SMO Deployment Challenges in an Open RAN Environment

Joint whitepaper by
Vodafone and NTT DOCOMO

Table of Contents

1. Summary

5G radio access networks (RAN) have become more complex than previous generations. This complexity, which comes from the introduction of more demanding applications and services, robust radio resource management, virtualisation and other enhancements, makes it no longer practical to operate networks manually.

O-RAN ALLIANCE has specified Service Management and Orchestration (SMO), a platform that utilises intelligence and automation to simplify the complex operation and maintenance of networks at scale. O-RAN ALLIANCE has defined SMO interfaces such as O1, O2 and A1 to manage this complexity. Through these interfaces, SMO automatically manages components within RAN including network functions (O-CU, O-DU, O-RU), cloud infrastructure (O-Cloud) and Near-Real-Time RAN Intelligent Controller (Near-RT RIC).

The value of SMO comes from its capabilities to perform intelligent automation, making it possible for operators to improve network availability and performance, enhance customer experience (QoE) and net promoter score (NPS), while reducing total cost of ownership (TCO) and improving energy efficiency.

While it would be ideal to have mature SMO interfaces and mature Open RAN architectures defined today, industry alignment will take time. Therefore, in order to enable intelligent automation in the RAN today, the Open RAN architecture currently defined by O-RAN ALLIANCE will require some vendor proprietary extensions. The paper names this architecture “initial Open RAN architecture”, and discusses a staged approach for operators considering introducing SMO with Open RAN.

Today’s initial architecture, however, does not provide the full benefits of a mature Open RAN with well-defined and open SMO interfaces. Some strategic benefits include a more competitive ecosystem, quicker innovation for new functionality, and a more diverse supply chain for SMO as well as RAN. While the initial architecture could be sufficient to meet some 5G service needs of today, it is in the industry’s interest to accelerate the standardisation of the interfaces between SMO and network functions to realise these additional strategic benefits. Recommended actions operators and vendors should take to accelerate towards a mature Open RAN with SMO are described in this paper.

For the future 5G and beyond, the ambition of the architecture will be to expand the SMO to also manage traditional RAN seamlessly and interact with an end-to-end orchestrator to coordinate more effectively with other domains beyond RAN. Arguably, the attainment of this ambition could be affected by industry alignment on a mature Open RAN architecture and SMO interfaces.

2. Introduction

One of the visions of O-RAN ALLIANCE, an industry association promoting network openness led by telecommunications operators worldwide, is the realisation of a more intelligent and innovative RAN with more automation capabilities. Networks in the 5G era will need to support a wide variety of demanding applications and will become increasingly complex. In doing so, it will become difficult to optimise operations and networks manually. It will become essential to realise more autonomous and automated operations using state of the art innovation techniques like Artificial Intelligence (AI) and Machine Learning (ML).

To realise this vision, O-RAN ALLIANCE is working on the standardisation of an 'Open RAN', where base station equipment from different vendors can be freely combined, while utilising AI/ML techniques to optimise network design and operation. RAN architectures and open interfaces are also being considered.

The component called SMO, which is specified by O-RAN ALLIANCE, is responsible for maintaining and orchestrating this RAN with automation and intelligence. At the heart of providing intelligence is a component called RAN Intelligent Controller (RIC), a logical node with intelligence and capabilities to use advanced techniques like AI/ML. The RIC is responsible for automatic optimisation of complex parameters and consists of two types of functions with different control cycles: the Non-Real Time RIC (Non-RT RIC) and the Near-Real Time RIC (Near-RT RIC).

SMO not only provides operation and maintenance capabilities that has been performed by EMS (Element Management System) in traditional systems, it also provides the following values to operators:

- Reduced TCO: it improves resource utilization by scalable allocation of infrastructure resources, reduces overall power consumption, and automates manual tasks for operating and maintaining the network.
- Improved QoE: it improves service availability by automatic network healing, enables complex RAN configuration and optimization for better network

performance (which would have been difficult to perform manually), and enhances customer experience for a higher NPS.

SMO uses various interfaces such as O1, O2 and A1 to connect with other functions in O-RAN ALLIANCE architecture. These interfaces are actively being specified by O-RAN ALLIANCE, but some aspects are not yet finalised. Therefore, connecting SMO to network functions (NF), Near-RT RIC, and O-Cloud currently requires the use of vendor proprietary extensions. SMO interface specifications need to be finalized as soon as possible to avoid prolonging vendor lock-in and delaying the widespread adoption of Open RAN. To address these concerns, O-RAN ALLIANCE is further specifying the decoupling of SMO functions and related SMO services with the aim of improving the SMO internal architecture to support multi-vendor interoperability.

