A Perspective of O-RAN Integration with MEC, SON, and Network Slicing in the 5G Era

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The deployment of 5G mobile networks has begun in earnest. The 5G network is built on a service-based architecture (SBA) which enables programmability of the control plane of 5G Core (5GC) and supports network slicing (NS) in both core and access networks. NS enables the creation of multiple, isolated network slices tailored for specific services with diverse KPI objectives [1]. SBA of 5GC facilitates core network user plane functions (UPF) being deployed near the network edge, which has triggered intense interest in edge activities such as Multi-access Edge Computing (MEC), whereas the traditional Self-Organizing Network (SON) functions are being enhanced continuously in 5G RAN. Meanwhile, the development of open and smart RAN led by an industry alliance, O-RAN, has received great attention. In this short paper we would like to sort out if and how all of the above would fit together in a consistent and efficient manner regarding their architecture aspects and functionalities.

A true Information Technology (IT), Communication Technology (CT), and Data Technology (DT) deep convergence has started since the beginning of the 5G journey. Open and Smart RAN represents that trend in the RAN domain, and carry forth a great momentum toward an open networking ecosystem. The central themes of O-RAN include disaggregation via open interfaces and open APIs, open-source software, open reference design hardware, and native machine learning (ML)/artificial intelligence (AI) embedded in RAN [2]. An open-source platform for adaptive management and control of 5G New Radio (NR) with maximal use of generic hardware and fully standardized interfaces is proposed to add intelligence functional elements and extensions to the 3GPP NR architecture. Specifically, O-RAN has introduced the hierarchical RAN Intelligent Controller (RIC), including the Non-Real Time and the near-Real Time RICs that support programmable, microservice based functions called rAPPs and xApps, respectively. RICs bring forth embedded ML/AI capabilities for performance optimization and operation complexity minimization. It helps to adapt the Radio Resource Management (RRM) operations (admission control, mobility management, radio link management, etc.) according to diverse applications' needs, which is particularly valuable in 5G networks when addressing various vertical industries. O-Cloud, a cloud computing platform comprising a collection of physical infrastructure nodes that can host the relevant O-RAN functions, is included to enable flexible deployment options in virtualized telco clouds [3]. The list of use cases supported by O-RAN includes traffic steering, cross-layer quality of experience (QoE) optimization, vehicle to everything (V2X) proactive handover support, flight path-based dynamic unmanned aerial vehicle (UAV) resource allocation, energy-aware operations, Multi-Input Multi-Output (MIMO) beam-forming control and optimization of RAN operations. The O-RAN Alliance not only develops O-RAN technical specifications but also incubates the open-source implementation of the concept with its O-RAN Software Community (SC) program [4] under the Linux Foundation.

With 5GC UPF deployed at the network edge for latency considerations, and 5G RAN central unit (CU)/distributed unit (DU)/radio unit (RU) transformation for flexibility, a turbocharged network edge came into focus for future networks. The MEC program by ETSI [5] enables placement of the applications close to the customer and the use of RAN contextual information. It supports seamless application mobility, provides service-oriented APIs for i.a. users location and radio conditions contexts exposure, handles applications-related traffic redirection and enables dynamic application deployment. The MEC architecture [5] consists of the MEC Platform (MEP) that hosts MEC applications; the MEC Platform Manager responsible for the management of platform and MEC applications life cycle; and the Virtualization Infrastructure and its Manager. It can be implemented with or without network function virtualization (NFV). While MEC has already been well defined for 4G networks, its integration with the 5G network, especially with network slicing, is still in progress. It is worth noting that MEC, in opposite to O-RAN, cannot change the RAN configuration.

The SON concept provides RAN management automation [6], namely self-configuration of newly deployed nodes, performance optimization and fault management. The self-optimization mechanisms concern coverage, capacity, handover, QoS, energy consumption and interference control. SON has been successfully deployed in 4G networks [6]. It is based on feedback loops with time resolution more in the range of O-RAN's Non-Real Time RIC; therefore, for its implementation, it is necessary to monitor RAN and reconfigure it in the management domain. There is no detailed architecture of SON provided by 3GPP, but it is assumed that SON is a part of the management system. So far, the SON concept does not use the NFV based orchestration of SON functions. Actually, there is ongoing work on the 5G SON. Its functions will deal with end-to-end 5G network management that include network slicing and virtualization. An important role in 5G SON will be played by the Management Data Analytic Service (MDAS) [7] that uses management and network data (collected through management services and from network functions) to make corresponding analytics. Some SON functions are already mentioned in the context of O-RAN; the SON functions, however, implement the network configuration concerns primarily, not directly related to services' goals.

