O-RAN: Towards an Open and Smart RAN

White Paper
October 2018

Acknowledgements

Special thanks must be given to the numerous people contributing to the White Paper, including

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Executive Summary

As mobile traffic increases, mobile networks and the equipment that runs them must become more software-driven, virtualized, flexible, intelligent and energy efficient. The O-RAN Alliance is committed to evolving radio access networks– making them more open and smarter than previous generations. Real-time analytics that drive embedded machine learning systems and artificial intelligence back end modules will empower network intelligence. Additional virtualized network elements with open, standardized interfaces will be key aspects of the reference designs developed by the O-RAN Alliance. Technologies from open source and open white-box network elements will be important software and hardware components of these reference designs.

The O-RAN Alliance is in pursuit of the vision of openness and intelligence for the next generation wireless networks and beyond.

- **Openness** – Building a more cost-effective, agile RAN requires openness. Open interfaces are essential to enable smaller vendors and operators to quickly introduce their own services, or enables operators to customize the network to suit their own unique needs. Open interfaces also enable multi-vendor deployments, enabling a more competitive and vibrant supplier ecosystem. Similarly, open source software and hardware reference designs enable faster, more democratic and permission-less innovation.

- **Intelligence** – Networks will become increasingly complex with the advent of 5G, densification and richer and more demanding applications. To tame this complexity, we cannot use traditional human intensive means of deploying, optimizing and operating a network. Instead, networks must be self-driving, they should be able to leverage new learning based technologies to automate operational network functions and reduce OPEX. The O-RAN alliance will strive to leverage emerging deep learning techniques to embed intelligence in every layer of the RAN architecture. Embedded intelligence, applied at both component and network levels, enables dynamic local radio resource allocation and optimizes network-wide efficiency. In combination with O-RAN's open interfaces, AI-optimized closed-loop automation is achievable and will enable a new era for network operations.

Toward this end, O-RAN Alliance is adopting the following principles.

- Leading the industry towards open, interoperable interfaces, RAN virtualization, and big data enabled RAN intelligence.
- Maximizing the use of common-off-the-shelf hardware and merchant silicon and minimizing proprietary hardware.

- Specifying APIs and interfaces, driving standards to adopt them as appropriate, and exploring open source where appropriate.

This white paper will provide readers with valuable insight into the motivation and plans of the O-RAN Alliance including:

- Challenges with conventional RAN,
- The vision for the future, and objectives for the Alliance
- The O-RAN Architecture
- Planned workgroup focus

Why O-RAN Alliance? – Trends driving the need for an operator driven industry alliance

The mobile industry is at a tipping point. At the end of 2017, there were 4.8 billion unique mobile subscribers representing 65% of the world's population, but mobile subscriber growth is slowing to a compound annual growth rate of 4.2% over the next few years to 2020, according to (GSMA, 2017); so revenue growth is limited. But, the volume and variety of mobile traffic continues to surge. According to (Cisco, 2018), mobile data traffic will increase sevenfold between 2016 and 2021, growing at a 47% annual growth rate. The number of Internet of Things (IoT)connected devices is also rapidly increasing. (Gartner, 2017). At the same time, 5G network capabilities are pioneering ultra low-latency (ULL) applications and, for the first time, massive machine-type communications, which will drive the volume and variety of data traffic ever higher.

Mobile operators are under pressure to meet this increasing capacity demand while containing costs and launching new offerings in highly competitive mobile services markets. Something must give. Operators cannot carry on business-as-usual and expect to meet surging bandwidth demand, compete with web-scale rivals and prepare for a 5G future. The cost-per bit model must change and revenue generating services must be explored.

These trends have spurred significant change in the network core recently with the advent of SDN and NFV, which have enabled building a more agile, less expensive network core. However, the RAN has largely remained untouched which is surprising given that the majority of the CAPEX and OPEX in building and managing networks is in the RAN. In general, its estimated that 65-70% of the total cost of ownership of a network is in the RAN.

Our goal in O-RAN is to bring a similar revolution to the RAN. First, we aim to bring cloud scale economics to the RAN. This has multiple layers, from being able to use off-the-shelf hardware to designing software in a modular fashion to enable scale out designs for capacity, reliability and availability, rather than expensive scale up designs to highly automated ways of managing and optimizing the infrastructure. These attributes have been a big source of web-services' companies' ability to build large scale yet cost effective clouds, and we aim to bring the same economics to the RAN.

