

5G NETWORK CONVERGENCE AND ORCHESTRATION INITIATIVES BY BBF, ONF, LF EDGE, TM FORUM AND ETSI



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The Broadband Forum (BBF) is a non-profit industry organization, is focused on engineering smarter and faster broadband networks. Many of its Technical Reports have become de-facto standards referenced by operators and manufacturers to build up the existing ultra-broadband networks in the last 25 years.

In the 2008-10 timeframe the BBF engaged a coordination activity with 3GPP about Fixed Mobile Convergence looking at potential convergence architectures.

The advent of 5G, represents a inestimable opportunity to specify converged architectures and interfaces and connect any kind of access to a Unified 5G Core.

Since 2017, the BBF has launched the 5G Project within its Wireline Wireless Convergence (WWC) Work Area. The main deliverables of this project are:

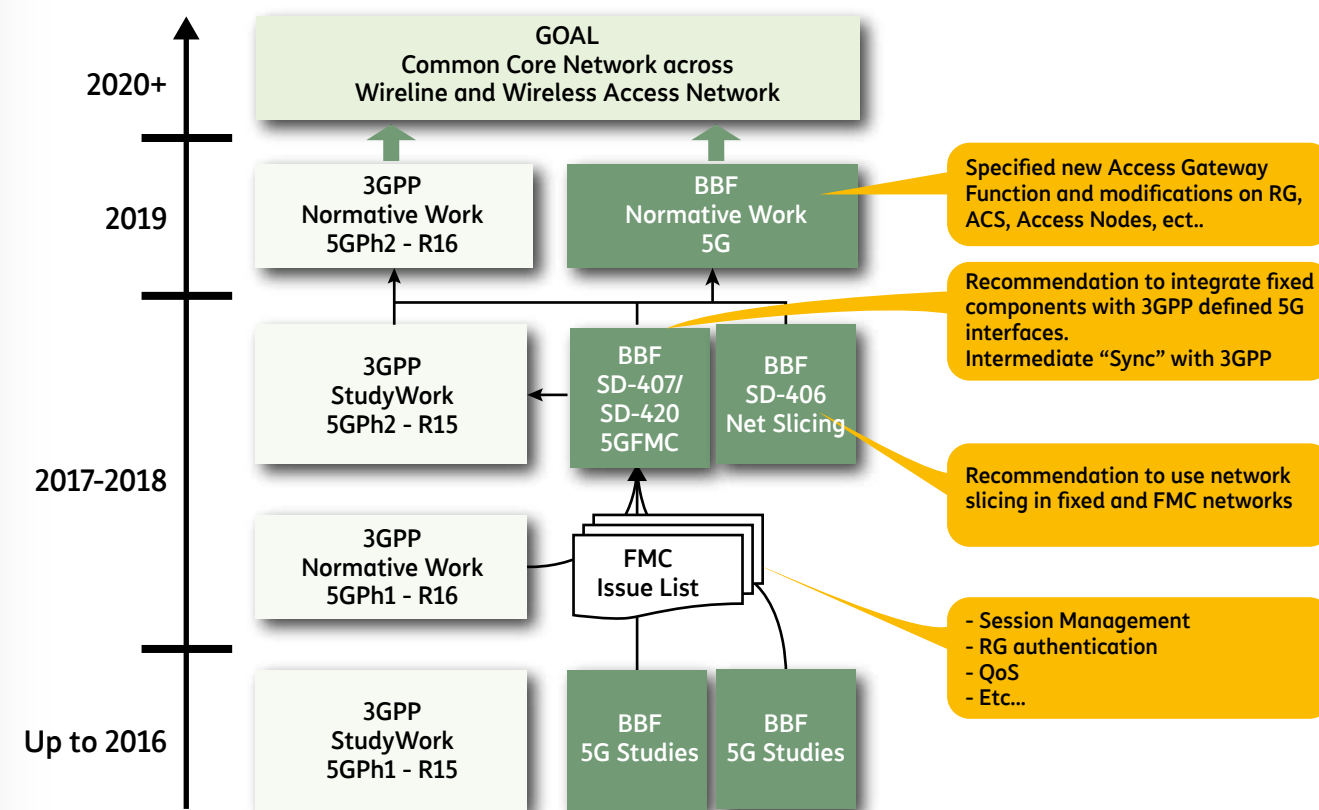
- Study Documents related with 5G topics applicable to broadband and back-/front-hauling networks to share with 3GPP. More specifically these are: SD-406 End-to-End Network Slicing, SD-407 5G Fixed Mobile Convergence Study and SD-420 R1bis 5G Fixed Mobile Convergence Study
- Normative specifications in the form of BBF TRs that define functions and requirements for devices compatible with the converged 5G network

