datacentres spread across multiple geographies to look like a single resource pool, available for all network functions and services. The DCI-SDN is a use case capable of solving this issue in a scalable, agile and flexible way. To interconnect the datacentres, a WAN composed of white boxes is of course required. One technology available today to manage the traffic among datacentres is based on virtual extensible LAN (VXLAN), which is an overlay data plane standard for datacentre networking. It can be viewed as a tunnel between two end points, which provides the capacity for multi-tenant VPNs, improved resources allocation and protection from topology or technology changes [28]. Google's use case of cloud DCI is probably the most known and successful, with Google generating more than 25% of all Internet traffic and the majority being handled by this new architecture. It also helped them push some network links to sustainably run at near 100% utilization for long periods [29]. It uses four components, developed by Google itself, built specifically for cloud DCI: Espresso, which deals with peer connections to ISPs; Jupiter, responsible for the traffic within datacentres; B4, which addresses connections between datacentres; and Andromeda, an NFV stack that provides monitoring and management capabilities [30]. Another technology enabling DCI-SDN uses transport layers, i.e. layers 0 (DWDM, photonics) and layer 1 (SDH and OTN), which can also double as an SDN use case applicable to the transport layers of the service provider WAN. Both technologies can complement each other to enable DCI-SDN.

As the DCI-SDN plays a role at the datacentres' interconnection, the DCN-SDN is implemented to bring out the software flexibility and economy from inside the datacentres onto each other by decoupling the control plane from the underlying network even further. Through a centralised management and traffic processing, the datacentre energy costs could be reduced by 30% to 40% [31] according to related studies and use cases. These savings are highly compelling in a business case since datacentres are significant consumers of energy.

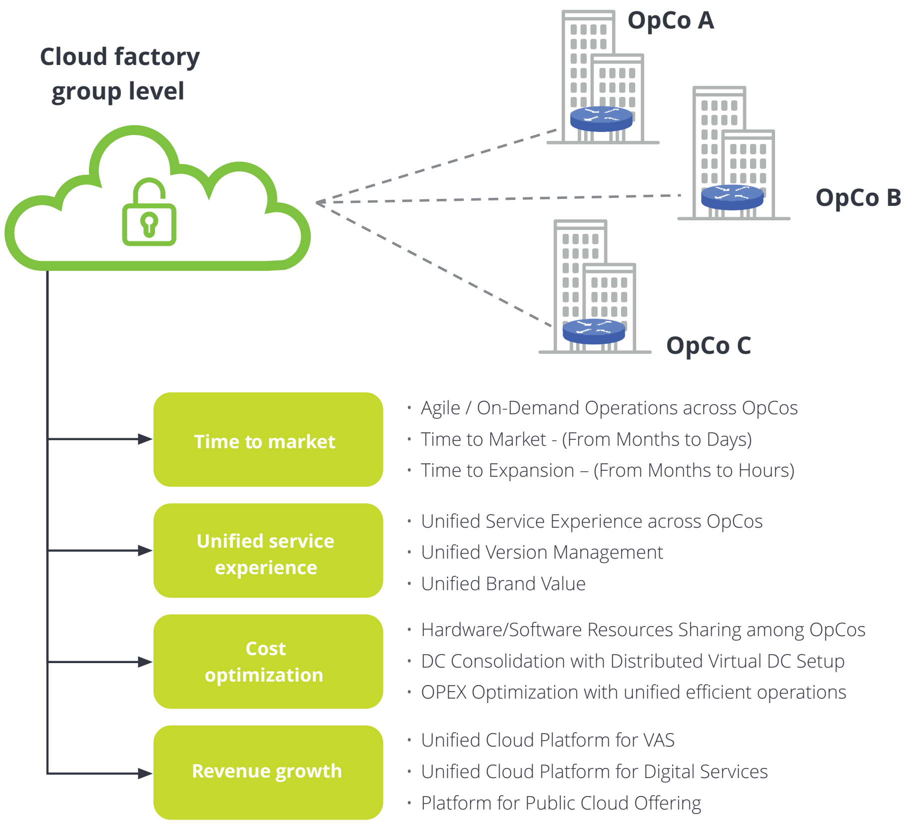
A solid cloud DCI/DCN architecture is a must-have in this age for telcos that want to abstract their multi-vendor infrastructure into a single cloud environment for end-to-end, multi-topology control, management and automation. In addition to the agility benefits, costs efficiencies will ramp up to pay off its implementation.

Figure 15: SDN solution to abstract the NFVI as a single cloud infrastructure



An integrated cloud for Etisalat International

Figure 16: Cloud factory architecture and benefits for a group level perspective



Another great area of interest for Etisalat is to see the possibility of centralization of its operations and solutions by leveraging cloud technology. Yet again, telcos should draw inspiration from Internet companies such as Google and Microsoft, who have benefited greatly by adapting a centralised operation model for their services and certain business functions.

Etisalat is of the opinion that telecommunication groups who have operations in multiple countries must explore this idea to improve their business operations and competitive position in the market. Etisalat terms this idea of unified production of services and certain network services "cloud factory", which refers to an integrated cloud platform and services where a centralised production of its network and operations support functions can be harnessed with local network entities in various operational companies which are situated in the Middle East, South Asia and Africa.