A preliminary analysis of O-RAN, MEC, SON and NS has shown that they are highly related, partly complementary and partly overlapping. Moreover, some mechanisms developed within one can be efficiently reused by others. However, their direct integration may lead to competing decisions of each that may degrade the overall system performance. Their proper integration with a new decomposition and the removal of redundant functional blocks to provide overall synergy will be highly beneficial. To achieve that, a new functional decomposition is required. In the following, we present initial thoughts concerning a set of potentially beneficial integration scenarios:

SON and O-RAN Integration: The benefits of this integration lie in the usage of the same infrastructure nodes, monitoring databases, and the ability of cross-operations. In particular, the usage of MDAS is of great synergy with the Non-Real Time RIC. Moreover, the O-RAN orchestrator can orchestrate SON services. Such integration is already visible in the O-RAN community, but it has to be enforced.

MEC and O-RAN Integration: MEC hosts can be combined with the near-RT RIC hosts of O-RAN, and the MEC-based control plane services can be just O-RAN services (data plane services cannot be deployed that way). MEC databases (about UE locations, cell performance, Radio Network Information Service (RNIS)) can be integrated with O-RAN databases; the Mobile Edge Application Orchestrator (MEAO) can be used for xApps orchestration (including SON functions). The MEC application mobility mechanism can be reused in multi-near-RT RIC environment, solving an essential problem of the inter-near-RT RICs cooperation.

NS and MEC/O-RAN Integration: The support of NS is an ongoing technical spec task group effort in O-RAN. It impacts O-RAN in several ways: (i) a slice xApps can be included in NR slice templates and orchestrated by the O-RAN/MEC orchestrator; (ii) each slice needs a separate, secure partition of the O-RAN/MEC databases; and (iii) the slice xApps hosting near-RT RIC architecture modification is required. Moreover, the 5GC (sub-)network slice and O-RAN network slice has to be stitched together using native 5GC network slicing-related mechanisms, as defined by 3GPP [1].

As we pointed out, O-RAN, SON, MEC and NS technologies have great synergies, but also overlapping components of their architectures and key functions. There are still some issues to be solved, including integration of O-RAN with NS, use of O-RAN for SON and the integration of O-RAN services with 5GC services. A step in that direction has been described in [8]. For efficient integration, some components of the contributory technologies can be reused, and others must be removed to achieve overall synergy. There is, however, no doubt that continuous synergistic efforts across multiple standard developing organizations (SDO) and relevant industry fora will be needed for the global ecosystem to jointly pursue the full benefits of the future network with true ICDT deep convergence.

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5G is a Cornerstone Technology of the Fourth Industrial Revolution

Chris Pearson, President, 5G Americas

Last year, during the first year of 5G's rollout, I wrote that 5G was going to be a lot bigger [1] than you actually think. As a trade association representing the voice of LTE and 5G throughout the Americas, 5G Americas is of course biased toward thinking the technology is incredibly important, but there are some clear reasons to consider the historical significance of 5G. Let's take a look at why I think 5G is a cornerstone of the Fourth Industrial Revolution.

The fifth generation of wireless cellular, or "5G," is the epitome of the evolving state of technology in wireless telecom today. 1G was introduced in 1979 and was the first time that communications could occur over wireless telephony. 2G, introduced in 1991, was the first time the industry used digital signals. In 1998, 3G emerged and opened the door to data being transferred on mobile phones. 4G continued this high speed data communications trend in mobile devices and brought high quality video to the mobile Internet age beginning in 2008. At the end of 2018, the current era of 5G began, ushering in the capabilities of wireless cellular for the Fourth Industrial Revolution.

We are still in the early days of 5G's rollout. While there are 129 5G networks globally [2], as of the end of October 2020, consumers are really only beginning to take their first steps with a new handset or 5G device. Many of 5G's capabilities, such as "network slicing" or ultra-reliable low-latency communications, are still in various early stages of being implemented, as 5G standalone networks get deployed. As many of these new technological capabilities reach maturity, you will begin to see a convergence of technologies that will make up one of the fundamental shifts in the history of industry.

> When you think about the impacts of any one of these technologies, it is staggering. AI alone has ripple effects across virtually every facet of life. The combination of all these things together? Profound, and 5G is right at the center of it all.

What do I mean by that?

Let's take a look at that term: "Fourth Industrial Revolution" — what does it refer to? The First Industrial Revolution included the development of water and steam to mechanize production. The Second Revolution included electric power to open the door to mass production. The third involved electronics and information technology. That is the revolution that we are currently undergoing, so it is sometimes difficult to fully see all of its impacts. In the Fourth Industrial Revolution [3], physical, digital and biological systems will converge, enabled by the power of technologies such as artificial intelligence and machine learning, cloud computing, edge computing, robotics, virtual and augmented reality, automated vehicles and drones, blockchain, IoT, "in silico" technologies merging biology and data science, and of course, 5G to connect the real world with the digital world.

When you think about the impacts of any one of these technologies, it is staggering. AI alone has ripple effects across virtually every facet of life. The combination of all these things together? Profound, and 5G is right at the center of it all.

For instance, manufacturing is a huge vertical industry for 5G applications. There is intense demand to manage real-time, automated factory operations that require precise orchestration. Imagine the future factory with automated drones, robots, and vehicles moving around and in-and-out of the facility, all sending and receiving data wirelessly. This type of automation requires