The following sections discuss challenges operators face in realising intelligent and automated RAN with SMO as currently standardised by O-RAN ALLIANCE. It will also provide recommendations to mitigate these challenges.

3. Deploying SMO on Open RAN today

3.1. Challenges of Deploying Open RAN

While there may be various reasons that lead an operator to choose to deploy Open RAN instead of traditional RAN, the starting point has a significant impact on the alternatives. In general, it is interesting to distinguish at least the following cases:

- operators starting from scratch
- operators starting the deployment of a certain technology from scratch
- operators complementing their current networks with one or more technologies using Open RAN

First scenario is usually named as “greenfield deployment” in contrast with the others, called “brownfield deployment”.

An operator with a greenfield deployment has a higher degree of freedom in choosing technology since it is not constrained by the existence of a certain management infrastructure. However, it faces higher expenses as it needs to integrate all the needed systems that it has not got yet.

On the other hand, an operator with a brownfield deployment is constrained to maintain compatibility between new and existing systems. This may imply high expenses as well. For example, the brownfield scenario of an operator complementing an existing network presents the worst difficulties. This is because, in addition to keep compatibility with existing systems, it must assure functional compatibility with the existing technologies to guarantee the management of a homogeneous network.

The operator's priorities with respect to Open RAN's promised benefits is also an important factor to consider. Key benefits that operators can consider include:

- functional disaggregation between hardware and RAN-related functions which allow functions to be virtualised on vendor neutral general-purpose hardware
- open interfaces between components and specifications of functional elements which assure flexibility to enable multi-vendor solutions
- solutions deployed on virtualisation platforms which can be managed intelligently by SMO

The market is full of solutions labelled as Open RAN that do not guarantee most of these points. In general, all "Open RAN" providers have undertaken the exercise of disaggregating hardware and software because this evolution allows them to transition to the use of general-purpose hardware and gain a competitive cost advantage.

However, the same cannot be said for adopting open interfaces or assuring flexibility for multi-vendor environments. Specifically, the specification of Open RAN interfaces is not mature enough in some cases, which limits vendors' ability to provide truly open interfaces.

Integrating a stable and commercial quality virtualised RAN (vRAN) will require that operators and multiple vendors collaborate diligently and methodically to resolve incompatibilities between the interfaces, functional elements and products that are being combined. Stability and compatibility in a commercial environment are prerequisites to incorporating SMO. Incompatibilities can come from implementation dependent elements that are not specified in standards, or even optional items which are defined in the standards. Some aspects which require alignment are as follows:

- **Alignment and validation of interfaces**: vRAN involves multiple elements, and interfaces are needed to ensure interconnectivity between these

elements. In addition to standardised interfaces, there may also be product-specific interfaces and protocols. When combining products from different vendors, these interfaces need to be properly aligned. It is also important to verify that each interface functions correctly and ensures compatibility.

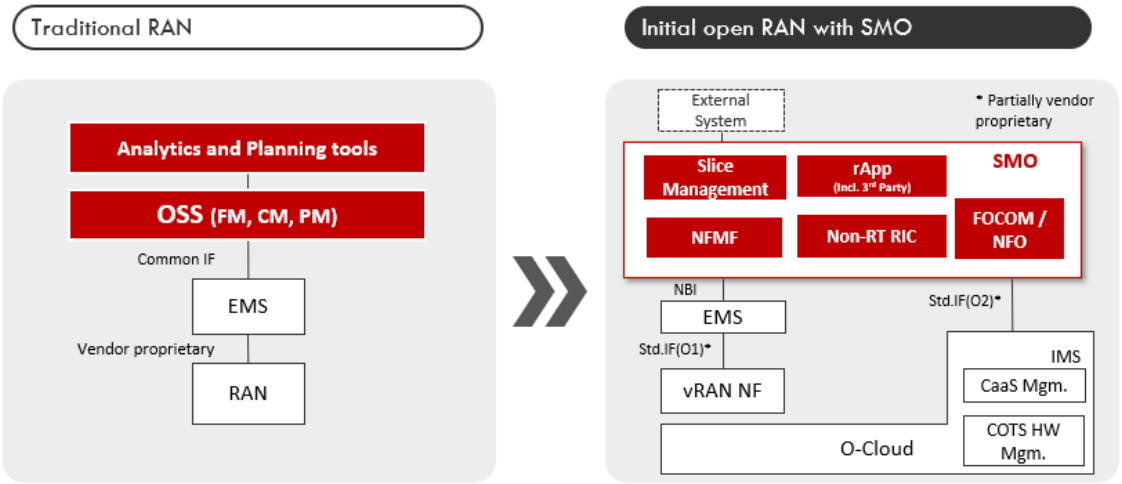
- **Consideration of implementation-dependent elements and optional features**: there are also unique elements and features that are not specified in standardised specifications but are provided by specific products or vendors. If these elements or features are required in commercial operations, appropriate agreement and verification are essential for their inclusion. When combining different products, the consistency of these elements and optional functions must be checked and combined appropriately.