Traditionally, most of the operators group have focused primarily on the centralization of operational services and procurement processes. However, recently some operators have already made the centralization of certain network and business support functions a key part of their digital transformation strategy. With cloud factory, Etisalat is not only hoping to optimise its cost structure but also to embrace a competitive edge with the unique ability to launch innovative digital services at a much faster rate across its market. This will also enrich synergy among its operational companies, enabling the sharing of best practices and highly skilled resources. Having conducted a successful proof of concept last year to prove the technical feasibility of cloud factory, Etisalat is now in the process of finalising its strategy related to it.

There are many obstacles which hinder the deployment of this concept, most notable of which are the regulatory requirements of "end-user data sovereignty". There is certainly a call from many industry players to re-evaluate regulatory terms related to the centralised deployment of network functions for telecommunication. Other challenges related to the technical maturity of integrated cloud-native based software for certain network and operational functions are also a concern for Etisalat. Lastly, Etisalat thinks global operators should decide on a central operative model and make careful consideration of all technical, organizational and regulatory concerns. If developed with comprehensive planning, a business model based on the cloud factory concept is assured to be highly beneficial for digital transformation.

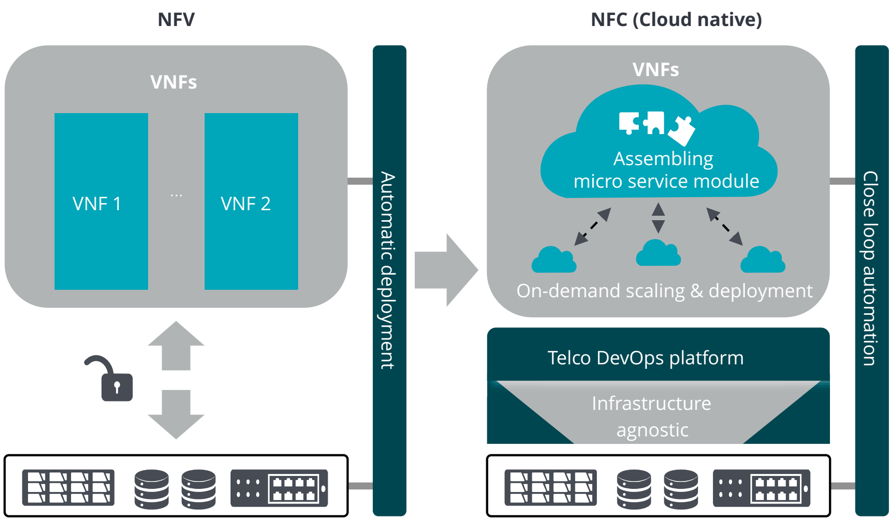
Embracing cloud native

The ultimate target for telcos is to evolve towards a more service-oriented, efficient, and agile operating model. Therefore, transforming all VNFs and the telco cloud to be 'cloud-native' is seen as one of the most important steps (and even a final frontier) in the cloudification journey. Specifically, this refers to telecom capabilities to bundle together small pieces of software (aka "micro-services") to create services on-demand with minimum resource obligations, and as per end-user requirements. This form of services is usually referred to as "stateless" and it is possible to deploy these services anywhere in the cloud with minimum human touch. The modular service will grow or shrink as required, and continues to consume or relinquish resources efficiently as per its need. This requires a scalable, elastic, and programmable network cloud with closed loop automation of all operational and business support systems.

A growing number of industry players are already pursuing this cloud-native paradigm and it is gaining momentum across all standards bodies, open-source organizations and consortiums. Worth highlighting, two technologies have become the poster children of cloud-native applications, although they may conflict down the line: containers (e.g. Kubernetes), and the more advanced serverless computing (e.g. the proprietary Amazon Lambda).

In any case, telcos in this age are moving away from vertical integrations and embracing common, agnostic platforms which will ease the journey to stateless services and unlocking the true potential of cloud computing. However, telcos have another justifiable concern in that telecom VNFs' behaviours and requirements are very different from IT workloads. Hence, a simplistic approach of juxtaposing the IT experience onto a telecom environment would not cut it in this context.