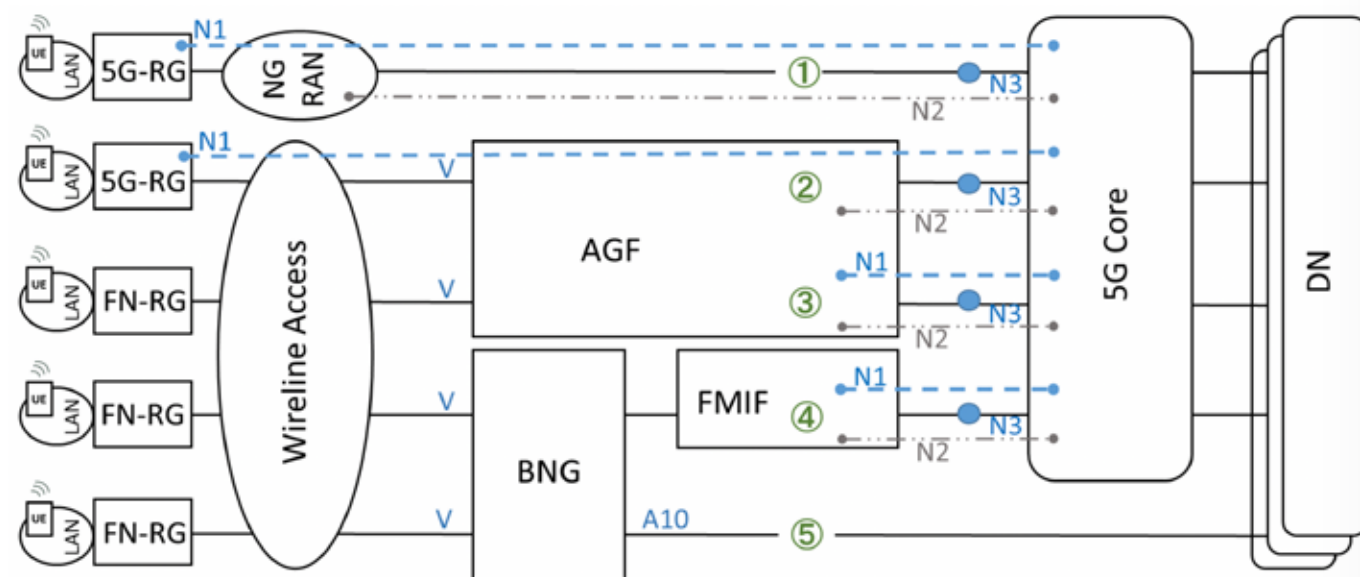
The workplan of this project, phased with 3GPP releases is shown in the picture Figure 1.

The current BBF work on 5G Fixed Mobile Convergence focuses on five scenarios described in the figure below, with different cases in terms of Residential Gateway (RG) type, access network and interfacing model with the 5G Core.

1. **Fixed Wireless Access (5G-RG)** – The 5G-RG is connected over the NG-RAN.
2. **Integration in Direct Mode (5G-RG)**– The RG is connected over the wireline access network. An Access Gateway Function (AGF) mediates between the wireline access network and the 5G core network, based on N2 and N3 interfaces.

5G FMC standardization timetable





5G Fixed Mobile Convergence scenarios

3. **Integration in Adaptive Mode** (FN-RG) – Similar to (2), but FN-RG does not support N1, so the AGF acts as end point of N1 on behalf of the FN-RG.
4. **Interworking** (FN-RG) – The session is managed by a BNG. Services that are based on 5G core network are passed to the 5G core via a Fixed Mobile Interworking Function (FMIF).
5. **Coexistence** (FN-RG) – This is not a converged session model, as these sessions are not part of the 5G core network. However, coexistence is required to allow services that are not supported by the 5G core network to be available in a converged service provider network.

The key goal in all this is to contribute to the specification of the 3GPP's Nx interfaces to the 5G Core

for wireline access concretely leading to a unified 5G architecture and interface specification.

Overall the following 5G activities are carried out by the BBF:

- **5G Fixed Mobile Convergence**
 - Common Core across Wireline and Wireless Access Networks
 - Direct access to 5G core – full operational integration
 - Enabler for seamless service delivery & operational efficiency
- **5G Fixed Access and Transport**
 - Backhaul & Fronthaul: Access
 - Routing & Transport: enhancements for 5G covering capacity, performance reliability & determinism
- **Other 5G Work**
 - Networking Slicing in User Plane and Control Plane and within the Transport Network

- Time Critical Applications: disaggregation policy, requirements, specifications of APIs.

ONF initiatives on network convergence

ONF (Open Networking Foundation – www.opennetworking.org) is a non-profit operator led consortium that hosts a consistent number of projects building solutions by leveraging network disaggregation, white box economics, open source software.

