RIC as the Next Generation SON for Open RAN and More – May 2021

From the base station controller (BSC) to 3GPP self-organizing networks (SON), the radio access network intelligent controller (RIC) becomes the next gen SON for all Gs

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Produced in association with Mavenir

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Key Takeaways: RIC is the next gen exoteRIC[1] SON that supports all Gs

As the mobile industry is entering its fourth decade of existence, 5G rollouts are gaining momentum and new innovative mobile architectures are being adopted worldwide. In 5G, D-SON and C-SON functions morph into a radio access network intelligent controller (RIC) platform. As a result, the need for D-SON and C-SON split goes away; D-SON paved the way to Near-real-time (Near-RT) RIC while Non-real-time (Non-RT) RIC replaces C-SON. However, with its open interfaces, RIC is G agnostic and rapidly becoming the much-needed next generation SON that can be deployed in all generations of RANs.

RIC enables open innovation in the RAN domains, gives RAN control and operations back to the communications service providers (CSPs). In addition, RIC allows fine-grained user equipment policy deployments, provides predictive and reactive RAN automation, and enables proactive network resource management and service differentiation. And finally, with its xApp domain, RIC fosters the development of a large ecosystem that allows end-to-end cloud-native telecom software provider Mavenir to develop and market its own next gen SON product and services suite.

Consequently, RIC is expected to disrupt the $1.3B global C-SON software and services market, which for the past decade, has remained a niche market for a dozen of specialists. C-SON needs tight integration with the OSS and is embedded in proprietary RAN 4G nodes, D-SON comes for free. LightCounting expects RIC SON apps sales to account for 40% of the global C-SON market in 2025.

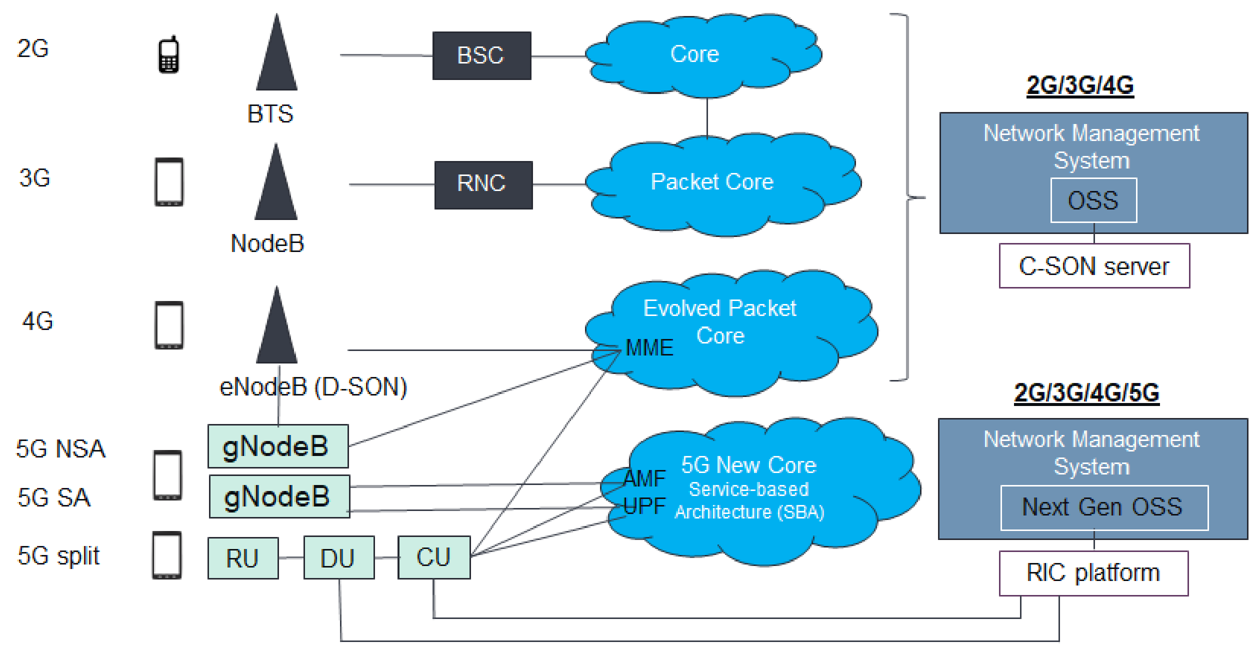
All in all, this outcome would have never been achieved without the forward-looking work conducted by the O-RAN Alliance and the ONAP Optimization Framework in the 2016–2018 timeframe.

[1] Unlike esoteric SON, RIC is exoteric or intended for a broader reach

RIC is the next gen SON

As mobile networks evolve, so does their radio access network (RAN) controller and management system, generation after generation. Figure 1 provides a simplified illustration of the long and never-ending mobile network architecture transformation journey and highlights the evolution of the radio controller through its generational iteration to eventually incorporate self-organizing network (SON) functions and become a programmable and open RAN intelligent controller (RIC).