Figure 17: The transition to a cloud native environment



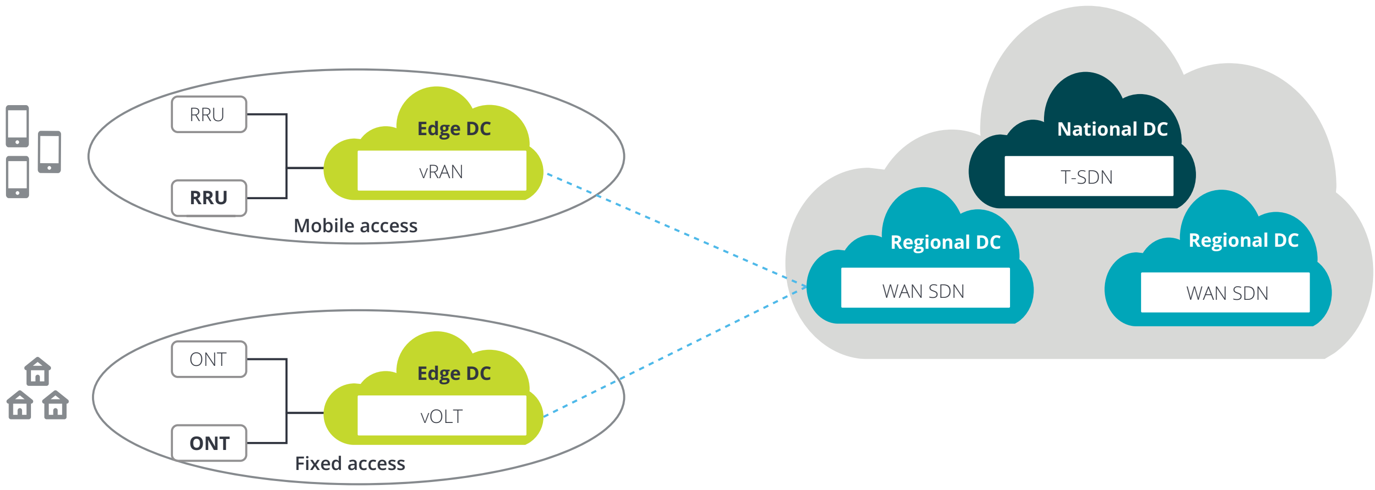
In what we call the 'first wave of virtualization', VNFs are a little more than 'ported' or 're-packaged' versions of their classical/physical ancestors, with handicapped cloud abilities. It may well be more challenging for many incumbent vendors to re-write their success stories from scratch to develop stateless-based software than to virtualise them in the first place. Nevertheless, the 'second wave of virtualization' has started to produce more cloud-based VNFs that avail more of what the telco has to offer. Fortunately, some of the incumbent vendors are committed to becoming cloud-native in their strategy and roadmaps as a necessity for the development of their future products. Although standardised specifications of 'cloud nativity' still lack clarity amongst most industry players, different approaches are being passionately pursued towards non-monolithic software development. This will trigger a 'third wave of virtualization' in which VNFs are written from the base to be truly cloud-native. Etisalat believes that it is vital for telcos in this age to aggressively increase their demands for cloud-native VNFs and applications, reducing their tolerance of ported or repackaged VNFs occupying the resources and capabilities of their telco cloud.

Scaling up the virtualization technologies

Scalability and elasticity are the hallmarks of cloud computing. A couple of NFV and SDN use cases can help with that. Virtualization resources will be needed in the edges of the network, covering a wider geographic area and ultimately enabling telcos to deploy new services to their customers. Thus, more efficient utilization of these resources will be required. These scaling use cases include the vRAN (radio access network), vOLT, vBGN and the T-SDN (transport controller). In order to deploy these technologies, the NFVI again needs to be ready, and the edge datacentre layer might make sense to be leveraged to host these virtualised functions and local SDN controllers. By logically centralising the control and management of the whole backbone and backhaul into the T-SDN controller, telcos will be able to provision resources in an agile and automated way, dynamically allocating and releasing network resources (backhaul/backbone/metro) when necessary. The vRAN can generate operational and cost efficiencies by pooling BBUs that will manage and control mobile resources through the RRUs, also significantly increasing the spectrum utilization, which is an expensive and scarce asset for telcos. By virtualising the function of vOLT, flexibility is also unlocked at the FAN (fixed access network). Scalability is also a key factor for both use cases, since the BBU and OLT functions are virtualised based on software. The architecture combining all these concepts is illustrated below:

By reaching the edge of the network infrastructure with the distributed telco cloud, it will be possible to adopt edge computing or multi-access edge computing (MEC), pushing the intelligence and processing closer to end-customers to unlock innovative service possibilities.

Figure 18: NFVI architecture reaching the edge of the network (fixed and mobile)