Second, we aim to bring agility to the RAN. This has multiple layers, from being able to quickly tune the RAN to adapt to new services/applications to operators being able to tune the network to their unique needs without having to wait on vendors to deliver features to enabling smaller vendors or even operators to introduce their own products/features into the RAN without requiring significant cooperation from the traditional vendors. The eventual goal is to bring a dev ops culture to the RAN, enabling fast development, testing and iteration of the RAN stack.

The O-RAN Alliance Vision

The O-RAN Alliance was founded by operators to clearly define requirements and help build a supply chain eco-system to realize the above objectives. To accomplish these objectives, the O-RAN Alliance's work will embody the following two themes:

Openness -- We cannot bring service agility and cloud scale economics to the RAN without openness. Open interfaces are essential to enable smaller vendors and operators to introduce their own services, or customize the network to suit their own unique needs. Open interfaces also enable multi-vendor deployments, enabling a more competitive and vibrant supplier ecosystem. Similarly, open source software and hardware reference designs enable faster, more democratic and permission-less innovation.

Intelligence – Networks will become increasingly complex with the advent of 5G, densification and richer and more demanding applications. To tame this complexity, we cannot use traditional human intensive means of deploying, optimizing and operating a network. Instead, networks must be self-driving, they should be able to leverage new learning based technologies to automate operational network functions and reduce OPEX. The O-RAN alliance will strive to leverage emerging deep learning techniques to embed intelligence in every layer of the RAN architecture. Embedded intelligence, applied at both component and network levels, enables dynamic local radio resource allocation and optimizes network-wide efficiency. In combination with open interfaces, AI-optimized closed-loop automation is achievable and will enable a new era for network operations.

O-RAN Alliance members and contributors have committed to evolving radio access networks around the world. Future RANs will be built on a foundation of virtualized network elements, white-box hardware and standardized interfaces that fully embrace O-RAN's core principles of intelligence and openness. An ecosystem of innovative new products is already emerging that will form the underpinnings of the multi-vendor, interoperable, autonomous, RAN, envisioned by many in the past, but only now enabled by the global industry-wide vision, commitment and leadership of O-RAN Alliance members and contributors.

The key principles of the O-RAN Alliance include:

- Lead the industry towards open, interoperable interfaces, RAN virtualization, and big data enabled RAN intelligence.
- Specify APIs and interfaces, driving standards to adopt them as appropriate, and exploring open source where appropriate.
- Maximize the use of common-off-the-shelf hardware and merchant silicon and minimizing proprietary hardware.

In line with the principles, the O-RAN alliance's workgroups will focus on the following fundamental dimension:

Software Defined, AI enabled RAN Intelligent Controller. A key principle of the O-RAN architecture is to extend SDN concept of decoupling the control-plane (CP) from the user-plane (UP) into RAN while bringing in embedded intelligence. This extends the CP/UP split of CU, being developed within 3GPP through the E1 interface, and further enhances the traditional RRM functions with embedded intelligence by introducing the hierarchical (Non-RT and Near-RT) RAN Intelligent Controller (RIC) with the A1 and E2 interfaces.

The first benefit decoupling offers is to allow the UP to get more standardized, since most of the variability is in the CP. This allows easy-scaling and cost-effective solutions for the UP. The second benefit is to allow for advanced control functionality, which delivers increased efficiency and better radio resource management. These control functionalities will then leverage analytics and data-driven approaches including advanced ML/AI tools.

O-RAN will lead the industry to develop AI-enabled, hierarchical RIC. Workgroups will develop specifications, software reference designs, drive operator proof-of-concepts and support operator field trials. Even the most complex networks supporting the O-RAN AI-enabled RIC will have the inherent ability to offer efficient, optimized device and radio resource management through closed-loop control.

RAN Virtualization. RAN cloudification is one of the fundamental tenets of the O-RAN architecture. Operators are delivering NFVI/VIM requirements to enhance virtualization platforms in support of various splits. For example: high layer split between PDCP and RLC, low layer split within PHY. Whenever possible, the O-RAN Alliance will leverage and verify the performance of relevant open source communities including – OPNFV, ONAP, Akraino, K8S, OpenStack, QEMU – to design key solutions such as programmable hardware accelerators, real time processing, light weight virtualization technologies.