Figure 1: From the BSC to the RIC



Source: LightCounting

AS 5G BRINGS WEB SCALE INNOVATION TO TELECOMS, THE NEED FOR A RIC AS A NEXT GEN SON HAS NEVER BEEN GREATER

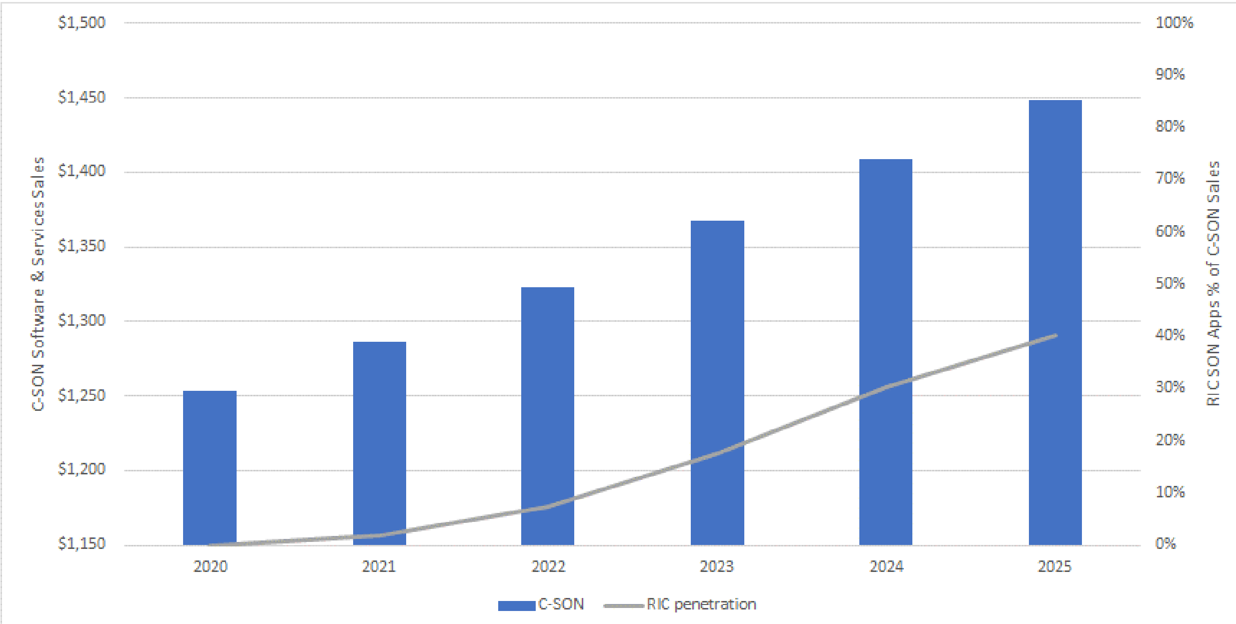
As illustrated in Figure 1, 5G is adding a new layer of complexity to existing multi-generational legacy cellular networks that will need some degree of inter-working for some time to come, even though CSPs have been gradually sunsetting 2G and/or 3G networks to re-farm the spectrum for 4G. For CSPs in the situation described in Figure 1, the RIC is more agile, scalable, flexible, and most importantly open platform for RAN Analytics and AI algorithms than to keep on adding new proprietary distributed and/or centralized SON (D-SON/C-SON) modules to their existing closed SON, provided they have one already. 5G brings web scale innovation to telecoms, from the Kubernetes platform to microservice-based application architecture. The benefit is the velocity of innovation, which can be realized by opening up the RAN Analytics and AI platform (i.e. RIC) to multi-vendor and non-RAN vendor communities.

In addition, the true promise of 5G is to enable a plethora of use cases grouped in 3 categories such as enhanced mobile broadband (eMBB), massive machine type communications (mMTC), and ultra-reliable low latency communications (URLLC), which all have different and diverging requirements that need to be met over a single programmable cloud-native architecture design.

WITH ITS OPEN INTERFACES, THE RIC PLATFORM BECOMES THE NEXT GEN SON FOR ALL RAN ARCHITECTURES

C-SON remains a niche market characterized by a dozen specialist vendors with proprietary offerings. In addition, a C-SON needs to be tightly integrated with the OSS and this is the only interface shared between the vendor and the CSP. In fact, in order to have full control of their C-SON, some CSPs developed their own in-house modules. When it comes to D-SON, it is another proprietary and closed box controlled by a handful of RAN vendors with no scope for open innovation. And as they are embedded in 4G eNodeBs and provided by the usual traditional proprietary RAN vendors, D-SON functions come for free. Figure 2 shows global C-SON software and services sales topped $1.3B in 2020 and are expected to surpass the $1.4B bar in 2025, growing at a CAGR of 3%.