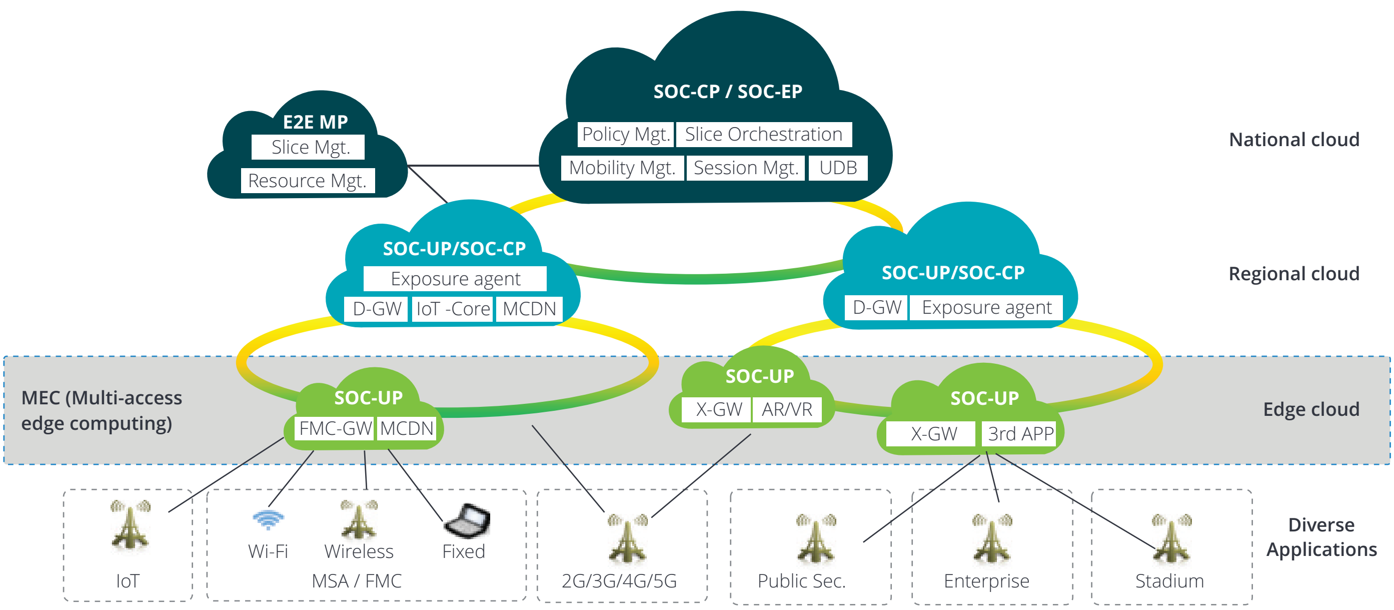


Edge computing appliedat the new telecom NFVI

Multi-access edge computing (MEC), fog computing, or otherwise known simply as 'edge computing', has emerged as one of the most significant technology trends. It paves the way for harnessing the full potential of future services like V2X, VR/AR, tactile internet and others, as pointed out previously. Additionally, it is also being promoted by some analysts as having an integral part in 5G deployment scenarios. Edge computing as a concept refers to deploying certain real-time processing, content distribution and intelligence functions in close proximity to the end-users, pushing intelligence and processing capabilities down where the data originates and is consumed. This not only helps in meeting the requirements for the aforementioned services, but it also reduces any unfavourable investment necessities and traffic engineering complexities towards the network core. With the availability of a distributed NFVI, the MEC technology can be executed at the edge layer of the cloud infrastructure in an environment characterised by ultra-low latency and high bandwidth.

MEC or fog computing technologies can be adopted in the Being Age since the telco will have a distributed NFVI by now, where the processing can be done at the edge layer of the telco cloud infrastructure.

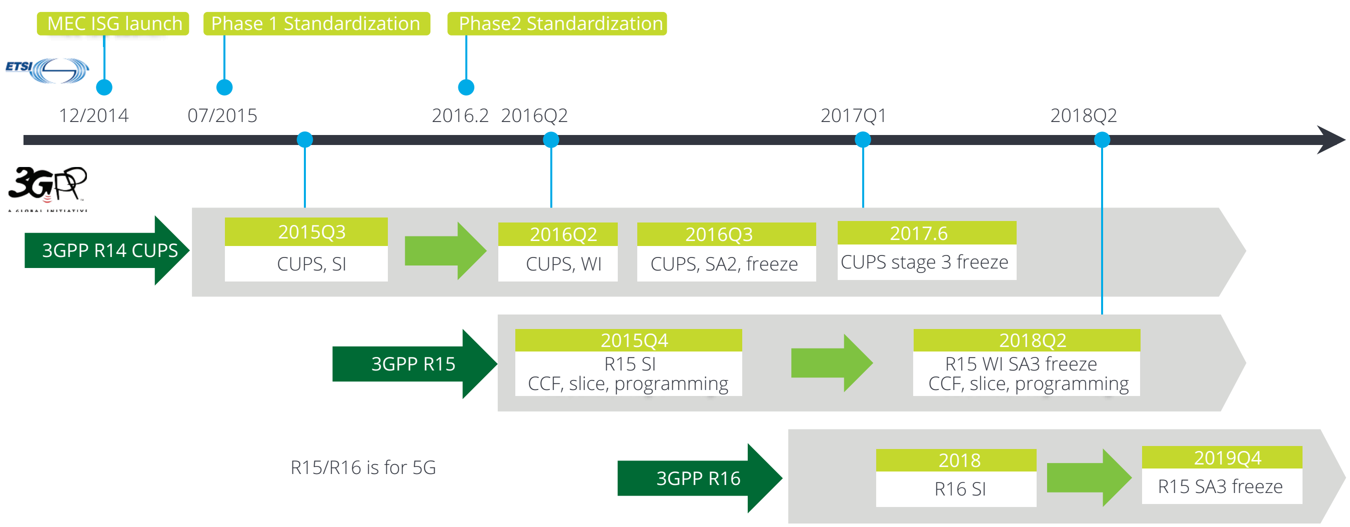
Figure 19: MEC application in a distributed infrastructure architecture (NFVI)