Open Interfaces. The O-RAN reference architecture is built on a set of key interfaces between multiple decoupled RAN components. These include enhanced 3GPP interfaces (F1, W1, E1, X2, Xn) for true multi-vendor interoperability. Additional O-RAN Alliance specified interfaces include an open fronthaul interface between the DU and RRU, an E2 interface, and an A1 interface between orchestration/NMS layer containing the non-real-time RIC (RIC non-RT) function and the eNB/gNB containing the near-real-time RIC (RIC near-RT) function.

White box hardware. To take full advantage of the economies of scale offered by an open computing platform approach, O-RAN Alliance reference designs will specify high performance, spectral and energy efficient white-box base station hardware. Reference platforms support a decoupled approach and offer detailed schematics for hardware and software architecture to enable both the BBU and RRU.

Open Source software. The O-RAN Alliance understands the value and supports the goals and objectives of open source communities. Many components of the O-RAN architecture will be delivered as open source, through existing communities. These components include: the RAN intelligent controller, protocol stack, PHY layer processing and virtualization platform. The O-RAN open-source software framework will not only implement the de facto interfaces, including F1/W1/E1/E2/X2/Xn, but also expects to offer the reference design for next generation RRM with embedded intelligence to enable the RIC.

Introducing the O-RAN Architecture

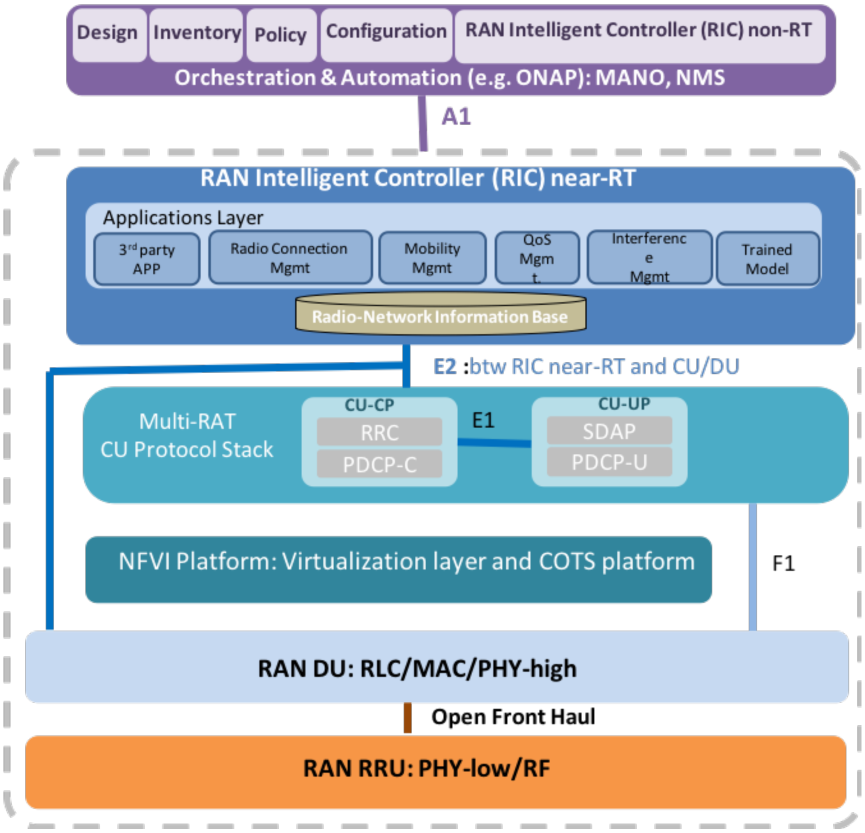

Figure 1: O-RAN Alliance Reference Architecture

The O-RAN Reference Architecture is designed to enable next generation RAN infrastructures. Empowered by principles of intelligence and openness, the O-RAN architecture is the foundation for building the virtualized RAN on open hardware, with embedded AI-powered radio control, that has been envisioned by operators around the globe. The architecture is based on well-defined, standardized interfaces to enable an open, interoperable supply chain ecosystem in full support of and complimentary to standards promoted by 3GPP and other industry standards organizations.