Figure 2: Global C-SON market and RIC SON Apps as a % of C-SON sales ($M)



Source: LightCounting Market Research – October 2020

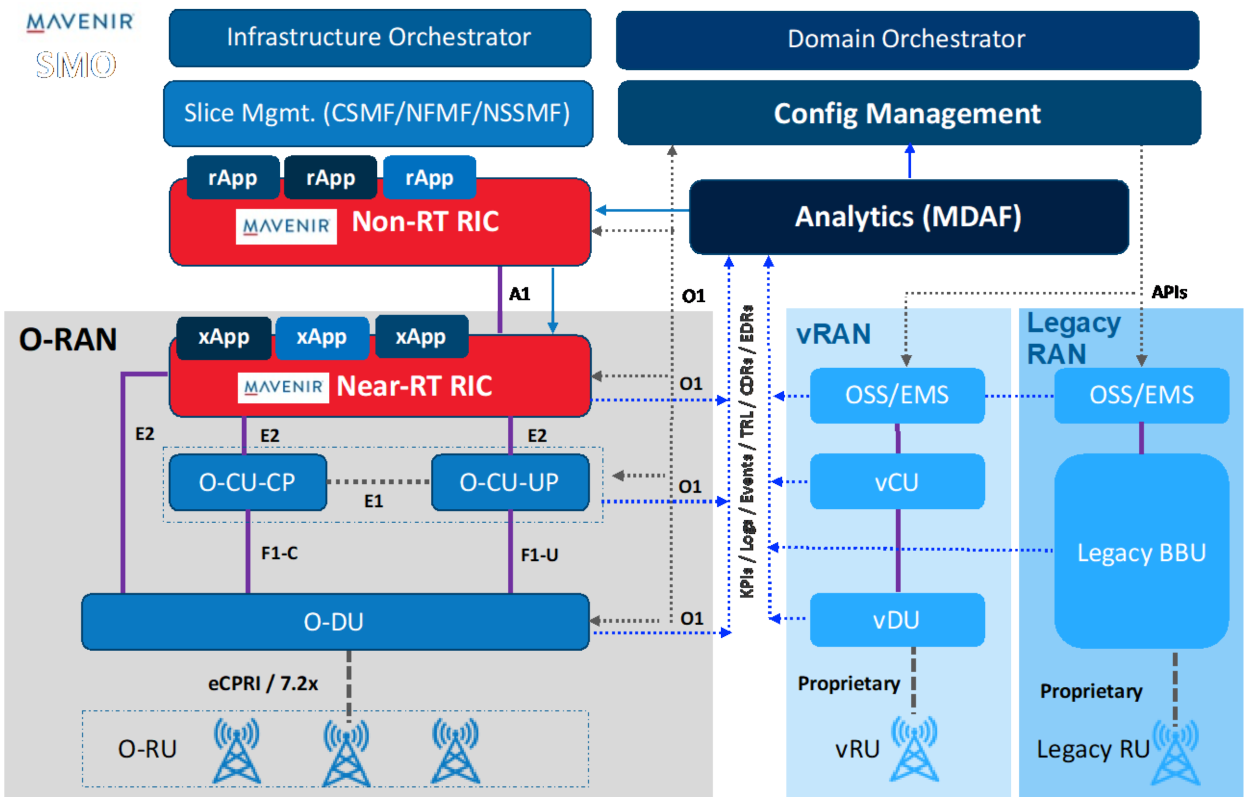
THE NEW RIC ENVIRONMENT IS A TOTAL DEPARTURE FROM THE C-SON AND D-SON WORLD AS WE KNOW IT

RIC's open interfaces and APIs allow CSPs to pick and choose the best of breed for each RIC component. In other words, Near-real-time (Near-RT) RIC replaces D-SON and Non-real-time (Non-RT) RIC replaces C-SON (see Figure 2). As a result of such great flexibility, RIC:

- Enables open innovation in the RAN domain
- Gives RAN control back to the CSPs
- Allows fine-grained UE policy deployments
- Provides near real-time RAN automation
- Enables proactive network resource management and service differentiation

LightCounting Market Research's CSP survey conducted in 2020 led to the conclusion that RIC SON apps sales have the potential to account for 40% of global C-SON sales in 2025.

Figure 3: RIC for all RAN architectures



Source: Mavenir

RIC ENABLES OPEN INNOVATION IN THE RAN DOMAIN

Showed in Figure 3, the Near-RT application layer opens the door to 3rd party apps (e.g., xApp) controlling radio resource management and therefore fosters innovation. This is in staggering contrast with the traditional closed proprietary RAN development approach that has been controlling the space for the past 3 decades or so; only a handful of vendors had access to RAN feature development.