Edge computing: specifications and challenges

The MEC technology mandates serious efforts towards new specifications and standards. ETSI's MEC framework is a good start, but it has gaps to close before commercial adoption. Etisalat is of the opinion that the whole ICT industry should work more closely and swiftly towards standardization of MEC's detailed specifications. Key considerations of MEC deployment that still need to be addressed in standards are the integration with the core network, billing and authentication, enabling lawful interception, how to incorporate 5G architecture (access-agnostic) and how to conduct traffic steering. Moreover, our view is that MEC should be considered as a 'solution container' rather than a solution itself. That is to say that it should have the capability to embrace several solutions, functions, APIs and applications from different vendors/third parties offering smooth integration. In parallel to the MEC standardization, the specifications from 3GPP are evolving; for instance, the current release 3GPP R14 related to CUPS (control-user plane separation) does not support MEC requirements—a topic that will be addressed at the next release 3GPP R15. Etisalat has an expectation to have at most in 2018 a standardised MEC technology ready to be launched. This accomplishment will only be possible with both standardization bodies (ETSI and 3GPP) working together and actively with the industry.

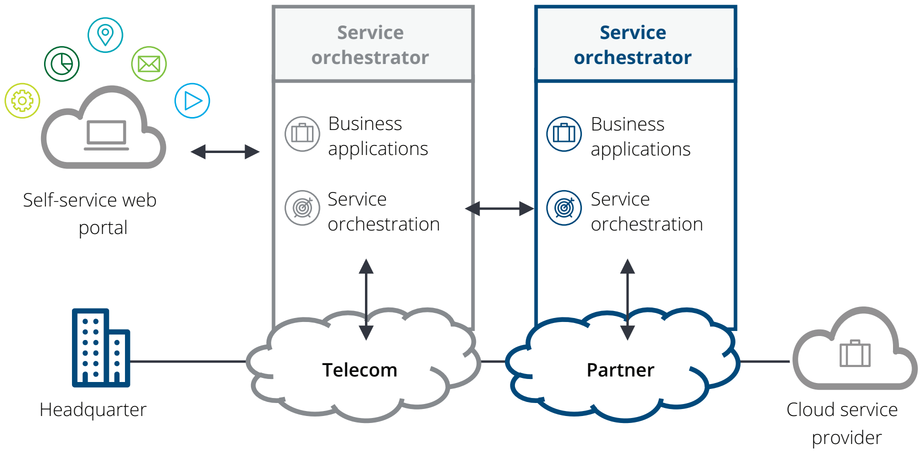
Figure 20: MEC standardization Vs 3GPP standardization timeline



The service orchestrator enabling zero-touch provisioning

Imagine ordering a book through the website of a digital bookstore. The online order will set off a cascading chain of automated service orchestration functions. No human from the digital bookstore will get on the phone to call the delivery company for the delivery of the book. Everything is automated. Unfortunately, many business-to-business (B2B) network services are still manually provisioned and require human intervention. This is even more so with telecom services. You cannot order an MPLS circuit like you order a book. The process of ordering the circuit is still long, manual and painful, and in dire need of automation. As a result, new services may take days, weeks or even months to be fulfilled.

Figure 21: The goal to provide E2E management and control across multiple network domains



Achieving zero-touch provisioning means automating the entire value chain so that when a customer wants a service, they just have to press a button on the company's website to begin the process of provisioning, and after a few minutes the process is complete. The service can then be used and even adjusted on demand, rather than requiring a locked-in service contract. This concept has been in the works by entities such as MEF through its specifications for the lifecycle service orchestration (LSO) approach [8], and TM Forum, which has a project named Zero-touch Orchestration, Operations and Management (ZOOM) that is focused on this topic [32]. According to TM Forum, to achieve zero-touch provisioning, operators must first close the loops. This means collecting and analysing data to figure out how the network can be optimised, and then implementing those changes in an automated way [33]. Later, telcos may adopt the LSO, which is basically an end-to-end agile approach to simplify and automate the service lifecycle in a sustainable fashion for coordinated management and control across all network domains responsible for delivering a full service.

By using a digital marketplace represented in the figure below as a self-service app or portal, customers will be able to request and customise the services as per their needs, and telcos will provide for such requests automatically through the service orchestrator. To achieve such a vision, telcos should guarantee that network orchestration is done in real-time and without human intervention. Independent of the type of orchestrator, it must be capable of simplifying the user experience via self-ordering for a complex service, with zero-touch provisioning and full integration with the critical business and operation process across a hybrid network with both physical and virtualised (NFV) infrastructure, including virtualised customer premise equipment (vCPE).

By closing the loop and implementing the service orchestrator, specialised staff will be free to focus on complex activities requiring their expertise, instead of monitoring the infrastructure, doing repetitive tasks and taking routine decisions. This will allow telcos to not only reduce OpEx and react faster to unplanned changes in the infrastructure, but also to focus more on innovation and optimizations. However, the specifications and practical use cases from the service orchestrator are far from being mature and ready to deploy.

Integration of service orchestrator with NG-OSS/BSS

Service orchestration arose mainly because today's OSS/BSS have not been designed and built for future digital products and service demands. They were built for static and predictable telecom services instead (figure 19).