How should operators position themselves right now regarding the deployment of Open RAN? Should they be 100% purist? Should they wait for complete and mature specifications? Should they disregard suppliers that are not fully committed to the idea? Operators must support the development of the Open RAN specification as well as the participation of as many players as possible in this new technological scenario. However, they cannot remain blocked while waiting for both specifications and products to become mature enough because they would be turning their backs on the functionalities that are already available and could be differentiators against competing operators. Moreover, if operators wait, new players who are still making their way may find it difficult to enter the market, giving advantage to the already well-established players. It is recommended that operators select appropriate maturity levels that meet their requirements and then proceed with the deployment of Open RAN according to realistic expectations based on that level.

3.2. Initial Open RAN architecture and SMO

The maturity and validity of an Open RAN network cannot and should not be evaluated based on its isolated elements but rather on the coherence of the whole. This is even more relevant in the case of components like the SMO, whose nature implies interacting with many different functional elements. It is natural for an operator to begin by selecting a radio solution provider, since radio capabilities are key and differentiating factors. An intelligent decision is then to make the rest of the choices based on the capabilities one wants to achieve, without sacrificing interoperability with the radio solution. No one needs the best SMO if it only provides pure Open RAN interfaces while the selected radio solution cannot interface with the SMO. Flexibility is therefore a key factor in selecting a management system like the SMO, and this also applies to the other functional elements – the hardware layer, the virtualisation platform and NFs.

What seems to make more sense today is to deploy a solution that we have nominated here as “Initial Open RAN architecture”, which is valid and functional with what we have in the market today and fits with the idea of the evolution of a traditional RAN. In the initial Open RAN architecture, RAN is virtualised, O-Cloud manages general-purpose hardware as a virtualisation platform, and SMO is introduced. The architecture utilizes Open RAN standard interfaces while partially including vendor proprietary interfaces and leverages EMS for RAN NF management to provide interconnectivity for SMO with NFs and O-Cloud. SMO may interact with external systems and exchange RAN analytics information.



This architecture is very advantageous when starting from existing networks since the EMS are already there. The cost of adding the SMO and interconnecting it with the partially proprietary interfaces would be justified by the management and optimization capabilities that it adds. On the other hand, when starting from scratch, in addition to incorporating SMO, operators may also need to install EMS for vRAN NF management. It’s still worth introducing SMO if highly valuable applications that run on Non-RT RIC are already available in the market and operators are eager to use them. Though there are only a limited number of applications that meet such use cases today, operators and providers are pursuing use case definitions, and so far, the most interesting ideas are related to these two areas:

- **Zero Touch Provisioning**, which means end-to-end automation of the deployment process
- **Energy Efficiency**, which means any mechanism that achieves a reduction in the electricity costs paid by the operators