The salient features and functional modules of the O-RAN reference architecture include:

RAN Intelligent Controller (RIC) non-Real Time (non-RT) layer

Non-RT control functionality (> 1s) and near-Real Time (near-RT) control functions (< 1s) are decoupled in the RIC. Non-RT functions include service and policy management, RAN analytics and model-training for the near-RT

RAN functionality. Trained models and real-time control functions produced in the RIC non-RT are distributed to the RIC near-RT for runtime execution.

Relevant interface – A1 is the interface between Orchestration/NMS layer containing RIC non-RT and eNB/gNB containing RIC near-RT. With the introduction of A1, network management applications in RIC non-RT are able to receive and act on highly reliable data from the modular CU and DU in a standardized format. Messages generated from AI-enabled policies and ML-based training models in RIC non-RT are conveyed to RIC near-RT. The core algorithm of RIC non-RT is developed and owned by operators. It provides the capability to modify the RAN behaviors by deployment of different models optimized to individual operator policies and optimization objectives.

RAN Intelligent Controller (RIC) near-Real Time (near-RT) layer

The O-RAN reference architecture provides next generation RRM with embedded intelligence, while optionally accommodating legacy RRM. RIC near-RT is completely compatible with legacy RRM and begins by enhancing well understood, but operational challenging functions such as per-UE controlled load-balancing, RB management, interference detection and mitigation. In addition, it provides new functions leveraging embedded intelligence, such as QoS management, connectivity management and seamless handover control. The RIC near-RT delivers a robust, secure, and scalable platform that allows for flexible on-boarding of third-party control-applications. RIC near-RT functions leverages a database called the Radio-Network Information Base (R-NIB) which captures the near real-time state of the underlying network via E2 and commands from RIC non-RT via A1.

Relevant interfaces (A1 & E2) –A1, as described above, is the interface between RIC non-RT and modular CU which contains RIC near-RT. E2 is the interface between the RIC near-RT and the Multi-RAT CU protocol stack and the underlying RAN DU. Originated from the interface between legacy RRM and RRC in traditional systems, the E2 delivers a standard interface between the RIC near-RT and CU/DU in the context of an O-RAN architecture. While the E2 interface feeds data, including various RAN measurements, to the RIC near-RT to facilitate radio resource management, it is also the interface through which the RIC near-RT may initiate configuration commands directly to CU/DU.

The RIC near-RT can be provided by traditional TEMs or 3rd-party players. While receiving an AI model from RIC non-RT, RIC near-RT will execute the new models (including, but not limited to traffic prediction, mobility track prediction and policy decisions) to change the functional behavior of the network and applications the network supports.

Multi-RAT CU protocol stack and platform

The function of the Multi-RAT protocol stack supports 4G, 5G and other protocol processing. The basic functions of the protocol stack are implemented according to the control commands issued by the RIC near-RT module (for example: handovers). Virtualization delivers a highly-efficient execution environment for CU and RIC near-RT, providing the ability to distribute capacity across multiple network elements with security isolation, virtual resource allocation, accelerator resource encapsulation, among other benefits.

Relevant interfaces – The existing interface definitions for F1/W1/E1/X2/Xn provided by 3GPP, will be enhanced to support interoperation among multi-vendors and the CU provided by TEMs offer a regional CP and UP anchor for DUs.

DU and RRU Function definition

The DU and RRU function includes real-time L2 functions, baseband processing and radio frequency processing.

Relevant interface – The interface between the DU and the RRU provides standard function segmentation, including the DU-RRU lower layer split interface (Open Fronthaul Interface), and the CU-DU higher layer split interface (F1), which ensures interoperability between different TEMs.

Key work groups of the O-RAN Alliance

The Non-real-time RAN Intelligent Controller and A1 Interface Workgroup

The focus of WG2 includes both the RIC non-RT and the A1 interface. The primary goal of RIC non-RT is to support non-real-time intelligent radio resource management, higher layer procedure optimization, policy optimization in RAN, and providing AI/ML models to RIC near-RT. With the amount of L1/L2/L3 data collected from eNB/gNB (including CU/DU), useful data features and models can be learned to empower the intelligent management and control in 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 learned and trained based on the big data analytics and machine learning. These well-learned data features and models are undoubtedly helpful for driving fine-grained near-real-time network radio resource management in the RIC near-RT and non-real-time optimization within RIC non-RT.