Hence, a new generation of OSS/BSS (NG-OSS/BSS) could be developed to deal with the new elements, such as the MANO, SDN controllers and also the service orchestrator, to facilitate the agile design and creation of new services and enable real-time, data-driven and on-demand provisioning and billing. If properly done, it will reduce time to design and on-board new services to just days instead of the average of 10 months in some telcos [35] [36].

Furthermore, the new systems should also be API-driven (in order to guarantee a seamless integration with the service orchestrator) and must have the ability to provide visibility across all network domains and vendors so they can support fulfillment and assurance of services that are constantly changing [37].

Therefore, the existing structure and systems need to be transformed to realise the full benefits of this age. The evolution towards a zero-touch provisioning environment requires a new system architecture to guarantee the integration of NG-OSS/BSS with 'self-service portal', 'orchestration' and 'marketplace' components. These key blocks will now own and be responsible for typical OSS/BSS functions that will be re-arranged in order to better connect customers/partners with services/products and resources/network management with the ecosystem orchestration and policies (figure 20).

Figure 22: As-is support system organization (based on TMF's TAM framework)

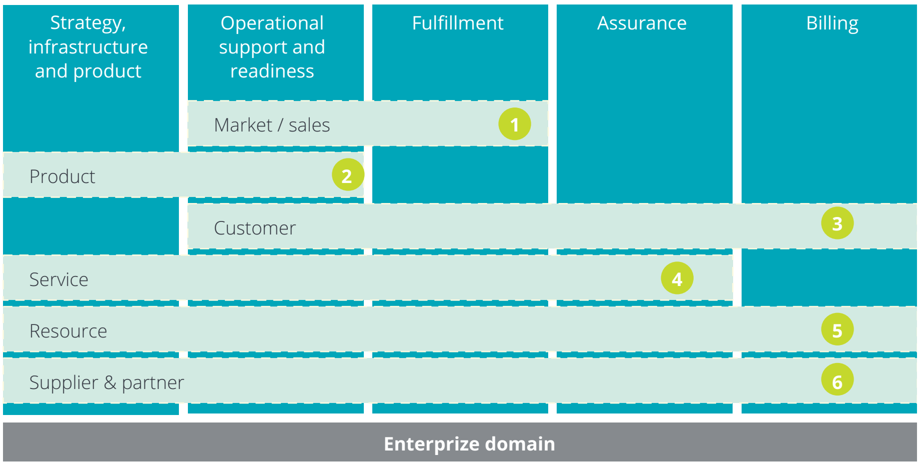
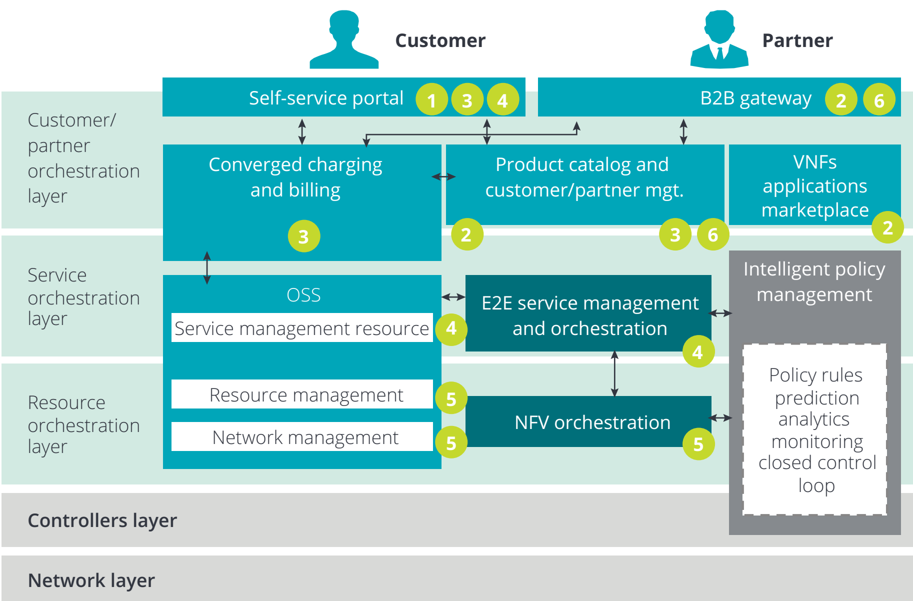


Figure 23: To-be systems and orchestration organization (based on TMF's ZOOM framework)