RIC GIVES RAN CONTROL BACK TO THE CSPS…

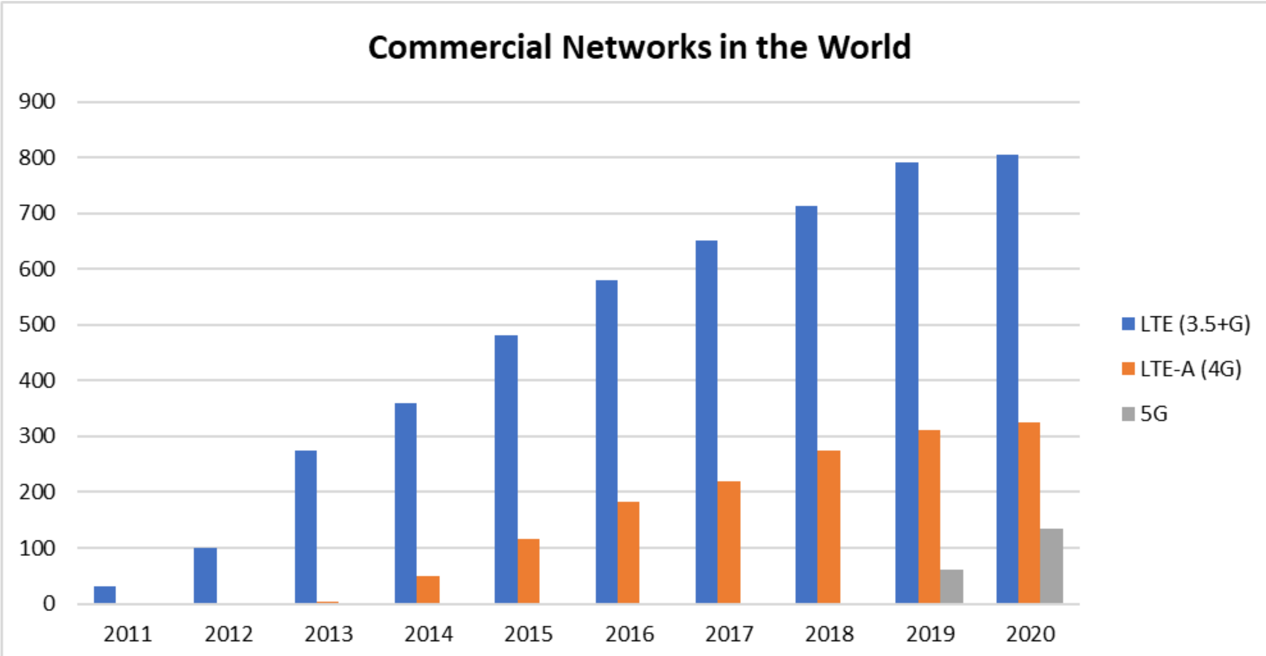
The core algorithms executing in or above the Non-RT RIC will be developed and owned by the CSPs, some aspects of which may be proprietary. This will provide them with the capability to modify the RAN's behaviors by deploying different policies and models optimized to individual CSP intents and objectives.

…AND WITH MORE THAN 800 LTE NETWORK IN THE WORLD, RIC IS THE IDEAL SON PLATFORM TO GIVE CSP CONTROL OVER THEIR OPERATIONS

Take drive testing for example, this task aimed at ensuring great quality of cellular services continues to be time consuming and costly. Preliminary RIC testing suggests that the algorithms in RIC can achieve same or better performance improvements without requiring extensive drive testing and post processing of data. That way, the drive testing process is minimized and leads to cost saving. And RIC for drive testing can be performed for all RAN architectures. In fact, while 5G rollouts are happening at a fast pace, we are still living in an LTE world with many networks lacking a SON component. According to the GSA, as of mid-December 2020, 135 CSPs in 58 countries had launched one or more 3GPP-compliant 5G services including mobile and fixed wireless access (FWA) services, up from 125 CSPs at the end of 3Q20; and Figure 4 indicates the number of LTE networks has reached a plateau of around 800.

This means the planet has reached the stage of having all live cellular networks migrated to LTE and ready for LTE-Advanced (LTE-A) upgrades to pave the way for 5G. However, with 324 live LTE-A networks worldwide, there is still a long way to go before reaching a true all 4G world. Ongoing RIC developments provide the CSPs with a new opportunity to revisit their network optimization and automation needs. Put another way, CSPs should strongly consider the implementation of a RIC approach for future network upgrades because RIC fully supports backward compatibility with a wide range of SON apps.

Figure 4: Number of commercial networks – LTE/LTE-A/5G



Source: Global mobile Suppliers Association (GSA), LightCounting

RIC ALLOWS FINE-GRAINED UE POLICY DEPLOYMENTS

In many cases, analytics, intents and policies defined for the Non-RT RIC are mapped to sub-policies, actions, parameter changes, analytics/learning tasks, etc., to steer the operation of the RAN through configuration changes and via the Near-RT RIC. Such changes enhance the local analytics/learning and decision processes in the Near-RT RIC to be enriched by higher-level context and goals. As a result, localized near-real-time decisions about load-balancing, ID allocations, handover decisions, resource allocations, etc., can greatly benefit from adjustment and guidance about the CSPs' high-level network-wide intents and therefore allow fine-grained UE policy deployment.

RIC PROVIDES PREDICTION-BASED NEAR REAL-TIME RAN AUTOMATION

Enhancing existing D-SON and C-SON functions in an innovative RIC platform augmented with AI/ML capabilities enable much needed RAN automation. It is worth noting that from 2G to 5G, mobile networks went from a dozen to thousands of key performance indicators (KPIs). When the first LTE commercial networks emerged in 2010, CSPs started to report the rising and overwhelming amount of network data they had to analyze and sort out to identify which data to prioritize. In 2013, early C-SON rollouts provided some level of relief through automation of a few selected use cases (e.g., drive testing for example). With 5G, considering a typical CSP network consists of 10,000 clouds ready for network slicing that requires highly distributed and hierarchical orchestration, given those complexities, AI/ML-powered SON automation is a must-have.