The A1 interface supports communication & information exchange between Orchestration/NMS layer containing RIC non-RT and eNB/gNB containing RIC near-RT. Key functions that the A1 interface is expected to provide include:

- Network & UE-level information/context exposure from eNB/gNB to RIC non-RT to support various requirements such as network management, online learning and offline training of AI/ML models and driving non-RT optimization into the network.
- Support for policy-based guidance of RIC near-RT functions/use-cases, deploying/updating AI/ML models into RIC near-RT, and feedback mechanisms from RIC near-RT to ensure SLAs.

A1 interface interoperability will be tested via field trials with partners selected by operators. The goal is to also release an initial A1 interface specification in Q1 2019, followed by refinement and enhancements in second half of 2019.

The Near-real-time RIC and E2 interface Workgroup

The focus of this work area will be on reference design of RIC near-RT and its interface E2. To fulfill the overall goal of building an architecture based on decoupled, , AI enabled software implementation of control plane, this work group will standardize this workgroup will specify the E2 interface between RIC near-RT and CU/DU stack, and it will develop the RIC near-RT architecture design, which includes R-NIB and modular on-boarding of RAN control applications from 3rd parties.

The specification of an open and inter-operable E2 interface is key to decoupling RRM functionalities, which are traditionally embedded into vendor-specific implementations or rely on closed proprietary interface. The presence of RIC near-RT will bring a higher degree of programmability and flexibility to the RAN as well as ensuring performance consistency across the network in a genuine multi-vendor environment. Considering control latencies falling within a 10ms-1s range, RIC near-RT can host control functionalities such as radio connection management, mobility management, load balancing on a UE-level granularity, QoS management, interference management, scheduling policies and slicing-related optimizations. As for the RIC near-RT architecture, this workgroup will produce an open and modular reference design supporting A1 and E2 interfaces. To further accelerate innovation, the reference design will allow 3rd-party application developers to on-board new control and optimization applications via related APIs.

With regard to AI-optimized closed-loop automation, the RIC non-RT and RIC near-RT will interact to enhance network performance and user experience.

For example, RIC non-RT can distribute well-trained user mobility and traffic prediction models to the RIC near-RT so that near-real-time predictions and decisions related to user mobility and traffic load are efficiently executed at the RIC near-RT. In a similar fashion, E2 interface can be leveraged to fetch data feeds from the radio nodes and provide those to the RIC non-RT to train AI models. Therefore, such interaction can be used to optimize and fine-tune control algorithms such as the one related to load balancing, mobility management, multi-connection control and network energy saving.

This workgroup aims to publish E2 interface specification and release a reference design of RIC near-RT to be developed together with the work on RIC non-RT and A1 interface. In the short term, the first release of E2 specs is expected at the end of 1Q19, RIC near-RT reference design in 2Q19, whereas further enhancements will follow up during 2019. In parallel to the specification activity, a PoC testbed will be developed to demonstrate and showcase operator-defined use cases.

The Open Fronthaul Interfaces Workgroup

The objective of this work is to deliver truly open fronthaul interfaces, in which multi-vendor DU-RRU interoperability can be realized.

Radio access network (RAN) with an architecture that splits the baseband units (BBUs) installed in centralized locations and radio units (RUs) distributed at cell sites, where the two is connected by a fronthaul interface, has proven to be effective in many commercial 3G/LTE deployments. Centralization provides performance benefits (e.g. multi-cell/frequency coordination) and cost benefits (e.g. opportunities to increase resource pooling and reduce site rent). With the requirements for RAN becoming ever more challenging and diverse, the need for such split RAN architecture is becoming increasingly important. However, conventionally, split RAN architectures have mostly been realized by single-vendor systems. In this work, the requirement is to realize multi-vendor DU-RRU interoperability by delivering truly open fronthaul interfaces.

The focus the work is on intra-PHY split, i.e. split RAN architecture with the split between centralized DUs and distributed RRUs inside the radio interface physical (PHY) layer, which reduces fronthaul bandwidth requirements compared to conventional split RAN architectures. Control, User and Synchronization (C/U/S) plane protocols and Management (M) plane protocols will be specified. xRAN fronthaul specifications will be inherited and maintained. The next release of these fronthaul specifications are targeted for 2019-H1, which may also include new features as needed. Furthermore, it is also intended to facilitate multi-vendor interoperability of the specified fronthaul interface through test profile/specification development and multi-vendor IOT PR activity. The first release of the test profile/specifications and PR for initial IOT is targeted for 2018-H2.