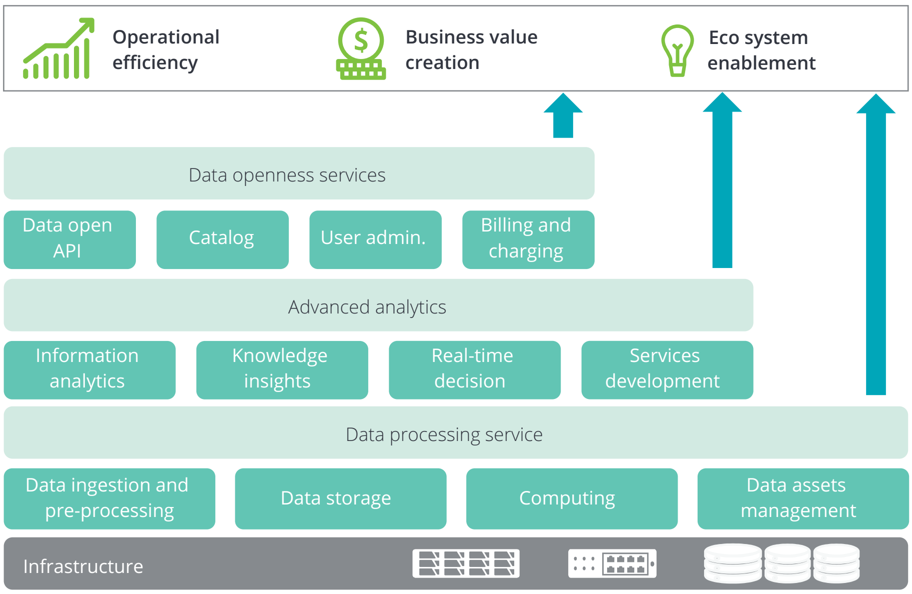


Integration of NFV and SDN with Big Data and AI

In order to transform to being a digital service provider, it is necessary to build intelligent systems that are self adaptable by harnessing the enormous data generated to enhance the customer experience. NFV and SDN have enabled the digitalization of the telecom environment and transformed it from hardware-centric to software-centric, which has led to exposure to huge oilfields of data. In order to drive meaning and extract the context and value out of the big data, it is necessary to build digital, intelligent systems that learn from experience and make real-time decisions whenever required to address customer requirements efficiently, through supervised or even unsupervised machine learning. This is different to traditional automation where humans hard-code the policies or bots replicate what a human would do. Machine learning is just that—its primary purpose is to learn while execution of the learnings can be delegated to appropriate systems like the service orchestrator and digital platforms. Moreover, the ever-growing use of mobile and data being moved to the cloud will forcefully demand the integration of NFV and SDN with big data and Artificial Intelligence (AI) in this age.

Additionally, ETSI has created a working group named Experiential Network Intelligence (ENI) to develop a cognitive network management architecture for the optimization of the telcos operational environment. Furthermore, incorporating AI technology in today's systems that can analyse millions of data can help make predictions to provide unique services to each customer (mass customization). Therefore, an efficient AI-powered big data and analytics ecosystem can help telcos improve quality of experience by analysing

Figure 24: Telecom big data analytics and its benefits generated



network traffic in real time, conducting predictive capacity planning, identifying fraudulent behaviours and anomalies instantly by analysing call data records, personalising marketing campaigns to individual customers using real-time location and social networks data, and developing new services unique to each customer. This can result in higher business velocity and increased profitability for telcos, which is not feasible via manual ways. [36]

In a telco cloud paradigm, where all the processes and the network itself are dynamic, the efficient use of the available data related to customers in every service and product decision will be a key success factor. A telco that incorporates such methods will gain a real competitive advantage and generate increased revenue.

The fusion of AI with NFV and SDN technologies to build digital intelligent systems will enable highly optimised and efficient resource utilization and cost efficiencies for telcos and customers alike. In addition to that, it will self operationalise the systems that require little or no human intervention, and can heal, scale and adapt on their own, taking the customer experience (and digital telco) to the next level.

We believe telcos will not be able to hire staff fast enough to do things manually to cater to the new suite of digital services. That is why analytics and AI are key for us.

Considerations from Etisalat's Sponsors

"Cloud computing presents unique opportunities for Etisalat to attain sustainable growth in the emerging digital ecosystem. Our aim is to deliver a differentiated service experience to empower a digital and happier society. This new opportunity-rich landscape calls for collaboration with diverse industry players focusing on open and agile operating and organizational models. Those who have yet to start this journey, must start now and respond boldly with the right strategy!"

Hatem Bamatraf
Etisalat International
Chief Technology Officer

"Customer needs, behaviours and even perspectives are changing constantly across all demographics and generations—now more rapidly than ever. Web start-ups and Internet corporations became good at seizing these opportunities. And telcos have to evolve faster to catch up. That is why we are cloudifying our network—to make it agile and adaptive to the maximum while maintaining profitability. How else could you be a 5G, an IoT or a digital provider?"

Esmaeel Alhammadi
Etisalat UAE
Senior Vice President Network Development

Our contributors' point of view
Considerations for Etisalat

Pedro Tavares
Deloitte Portugal
Telecom Engineering Centre of Excellence (CoE) Leader

"At Deloitte we believe that digital transformation is not only about technology: deep transformations might happen in telcos at multiple dimensions in order to revamp their business. We also believe that a "big bang" approach has a lower probability of succeeding; instead, the journey might be travelled step by step and harvest benefits along the way that would, in turn, help to fund more complex transformations. That being said, this paper focuses on the technological perspective, since it represents the foundation to support all other dimensions. Additionally, in terms of investments and effort, it might be the heaviest expenditure for telcos in the digital transformation.