RIC ENABLES PROACTIVE NETWORK RESOURCE MANAGEMENT…

With the amount of L1/L2/L3 data collected from eNB/gNB (including CU/DU), useful data features and models can be learned or abstracted to empower intelligent control and management in the RAN. For example, network spatial-temporal traffic patterns, user mobility patterns, service type/patterns along with the corresponding prediction models, network quality of service (QoS) prediction patterns, massive MIMO parameters configuration, and more, can be reused, abstracted, or learned. This information can then be combined with additional network-wide context and policies to drive fine-grained near-real-time network radio resource management in the Near-RT RIC and non-real-time optimization within Non-RT RIC.

…AND SERVICE DIFFERENTIATION

In a highly competitive marketplace characterized by a low single digit revenue growth, the overall RIC capabilities enable much needed service differentiation. In the current environment, CSPs are using the same RAN equipment and therefore cannot differentiate themselves and fail to create customer stickiness. With RIC, each CSP can define its own control application to turn up and deliver tailored services in a unique manner.

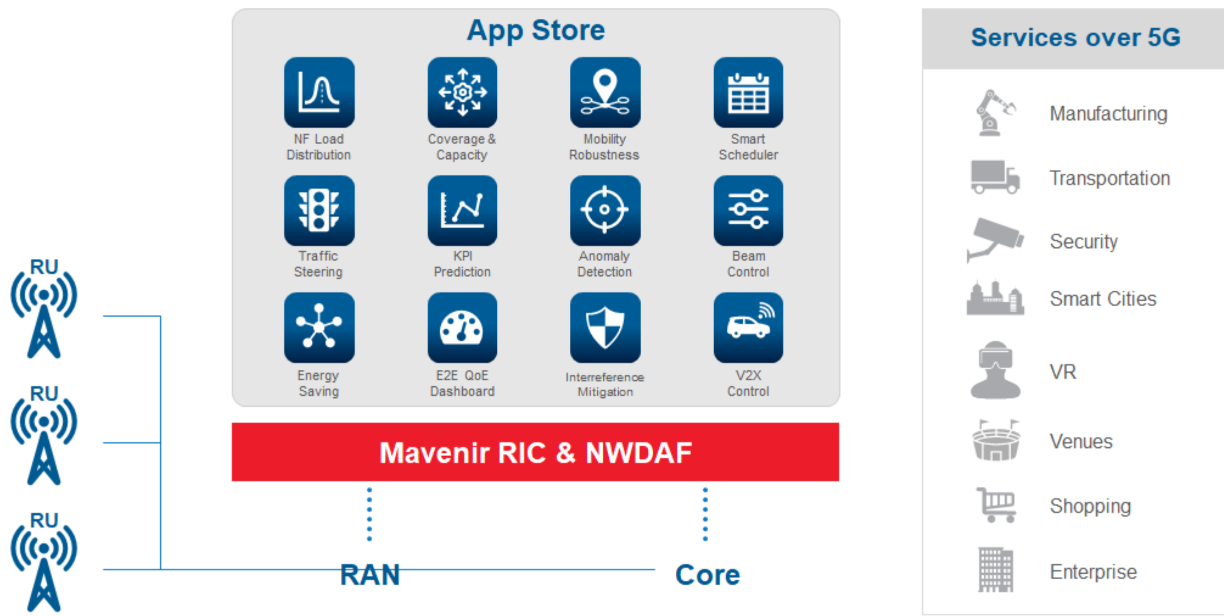
MAVENIR EMBRACES THE RIC CONCEPT TO DEVELOP ITS OWN NEXT GEN SON AND FRAMEWORK

Fueled by the U.S. initiative to ban the use of Chinese vendor RAN equipment, open RAN and virtual RAN developments went from incipient to booming over the past 2 years. As a result, a new ecosystem composed of a broad variety of new players has emerged. Among them, Mavenir has become a leading provider of end-to-end cloud-native network software for CSPs' 2G/3G/4G/5G networks.

To support next generation networks, Mavenir offers a Universal Radio Controller with a comprehensive application catalogue (xApps and rApps), that can manage both O-RAN compliant and legacy RAN, simultaneously. Mavenir's Universal Radio Controller has an AI Engine as a core element of its architecture, along with the ability to train and deploy ML models for both its near-real time and non-real time components. Service Management and Orchestration (SMO) functionality is also supported by its Universal Radio Controller platform (Figures 3 and 4). Furthermore, Mavenir's controller provides a comprehensive and growing application catalogue with key SON functions, like Coverage and Capacity Optimization (CCO), Mobility Robustness Optimization (MRO), Mobility Load Balancing (MLB), Automatic Neighbor Relation (ANR) and Physical Cell Identity (PCI) Conflict Detection and Resolution, described in the next section of this report. More complex use cases like traffic steering, QoS/QoE optimization and MIMO beamforming optimization are also supported. Finally, the controller supports interworking with third party xApps and rApps, aligned with O-RAN Alliance's multi-vendor ecosystem principle, that gives CSPs more choices and a path to faster innovation. By combining the controller (RIC), fully virtualized CU and DU, and RU, Mavenir offers an end-to-end RAN solution for CPSs.