ONF has several initiatives running to build unified platforms by introducing hardware disaggregation and functional decomposition of mobile and broadband components. The **Converged Multi-Access and**

Core (COMAC) and Open Evolved Mobile Core (OMEC) are two key projects to enable this evolution: OMEC is a proposed commercial implementation of the Evolved Packet Core (EPC), while COMAC initiative is aimed at delivering next-generation services over both mobile and broadband networks, regardless of access technology.

COMAC is an ONF **Reference Design (RD)** supported by carriers such as AT&T, China Unicom, Deutsche Telekom, Google and by a supply chain ecosystem including Adtran, Intel, Radisys, GSlab and HCL. The ONF RDs represent a particular assembly of components that are required to build a deployable

platform. They are “blueprints” developed by ONF’s Operator members to address specific use cases for the emerging edge cloud.

Scope of COMAC is to program network slices combining various access and core technologies to support a wide variety of use cases, deployment options and service offerings. COMAC will leverage SDN and cloud techniques to create the necessary converged access and converged core capabilities on a single platform.

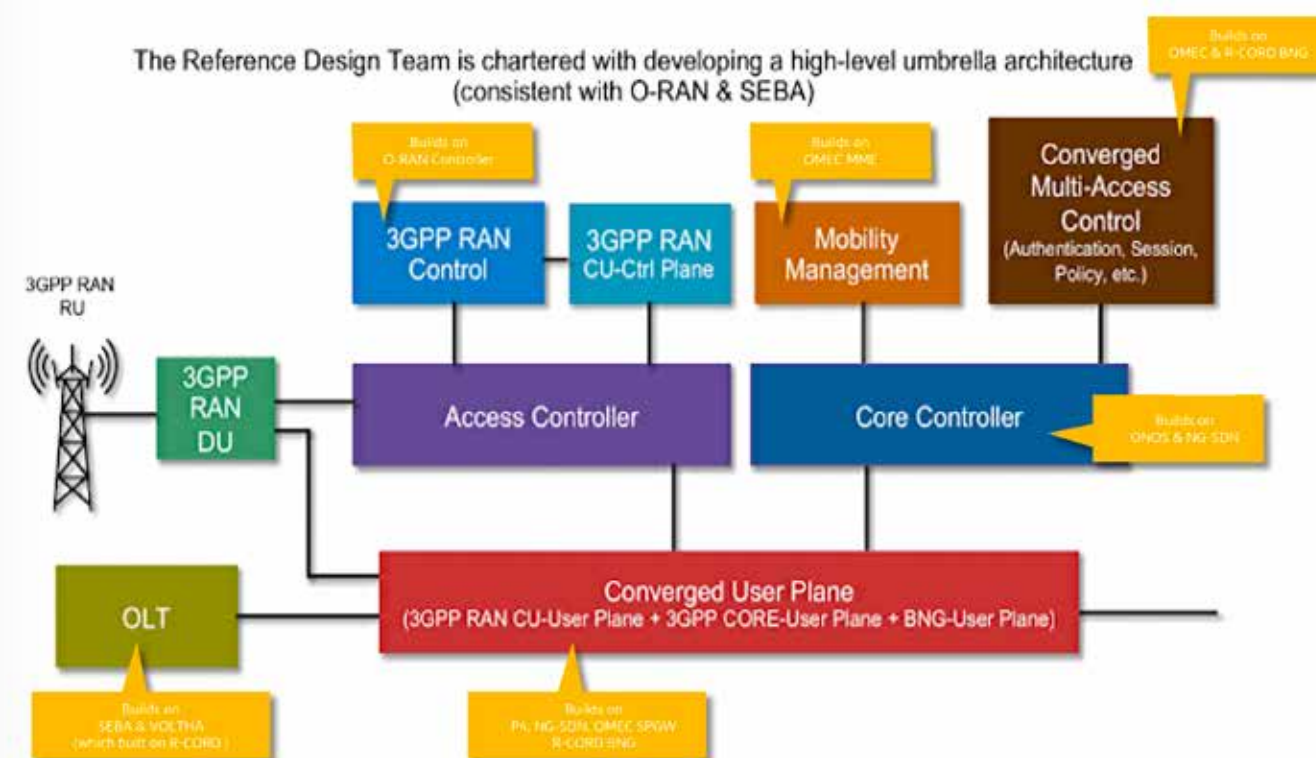
Essentially COMAC is made by a **Converged Access Architecture**, built on disaggregated RAN (leveraging the O-RAN RU/DU/CU architecture), disaggregated mobile core, and

disaggregated Broadband Network Gateway (BNG) components. Elements from each are then redistributed and aggregated into a unified access layer, creating a SDN powered control plane and P4 powered user plane that each contain elements of the RAN CU, Mobile Core and BNG.

About the **Converged Core**, COMAC integrates unified subscriber management, blending Mobile MME, HSS and BNG-Authentication and billing functions into a common platform.