During the development of this white paper, we were able to corroborate our hypothesis that telcos are just scratching the tip of the iceberg with virtualization and cloud technologies, not having yet reaped all of the promised benefits. This situation might lead to the complete discredit of these exponential technologies. Clearly, the main point that has to have the pace stepped up regards the standards, which are not mature enough. The Cloudification journey is part of telcos' digital transformation and it is the road to reach the envisioned end-state scenario. It has such a high importance that telcos and their partners (vendors, consultancies) must be more proactive when it comes to investing and allocating efforts with the standardization bodies to evolve the technologies that compose the pathway. There is an evident gap of engagement (very high to none) from different stakeholders in the telecommunication industry.

Deloitte will invest effort to push forward the frontiers of knowledge related to virtualization technologies (SDN/NFV) until they reach a viable maturity level for our clients. We will support our clients to accomplish their vision, providing agnostic advisory in terms of the best suitable solutions for their businesses in addition to address the challenges across all layers from the operating model."

Peng Xiongji
President Etisalat Key Account
Huawei Technologies

"There is no doubt that the emergence of a digital lifestyle and services is re-shaping the industry landscape and 'transformation' has become inevitable for service providers. The potential of 'cloudification' and SDN/NFV technologies has certainly raised the expectations of the industry with a practical answer to the impending challenges of increasing services deployment time, cost and rigid and inefficient operational model. It is encouraging to see Etisalat taking the strategic step to embark on its digital transformation journey.

Network transformation should be considered as an opportunity to deploy an "experience oriented" agile network and operating model rather than an imperative compulsion to address short-term business challenges.

Huawei deems that it is of extreme significance to have an unambiguous and comprehensive plan upfront before initiating a network transformation program, especially one related to the deployment of distributed NFV infrastructure and virtualised network services with operational automation.

Telcos should be aware of the distinction between hyped expectations and realistic goal-setting. Therefore, it is of critical importance to form trustworthy long-term partnerships with solution providers who have an in-depth familiarity with the intricacies of both the IT and communication industries. While doing so, carriers should always keep an "enriched digital experience" as the top-most driver and fundamental criterion for any future network design and re-architecture.

Huawei, as an active contributor to the industry advancement, and long-term strategic partner of Etisalat, is fully committed to assist Etisalat on this digitalization path and would feel privileged to work with Etisalat to help them achieve their goals."

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Further details
Index of acronyms

AAA	Authentication, authorization and accounting server
AEB	Automatic emergency break
API	Application programming interface
AR	Augmented reality
B2B	Business-to-business
B2C	Business-to-customer
BBU	Baseband unit
BNG	Broadband network gateway
BSS	Business support systems
CAGR	Compound annual growth rate
CDN	Content delivery network
CEM	Customer experience management
CGNAT	Carrier grade NAT
COTS	Commercial-off-the-shelf
CPE	Customer premises equipment
CRM	Customer relationship management
CSP	Communications service provider
DC	Datacentre
DCI-SDN	Datacentre interconnect SDN
DHCP	Dynamic host configuration protocol
DNS	Domain name server
DPDK	Data plane development kit
DPI	Deep packet inspection
DSP	Digital service provider
DWDM	Dense wavelength division multiplexing
E2E	End-to-end
EBIT	Earnings before interest & taxes
ePDG	Evolved packet data gateway
FAN	Fixed access network
FMC	Fixed-mobile convergence
GPON	Gigabit passive optical network
GW	Gateway
HLR	Home location register
HSS	Home subscriber server
HW	Hardware
IaaS	Infrastructure-as-a-service
IMS	IP multimedia subsystem
IoT	Internet of things
ISP	Internet service provider
LAN	Local area network
LB	Load balancer
LSO	Lifecycle service orchestration
MANO	Management and orchestration
MCDN	Mobile CDN
MEC	Multi-access edge computing
MGW	Media gateway
MME	Mobile management entity
MSC	Mobile switching centre
NAT	Network address translation
NG	Next-generation
NFV	Network function cloudification
NPV	Net present value
NFV	Network functions virtualization
NFVI	NFV infrastructure
NFVO	NFV orchestrator
OCP	Open compute project
OLT	Optical line terminal
OSS	Operations support systems
OTT	Over-the-top
PCRF function	Policy and charging rules
PNF	Physical network function
PoC	Proof-of-concept
PSTN network	Public switched telephone
QoE	Quality of experience
RAN	Radio access network
RRU	Remote radio unit
SaaS	Software-as-a-service
SBC	Session border controller
SDN	Software-defined networking
SDP	Service delivery platform
SD-WAN	Software-defined WAN
SOC	Security operations centre
SW	Software
TCO	Total cost of ownership
T-SDN	Transport SDN
UDC	User data convergence
UI	User interface
VAS	Value-added services
vCPE-R	Virtual CPE residential
vE-CPE	Virtual enterprise CPE
VIM	Virtual infrastructure manager
VNF	Virtual network function
VNFM	VNF manager
VoLTE	Voice over LTE
VoWiFi	Voice over WiFi
VPN	Virtual private network
VR	Virtual reality
V2X	Vehicle-to-everything
VXLAN	Virtual extended LAN
WAN	Wire area network

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