As a member of and a contributor to the xRAN Forum (now in the O-RAN Alliance), Mavenir has been heavily involved in RIC development and has designed a platform that truly delivers open innovation in the RAN domain, gives RAN control back to CSPs, allows fine-grained UE policy deployments, provides RAN automation, enables proactive network resource management and CSP service differentiation. And finally, as RAN functions are virtual (e.g., vDU, vCU), all G services can be enabled. For example, in 2G and 3G, the BSC and the RNC are virtualized, respectively.

Figure 5: Mavenir's RIC framework and applications



Source: Mavenir

RIC origins: From BSC to D-SON and C-SON

The journey started in the nineties with 2G and circuit switched services. At the 2G cell site, the base transceiver station (BTS) hosts the antennas and handles the radio link protocols with the mobile switching center (MSC) located in the core. In between resides the base station controller (BSC), which is the connection between the BTS and the MSC. The BSC manages the radio resources for one or more BTS, and handles radio channel setup, frequency hopping, and handovers.

In 3G, the BSC became the radio network controller (RNC) and in 4G LTE, as part of the migration from circuit switched to packet networking, some of the RNC functions shifted to the MME located in the Evolved Packet Core (EPC), which technically is a converged IP core and the remaining radio resource control functions moved to eNB. That way, any cell site (eNB) could be connected anywhere in the network to connect to a pool of MMEs through the IP network, while the near real-time radio resource control remains with the eNBs.

BAKED IN LTE, D-SON IS IN EVERY 4G NETWORK AND C-SON ACTS AS THE 2G/3G/4G ORCHESTRATOR

Defined by the NGMN in 2008 and standardized by the 3GPP in Rel.8 (Release 8), SON has been around for a decade and took off when LTE rollouts started in 2010. After all, it was designed to self-configure, self-optimize and self-heal LTE and 4G LTE-Advanced networks and is in fact an integral part of LTE. The SON architecture commonly seen in mobile networks can be distributed, centralized or hybrid:

- **D-SON** (Distributed SON): functions are embedded in LTE base stations, known as eNodeBs, supplied by RAN vendors; in other words, SON functions are distributed among the eNodeBs at the edge of the network
- **C-SON** (Centralized SON): functions are located at the OSS level and manage an entire network of eNodeBs and act as an orchestrator; C-SON implements proprietary algorithms to provide some level of automated optimization and requires inter-working with eNodeB suppliers and therefore can be supplied by third parties only after a costly integration effort, since the interfaces are not standardized. Also, it cannot host multi-vendor SON algorithms because the SON vendor provides all the algorithms
- **Hybrid SON**: a mix of D-SON and C-SON

Although self-configuration and self-optimization is mission accomplished, self-healing with real-time closed loop automation to deliver on the concept of a zero human touch network with full automation remains a work in progress in the 5G domain.

ANR AND PCI ACHIEVE SELF-CONFIGURATION…

Each eNB has a dynamic plug-and-play configuration. When newly deployed and added to the network, the eNB will by itself configure the Physical Cell Identity (PCI), transmission frequency and power, leading to faster cell planning and rollout. To further reduce manual work Automatic neighbor relations (ANR) is used. ANR configures the neighboring list in newly deployed eNBs and optimizes the list's configuration during operation. This is how ANR and PCI features work with D-SON. This gets augmented with oversight from C-SON to blacklist poorly performing neighbor relationships after system level analysis of performance per neighbor or due to other operational criteria. C-SON also provides a better and faster, more deterministic way of PCI collision mitigations.

…AND MLB AND MRO ACHIEVE SELF-OPTIMIZATION

Mobility load balancing (MLB) is a function that allows cells suffering congestion to transfer load to other cells that have spare resources. It also allows the communication service provider (CSP) to distribute load across all the frequency layers it has deployed. MLB in a D-SON setting includes load reporting between eNBs to exchange information about load levels and available capacity.

Mobility robustness optimization (MRO) performs automatic detection and correction of errors in the mobility configuration, and tunes parameters related to handover such as measurement intervals and thresholds.

Other commonly deployed features include:

- Random access channel (RACH) optimization to minimize the number of attempts on the RACH channel that cause interference
- Coverage and capacity optimization (CCO) to enable automatic correction of capacity problems that arise from the slowly changing environment due for instance to seasonal variations.
- Minimization of drive tests (MDT) to enable normal user equipment (UE) to provide the same type of information as those collected in drive test.

ALL C-SON PRODUCTS EXTRACT OSS DATA FOR SELF-OPTIMIZATION

Since the beginning, C-SON has been deployed for ANR, cell configuration, power control, and management of interference and load at the network operations center (NOC) where it is connected to the OSS. When introducing a C-SON into a network, it must be tightly integrated with OSS processes because network data collection occurs there. C-SON requires network data and some customer relationship management (CRM) data.