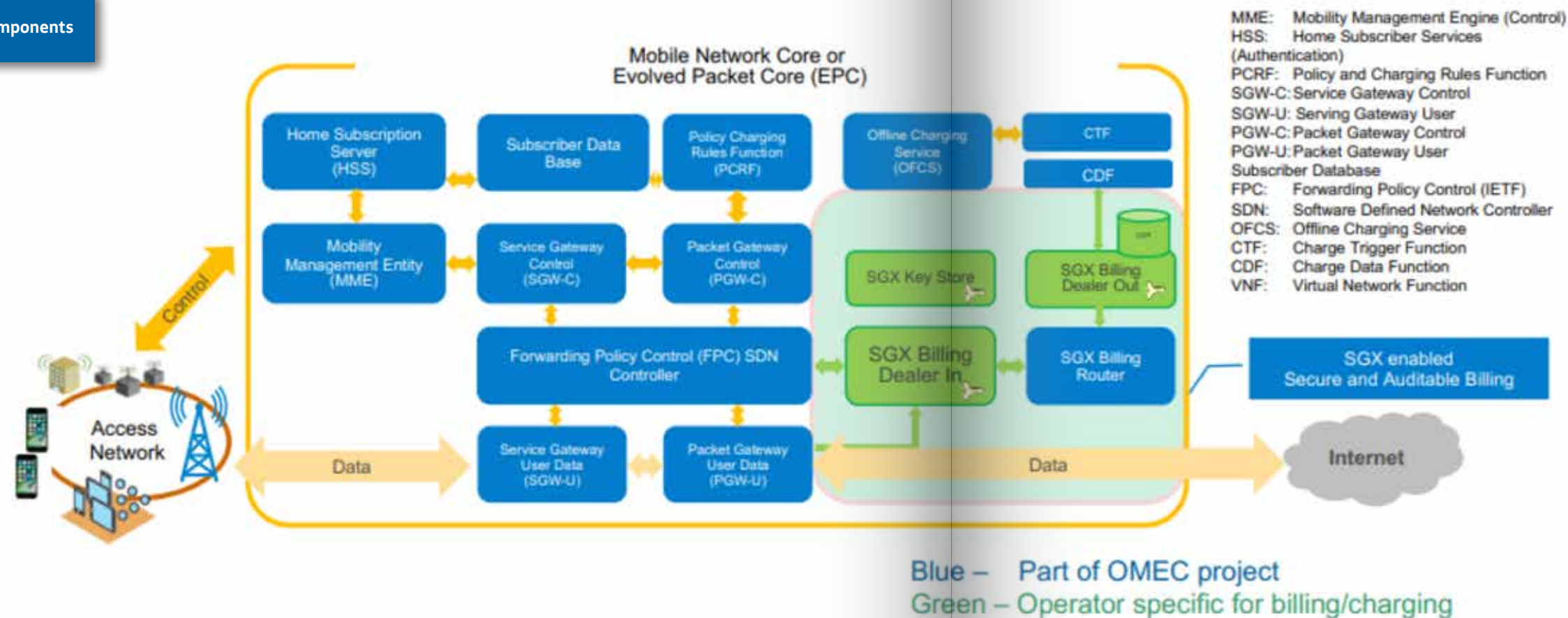
Following pictures Figure 3 (as from ONF site) represent COMAC Architecture and which are the components used to build it.

COMAC - High Lever RD Architecture



1 EPC connects mobile subscribers to the carrier's infrastructure and to the internet.

OMEC Components



OMEC is serving as an upstream project to COMAC RD and it is an open source Evolved Packet Core (EPC [note 1]), designed to be used as a stand-alone EPC, compliant with 3GPP Release 13 and built using an NFV (Network Function Virtualization) architecture optimized for Intel platforms. OMEC provides full connectivity, billing and charging capabilities. It is also designed for lightweight and cost-effective deployments, including IoT and edge applications. As in the picture below OMEC includes EPC components, operational tools including CLI, Logging and Statistics Interface APIs to VNFs, CI/CD tools for

deployment configuration and automation.

LF EDGE initiative

5G is not just a new radio access and core infrastructure, but it will integrate fixed-mobile networks with highly distributed Cloud-Edge Computing facilities composed by big-medium Data Centers (replacing current Operator's PoPs) and a large number of small-medium Data Centers at the edge of the current infrastruc-

ture (i.e. in the access / distribution segments).

Edge computing as an evolution of cloud computing brings application hosting from centralized data centers down to the network edge, closer to consumers and the data generated by applications. Edge computing then opens the network edge for applications and services and it is one of the key technologies required to support low latency together with mission critical and future IoT services.

5G networks are a key future target environment for Edge computing deployments and in this scenario a lot of initiatives have been

computing applications running in virtual machines and containers to support reliability and performance requirements.