The Stack Reference Design and Open F1/W1/E1/X2/Xn interface Workgroup

The objective of this work is to provide fully operable multi-vendor profile specifications (which shall be compliant with 3GPP specification) for F1/W1/E1/X2/Xn interfaces and in some cases will propose 3GPP specification enhancements.

High Layer Split (HLS) between Centralized Unit (CU) and Distributed Unit (DU) has been specified by 3GPP and is illustrated in Figure 1. Each individual functional entities DU, CU-UP and CU-CP entities may be placed at different physical locations according to operator requirements.

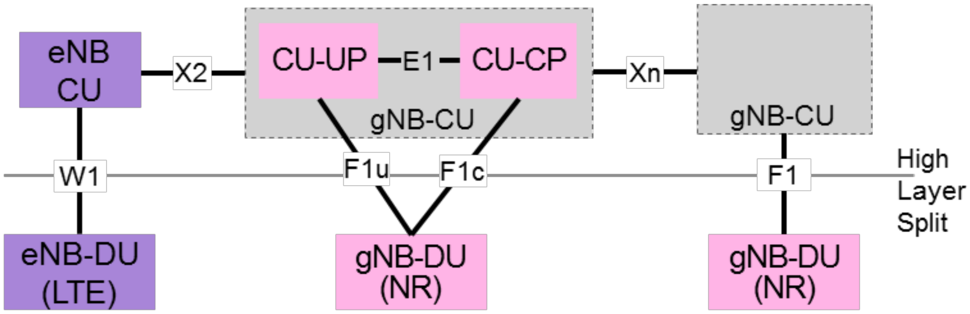

Figure 2: F1/W1/E1/X2/Xn interfaces

The definition of HLS has introduced two new interfaces. F1/E1 interface for gNode B (gNB)/gNB-CU functional split, which has been specified in 3GPP for Rel 15, and W1 interface for eNode B (eNB) functional split, which is being specified in 3GPP in Rel 15. It should be noted that within the central RAN function gNB-CU a split in control and user plane (CU-CP and CU-UP) is specified, which has generated a new interface called E1. Furthermore, interfaces between RAN nodes are also specified: X2 interface, between central RAN functions in eNB and eNB or en-gNB (for Non-Standalone 5G) and Xn interface, between central RAN functions in ng-eNB (next generation eNB connected to NGCN) and/or gNB.

Regarding these new interfaces (F1/W1/E1/X2/Xn), the 3GPP will provide specifications aimed to cover all possible deploying scenarios and, thereby, try to ensure a support for multi-vendor interoperability. Nevertheless, in the light of past experiences (i.e. Iub, x2 interfaces), O-RAN alliance aims to enhance 3GPP specifications in order to turn F1/W1/E1/X2/Xn interfaces truly open, supporting multi-vendor interoperability at user plane, control plane and management plane. O-RAN alliance will also work on the specification of an open-sourced protocol stack, providing frameworks and necessary module design including basic functions and procedures for each protocol stack at CU level. As a result, any vendor will be able to accelerate the development of protocol stacks and private algorithms based on the open framework and modules.

The first release of these O-RAN F1/X2 interface specifications is targeted for late November or early December of 2018. Furthermore, O-RAN WG5 also will provide multi-vendor CU/DU IOT test specifications and in case of O&M, it aims to provide first specifications based on industry trend in order to be compatible with other related frameworks (e.g. ONAP and other O-RAN WGs). The first release of the O&M specification is targeted for 2019-Q1, and first multi-vendor CU/DU IOT specifications is targeted for 2019-Q3.

The Cloudification and Orchestration Workgroup

The cloudification and orchestration workgroup seeks to drive the decoupling of RAN software from the underlying hardware platform and to produce technology and reference designs that would allow commodity hardware platforms to be leveraged for all parts of a RAN deployment including the CU and the DU. The objective of doing so is to allow seamless and targeted rolling upgrades, flexible intermingling of CUs and DUs from multiple vendors to enable innovation in the PHY and MAC layers, and dynamic demand-driven capacity management and slicing allow flexible RAN provisioning based on application needs.