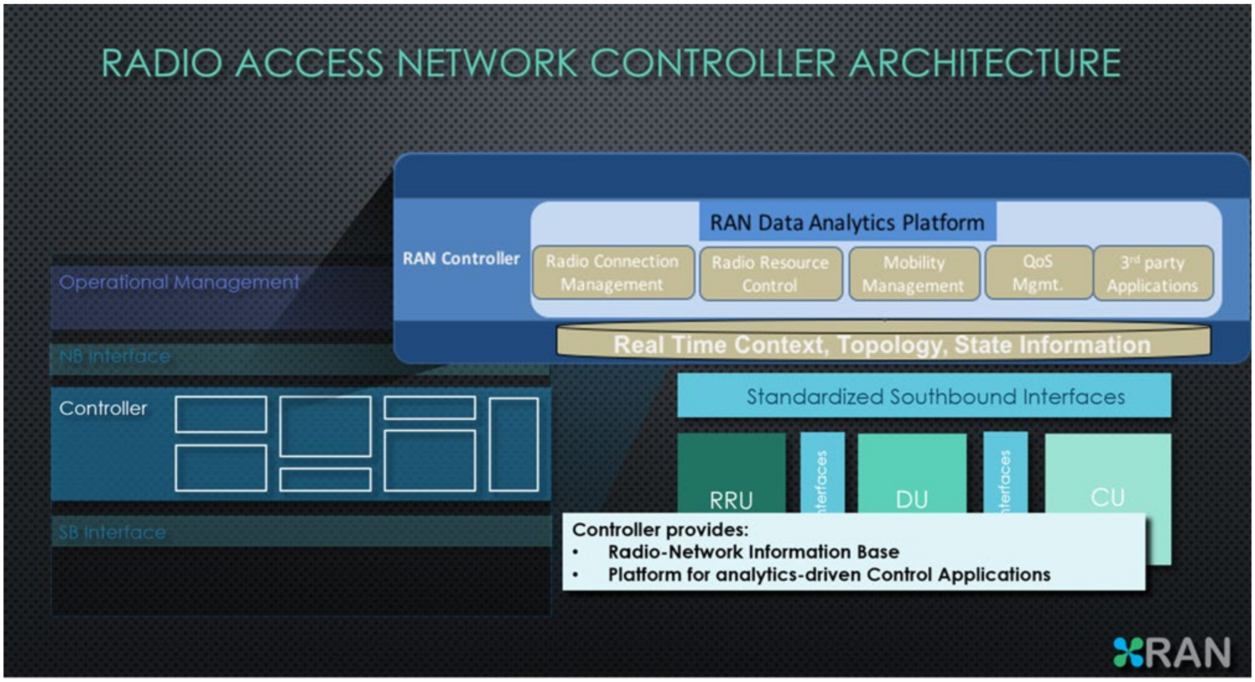
This OSS-level SON first appeared in 2008 in 3GPP Rel. 8 and was further expanded with additional use cases in Rel. 9 in 2010 and 2011. C-SON's optimization algorithms reside in the network management system (NMS) or a central SON server that manages all edge radio nodes. It orchestrates the behavior of RAN equipment across an entire network consisting of multi-vendor and multi-technology network elements (NEs). C-SON can take into consideration data from all nodes in the network to identify and address network-wide issues. And since the control of all SON functions is done centrally, these interactions can easily be coordinated and managed using a variety of resolution techniques.

THE XRAN FORUM PUBLISHED NORTH- AND SOUTH-BOUND INTERFACES

Prior to merging with the C-RAN Alliance and becoming the O-RAN Alliance at the Mobile World Congress in February 2018, the xRAN Forum was founded in June of 2016 by AT&T, Deutsche Telekom, SK Telecom and Dr. Sachin Katti, professor at Stanford University, to develop, standardize, and promote an open alternative to the traditionally closed proprietary hardware-based RAN architecture. The idea was to develop a software-based, extensible RAN (xRAN) with standardized critical elements of the xRAN architecture. xRAN fundamentally advanced RAN architecture in three areas, namely it (see Figure 6):

- Decoupled the RAN control plane from the user plane
- Built a modular eNB software stack (BBU disaggregation into DU and CU) that operates on common-off-the-shelf (COTS) hardware
- Published open north- and south-bound interfaces to the industry

Figure 6: xRAN Forum's RAN controller architecture



Source: xRAN Forum (now in O-RAN Alliance)

AND ITS XRAN CONTROLLER IS RIC'S NEAR-REAL TIME PREDECESSOR

Within a year, the RAN controller architecture was born with its key RAN data analytics components (e.g., radio connection management, radio resource control, mobility management, QoS management, and 3rd party Apps), which paved the way to the O-RAN Alliance RIC concept. All this would not had been achieved without the leadership from operators AT&T, Deutsche Telekom, NTT DOCOMO, SK Telecom, Telstra, and Verizon as well as the vendor community including Altiostar, Amdocs, Aricent, ASOCS, Blue Danube, Ciena, Cisco, Commscope, Fujitsu, Intel, Mavenir, NEC, Netsia, Nokia, Radisys, Samsung, Stanford University, Texas Instruments, and the University of Sydney.