- **EdgeX Foundry:** focused on developing a common platform for the IoT edge;
- **Open Glossary of Edge Computing:** dedicated to edge computing definitions, developing a glossary and ensuring that projects share a common vocabulary;
- **Home Edge Project:** focused on IoT for end-user devices;
- **Edge Virtualization Engine (EVE):** a framework, based on APIs, for edge application management in the enterprise.

TM Forum Digital Services

started such as: MobileEdgeX the edge computing company founded by Deutsche Telekom (<https://mobiledex.com/>), ETSI ISG MEC (<https://www.etsi.org/technologies/multi-access-edge-computing>) to define standards specifications, Open Source Projects such as Akraino launched by ATT in 2018 and the new Kinetic Edge Alliance, an industry alliance of software, hardware and networking companies to accelerate the rollout of edge computing. Just in February 2019, the Linux Foundation, a consortium that promotes and standardizes Linux Operating System and other open source

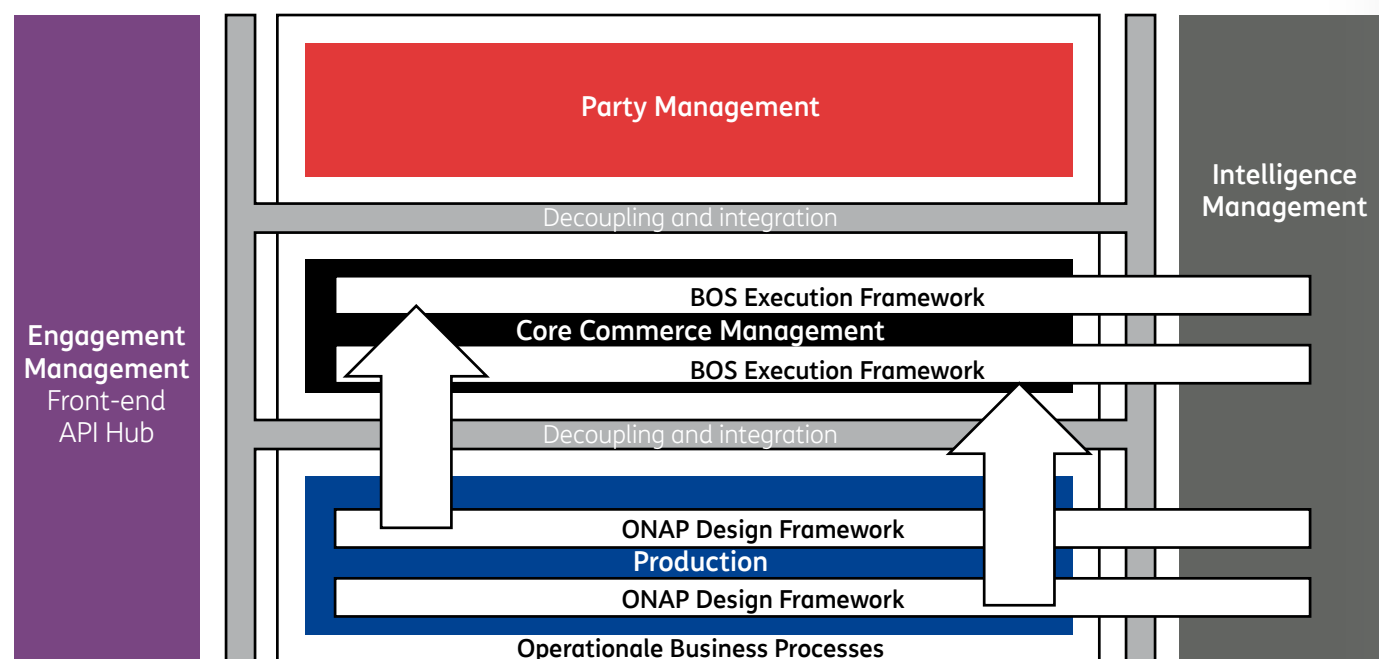
technologies, launched the LF Edge a new 'umbrella organisation' (www.lfedge.org) aimed to create an open and interoperable framework to address and solve the problem of the fragmentation of the edge market. This new organization, supported by more than 60 industry members, will initially take charge of these five projects:

- **Akraino Edge Stack:** founded by ATT it provides a collection of software tools that enable creation of edge-optimized cloud services and applications, based on either VMs on containers. To seed the project, AT&T provides code designed for carrier-scale edge

TM Forum (www.tmforum.org) is the global industry association that drives digital transformation of the communications industry through collaboration.

BOS (Business Operating System) is the answer of TMF to the need to create a common and fully interoperable software framework for CSPs' core and future business, their future digital services and the ecosystems behind them (<https://vimeo.com/317162198>).

The core BOS kernel is composed of a Design Framework (implemented by the BOS Design Center) and an Execution Framework in charge of executing functions



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supporting the Core Commerce Management and the Intelligence Management blocks of ODA, to create an agile IT.