The workgroup will accomplish its objective in a two-fold manner. First, the working group will work to define an NFVI and orchestration reference architecture that supports different deployment models of how the parts of the O-RAN architecture (RIC near-RT, RIC RT, CU-CP, CU-UP, and DU) are distributed across a distributed cloud infrastructure and specifies requirements on CPU, memory, storage, accelerator, and network that the cloud infrastructure must support. It will also work to standardize orchestration/automation APIs for the CU and DU to support discovery and configuration of virtualized RAN elements and the management of RAN slices including placement and dynamic resource management, including fault tolerance and auto-scaling, based on real-time usage monitoring. On the DU, APIs will be worked to facilitate remote lifecycle management of up to tens of thousands white-box DU locations and coordinate software lifecycle automation across such a footprint including rolling software upgrades and zero touch configuration.

Subject to the availability of open source implementations of RAN software components, the architecture and integration with open source cloud/MANO software such as Openstack, Kubernetes, and ONAP will be demonstrated through reference blueprints contributed to existing open source projects on NFV and edge integration such as OPNFV and Akraino. The first draft of the NFVI/orchestration specification is targeted for 2018-Q4, with further enhancements to follow in 2019.

Second, the working group will also seek to develop and demonstrate, through operator field trials and existing open source efforts, hardware and software technology that contributes to efficient virtualization of the RAN software stack and to a clean hardware/software separation. This includes technologies such as real-time hypervisor support in NFVI cloud stacks, acceleration of numerically intensive DU data plane functions such as signal processing and beam forming through general purpose programmable accelerators such as GPUs and FPGAs, low latency traffic processing, and the development of platform technologies for real-time ML-driven inferencing and action.

The White-box Hardware Workgroup

The promotion of white box hardware is a potential way to reduce the cost of 5G deployment, which will benefit both the operators and vendors. The objective of this working group is to specify and release a complete reference design and thereby fostering decoupled software and hardware platform. Currently there is no open interface base station reference design architecture, making it impossible for operators and vendors to develop software for optimizing their network operation in various application scenarios. Therefore, it is further envisioned that the group will research all related content to build valuable reference design.

The deployment of a wireless network is closely related to the application scenarios. Therefore, the group will first identify all application scenarios e.g., indoor coverage, outdoor coverage and outdoor to indoor coverage. This is then followed by identifying the related base station classes associated for each scenario, such as sub 6GHz/mmWave, single-band/multi-band, SU/MU/FD-MIMO, IAB, Multi TRP, etc. This work has been tentatively decided to be finished by mid-2018.Q4.

Next, the group will specify and document detailed reference architecture and base station requirements for certain identified base station classes. The reference architecture shall include both split RRU-DU design and integrated RRU-DU design according to the application scenarios and deployment cost. The working group will define all base station requirements for each use case scenario and its architecture. This will include parameters such as output power, EIRP, bandwidth, MIMO layer, automatic power consumption reduction, to name a few. This work is planned to be completed by the end of 2018.Q4.

The working group will then proceed to complete 5G base station design for all selected architecture and providing requirements for all RF components (such as Passive/Active antenna system, RF chain (PA, Filter), Digital control chain, IF(digital/analog)), hardware components (such as Reference COTS architecture and other components like FPGA, DSP, ASIC, x86/x64), as well as software components (such as control/management, 3GPP defined components and 3GPP transparent components like WG4 split RRU/DU interface, digital beam-forming, advanced receivers). This work shall start tentatively in 2019.Q1 and finish by 2019.Q3. During this period, the group will also try to complete the function decomposition, requirement of each function module, key component selection and verification, key technology research (e.g., DPD, beamforming etc.), initial POC and certification of reference designs.

Finally, the group will release detailed documentation of the white box base station reference architectures and detailed reference designs for considered scenarios, and complete White box reference hardware design of one or two types of base station.

Conclusion

As mobile traffic increases, mobile networks and the equipment that runs them must become more software-driven, virtualized, flexible, intelligent and energy efficient. The O-RAN Alliance is committed to evolving radio access networks– making them more open and smarter than previous generations. Real-time analytics that drive embedded machine learning systems and artificial intelligence back end modules will empower network intelligence. Additional virtualized network elements with open, standardized interfaces will be key aspects of the reference designs developed by the O-RAN Alliance. Technologies from open source and open white box network elements will be important software and hardware components of these reference designs. The O-RAN alliance community of operators and vendors will strive to lead and drive this transformation.