ONAP'S OOF IS RIC'S NON-REAL TIME PREDECESSOR

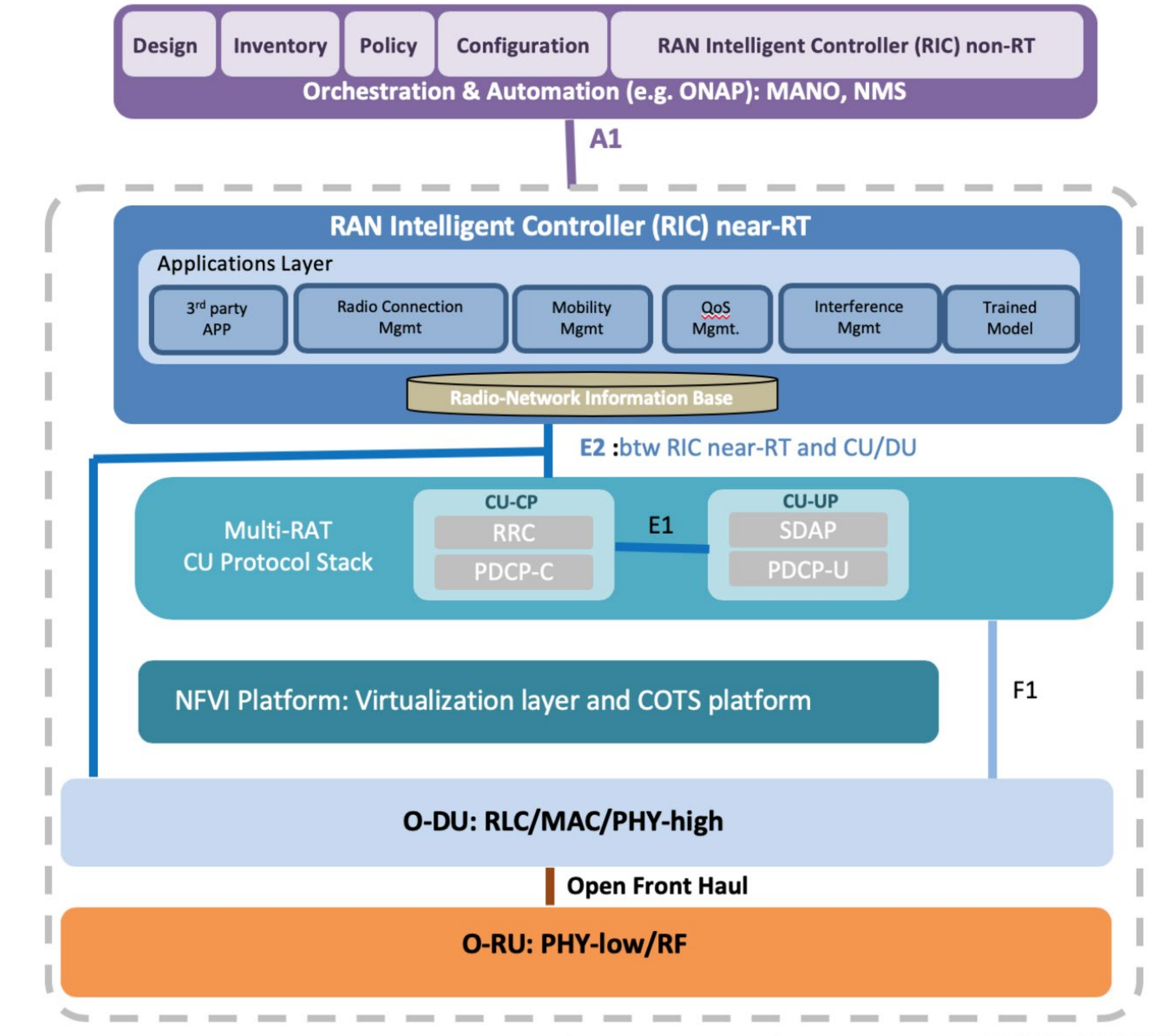
Proposed in the 2017–2018 timeframe, the ONAP Optimization Framework (OOF) successfully demonstrated how to optimize and enhance D-SON PCI and ANR functions by implementing an ONAP-based SON, which in turn paved the way for the O-RAN Non-real-time RIC.

WITH THE ADVENT OF NON-REAL-TIME AND NEAR-REAL-TIME RIC, THE NEED FOR D-SON AND C-SON SPLIT GOES AWAY

All RAN optimization and RAN orchestration get ultimately merged in the RIC as a universal RAN controller. Figure 7 depicts the ORAN Alliance RIC architecture.

- **Non-real-time (Non-RT) RIC**: supports non-real-time intelligent radio resource management, optimization of RAN parameters, policy-based optimization, and provides guidance, parameters, policies, and Artificial Intelligence/Machine Learning (AI/ML) models to support the operation of the Near-RT RIC. The Non-RT RIC functions include service and policy management, RAN analytics, and model-training. The rApps in the Non-RT RIC perform their optimization control loops in non-real time (order of minutes or hours).
- **Near-real-time (Near-RT) RIC**: factors out some of the radio resource management control loops from the gNodeB to a more open platform where they can be customized. The xApps in the Near-RT RIC can respond to events from the CU and DU in near-real time (order of several to a few tens of milliseconds).

Figure 7: Non-real time and Near real-time RIC



Source: O-RAN Alliance

BOTTOM LINE: RIC IS INDEED THE DE FACTO NEXT GEN SON

History indicates that the O-RAN Alliance came up with RIC to enable fine grained UE/service level real-time control and AI/ML-based radio resource management (RRM) optimization, which are being merged with the existing C-SON functionality. This forms the foundation of the next gen SON.

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