ODA is the TM F reference architecture which sets a new vision for operational and business support systems (OSS/BSS), and a de facto standard for the design of open digital platforms (see picture where ODA blocks).

A reference implementation of BOS is being developed in a DTW 2019 Catalyst to validate and showcase the ODA architecture and to check API + data models completeness and consistency, to federate energies towards the same ODA target, and to check compliance of vendors' solutions. It will expose public open APIs towards the Engagement Management and the Party

Management functional block and since it does not enforce any Engagement Management by default, it allows a total freedom to differentiate through a fully customized customer experience on all channels.

One interesting aspect of the BOS Reference Implementation is the complementarity of its architecture to network Operating System, by natively interworking with ONAP (www.onap.org) based network factories. Starting from Beijing Release, ONAP used already TMF Open APIs exposing northbound the serviceCatalog, the serviceOrder, and the serviceInventory and in the future other Open APIs are expected. These APIs will be used by BOS to communicate with the Production Block. Having an architectural approach close to ONAP - BOS is expected to have the same clear distinction be-

tween design and execution frameworks - the same tools used for the development of ONAP can be reused and therefore making easier the BOS kernel development.

According to TM F, there is a strong link with ONAP modules: ONAP SDC and DCAE modules could potentially be leveraged to develop BOS design center. The BOS orchestrator could also be implemented on Camunda BPM engine, the Active Inventory might be a good starting point for the Customer Products and Offers Installed Base. DMaaP is a generic powerful mechanism to collect data and implement event notifications. AAF (application authorization framework) is an interesting role based (and also attribute based) access control framework for all ONAP subsystems.

In the short term (between now and 2020), an opensource reference im-

plementation will not replace a full commercial "commerce management" platform, but in the long run, commercial solutions are expected to leverage this reference implementation and add commercial innovative features.

ETSI Artificial Intelligence to network management

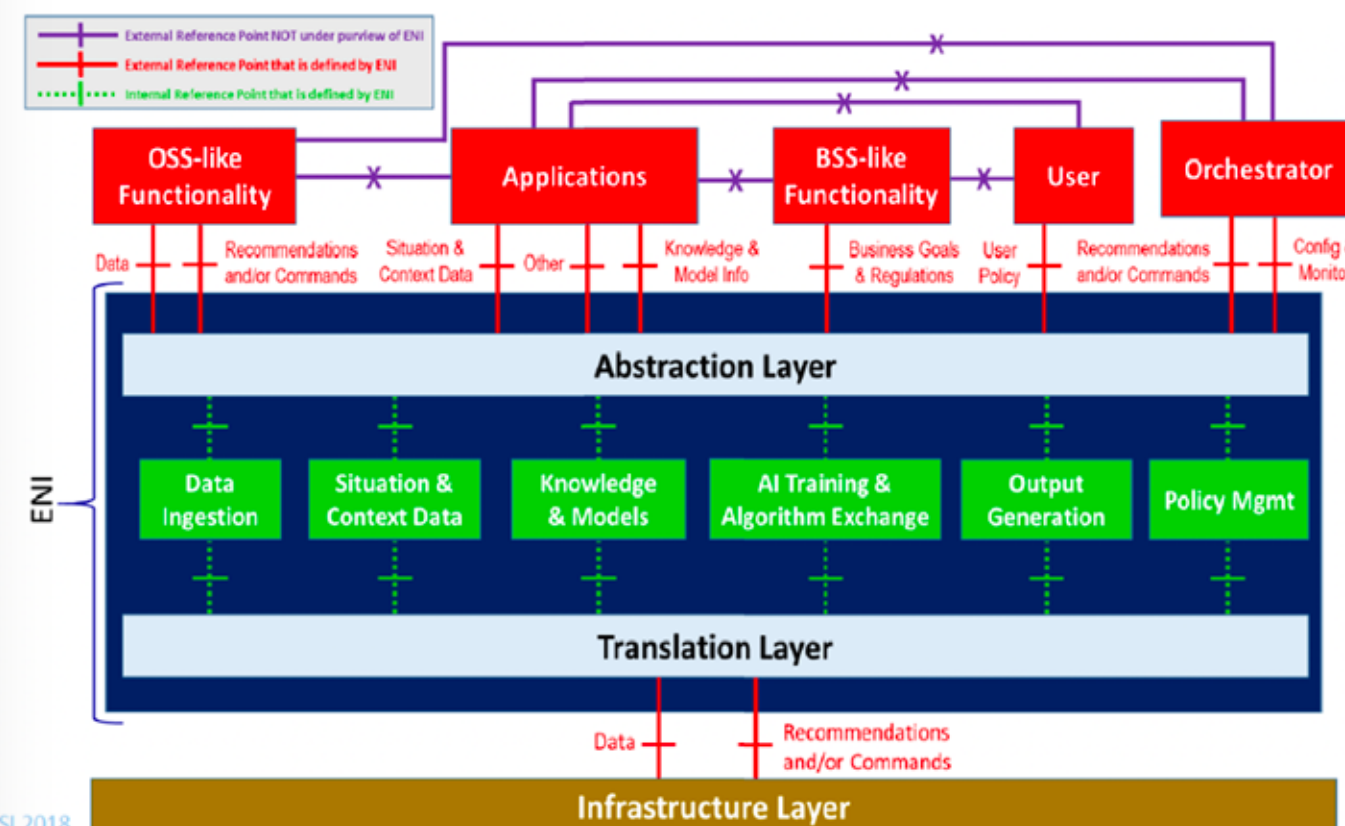
ETSI-ISG ENI (Experiential Network Intelligence) is active since February 2017 to define a standard for the application of Artificial Intelligence (AI) to networking and, in particular, to

network management and operation, addressing increasing levels of automation and self-management (autonomicity, according to IEEE definition). The application of AI starts in fact from the assistance (to the network operator) for diagnostic and fault management purposes on traditional network systems (low or no automation), and is expected to become more and more penetrating and significative with the increasing level of virtualization. AI implementation will be essential in the final picture of the extensively virtualized and sliced network model proposed for 5G full exploitation, targeting full autonomicity, i.e. automation of the network adaptation to detected changes in the operation condi-

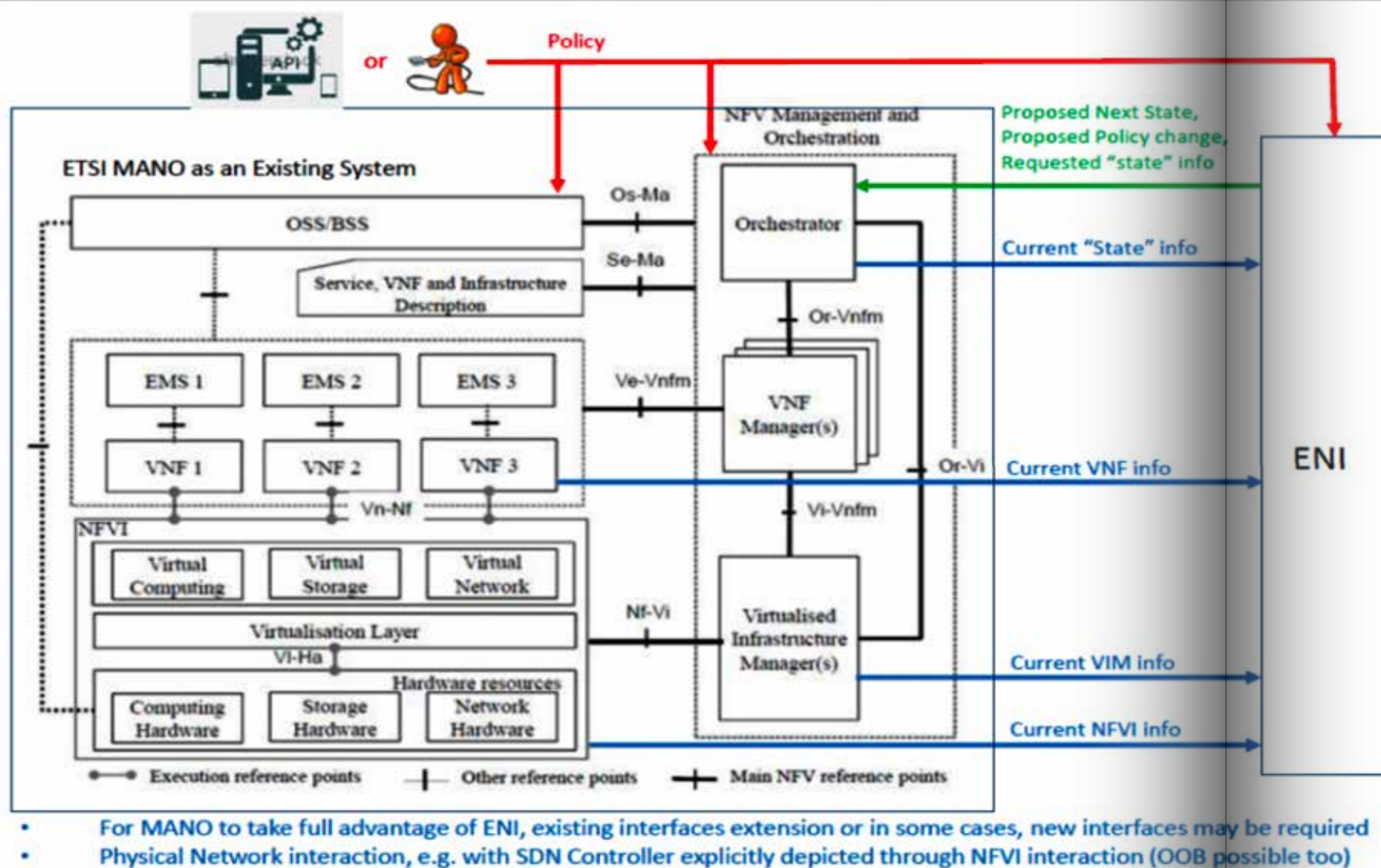
tions, new configurations, addition or removal of functionalities.

The aim of ETSI ISG ENI is in fact to specify a Cognitive Network Management system incorporating a closed loop control approach, which is based on a "monitor-analyze-plan-execute" model and is enhanced by learning capabilities. ETSI ISG ENI has so far defined and published the Terminology, Use Cases and the Requirements for a Release 1 of the specifications together with a Gap-Analysis of Context-Aware Policy Management exploiting AI. The

ENI high level architecture with interconnecting interfaces



ETSI 2018



Integration of ENI system with ETSI NFV/MANO architecture

group is presently working at a detailed Architecture by specifying the details of the high level representation in "ENI high level architecture with interconnecting interfaces".

Also the integration of ENI system with the network architectures defined by the main reference groups

has been addressed. For instance the integration with ETSI NFV/MANO architecture is reported in figure.

ENI Architecture will be released in the next months, as well as a definition of the different categories for the autonomy degree of AI assisted networks operation and management.

ETSI ISG ENI is planning a release 2 of its specifications, following

the publication of the Architecture, to address the APIs needed for the ENI subsystem and the information model, and a further enhancement of the architecture including interfaces and protocols, detailed functional flow diagrams, sequence and interaction diagrams, state machine diagrams, Reference Points. Security is considered a fundamental aspect to be addressed too ■



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laureato in Fisica, è entrato in azienda nel 1994. Dal 2011 si occupa di standardizzazione per "Cloud Computing", "Big Data Analytics" e "Management Support Systems evolution" all'interno di vari enti di normativa. Precedentemente è stato responsabile della realizzazione di linee guida per l'utilizzo di software open source in sistemi Business critical in Telecom Italia IT e fino al 2007 responsabile del Configuration Management Competence Center nella Software Factory di Telecom Italia dove si occupava di tutte le attività inerenti l'identificazione, il build ed il rilascio del software. Ha svolto anche attività accademica presso l'Università di Bolzano nella Facoltà di Computer Sciences fino al 2012 ■



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Laureata in Matematica, è entrata in Azienda nel 1989 ed è Senior Project Manager nel gruppo Technology Innovation Management - Standard Coordination & Industry Influencing. Si è occupata di attività di innovazione interna ed è stata responsabile di diversi progetti per lo sviluppo e messa in campo di servizi innovativi per gli Operatori Mobili delle consociate estere. E' responsabile del coordinamento delle attività di standardizzazione e partecipazione alle Open Communities per quanto riguarda la Virtualizzazione della rete e le tematiche di Orchestrazione ed Automazione. Ha ricoperto diversi ruoli di chairmanship in diversi enti e attualmente rappresenta Telecom Italia in ETSI NFV, ETSI ZSM ed è membro del Board di Linux Foundation Networking Project ■



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In Azienda dal 1992, è coordinatore delle attività di standardizzazione su IPTV e media delivery, Accesso Fisso e Trasporto dal 2006. Dal 2008 al 2014 è stato deputy Board Director per Telecom Italia dell'Open IPTV Forum e dal 2012 ne è stato il Vice-President. Fino a febbraio 2015 è stato Chairman dell'ETSI Project E2NA (End-to-end Network Architecture) ed è attualmente Chairman del Working Group M493 del TC NTECH. Prima del 2006 ha seguito varie attività in Telecom Italia con ruoli di project manager, nell'ambito di progettazione di sistemi di interconnessione ottica e sistemi di sicurezza per comunicazioni fisse e mobili. Ad inizio anni 2000 ha fatto parte del team di progetto del Backbone Nazionale Integrato. Prima di entrare in Telecom Italia ha lavorato per tre anni presso l'Università e la sezione INFN di Torino dopo il conseguimento del Ph.D in fisica ■



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ingegnere in telecomunicazioni, è in Azienda dal 1994. Si è occupato inizialmente di reti di trasporto e in seguito di rete di accesso fisso in particolare di tecnologie in rame. È stato responsabile delle attività di scouting, specifica, qualificazione e interoperabilità di apparati DSL a supporto dello sviluppo della rete di accesso broadband e ultra-broadband (NGAN). Attualmente è responsabile di un progetto che definisce le specifiche per soluzioni FTTh e test list di validazione e si occupa dello studio e scouting di soluzioni SDN ed NFV in accesso. Partecipa alle attività di standardizzazione del Broadband Forum ed è membro del Board of Directors dal 2008. È inoltre chairman del Service Provider Action Council e co-director dell'Innovation Work Area e membro dello Steering Committee ■