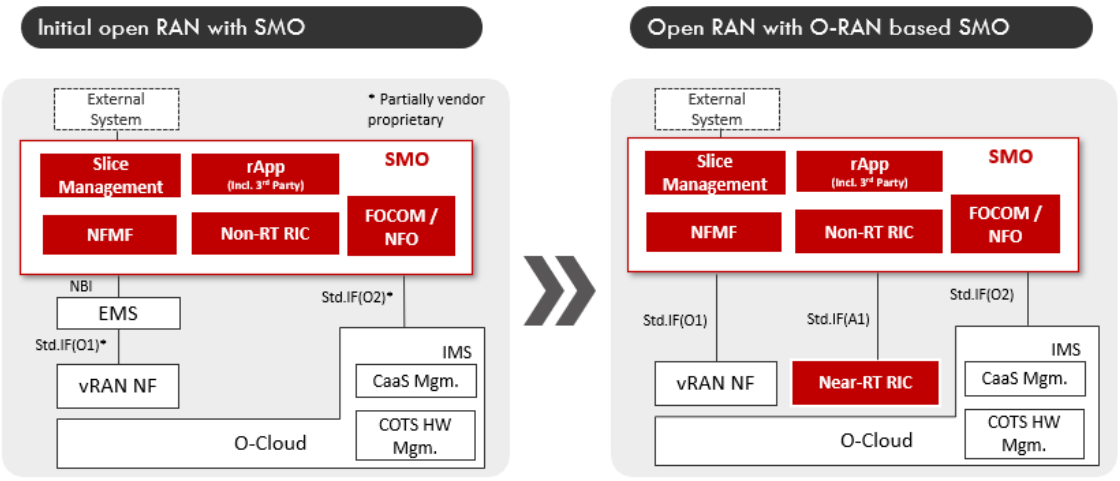
Assuring that this “Initial Open RAN architecture” is valid and functional enough to fulfil operators’ expectations is not an easy task, as it includes aspects that are in the process of being specified by O-RAN ALLIANCE.

In order to make maximum use of multiple standard specifications, including O-RAN ALLIANCE, and to promote openness and verification of each interface to realise interconnection of vRAN applications, SMO and O-Cloud across multiple vendors, it is recommended that operators work on the following two specific points:

- **Create guidelines for operational methods**: Guidelines for operational methods need to be developed with the aim of achieving vRAN solutions that can guarantee interoperability even when combining products from vRAN application vendors, hardware accelerator vendors and O-Cloud vendors. In particular, as sufficient redundant configuration may not be possible at base station sites, operations for situations such as network disconnection or management node down need to be considered.

- **Provide an end-to-end validation environment for the solution and validate the functionality:** An end-to-end validation environment is required and can be done in a community lab. In community labs, verification environments are available for multiple combinations of vRAN applications, virtualisation platform, generic servers and hardware accelerators. For example, NTT DOCOMO is providing a verification environment in the OREX Shared OPEN LAB and is proceeding with end-to-end verification from upper-level equipment to terminals. Currently, verification is being conducted in these labs, and multiple combinations of vRAN applications, virtualisation platform, general-purpose servers and hardware accelerators are being verified. In addition to these, verification of configurations including SMO should also be promoted.

4. Mature Open RAN deployments



Is this enough then? Does an initial Open RAN solution cover all the needs? Of course, the answer to both questions is the same: not at all. Operators must keep on working on the availability of valid "true Open RAN environments as specified by O-RAN ALLIANCE", and it is a fundamental task of operators to put pressure on the industry and keep them aware of the real value behind it, even though it is economically justifiable to survive nowadays with initial Open RAN.

This section will discuss the benefits to both operators and suppliers of deploying SMO on a mature Open RAN architecture, the underlying enablers which will allow these benefits to be realized, and a recommendation on how a mature Open RAN with SMO can be accelerated.

4.1. Direct benefits of SMO in mature Open RAN architecture

Benefits for procurement and suppliers: For operators, reasonable pricing and ultimate reduction in capital expenditure (CAPEX) will be feasible because well-defined open interfaces will facilitate some degree of competition between Open RAN NF vendors as well as SMO vendors. The well-defined interfaces will also provide a larger addressable operator market for innovative new vendors or for incumbent vendors providing new products, stimulating an uplift in equipment quality.

Operators will also have freedom to choose the optimal combination of vendors of SMO and managed NFs. This will become feasible because of a well-defined, consistent and open interfaces between O-CU/O-DU/O-RU/O-Cloud, and between SMO and NFs. This will not only allow operators to mix and match best of breed

vendors to suit their very specific requirements, but also allow vendors to focus and innovate on their unique strengths with less effort on multi-vendor integration.

Operational benefits: Operationally, a mature Open RAN architecture with SMO can improve service availability. One example is automatic network healing which is performed when a part of the RAN is disrupted, requiring a resilient mechanism to redeploy NFs to other locations to recover the service availability.

Other operational benefits of a mature Open RAN with SMO include intelligent configuration of large volumes of highly complex 5G radio parameters, which is enabled by the automation and intelligence provided by Near-RT RIC and Non-RT RIC with rApps/xApps, and efficient deployment of NFs across O-Cloud.

Energy efficiency, an important part of managing TCO, is another benefit of mature Open RAN with SMO. Various automatic and intelligent mechanisms to reduce or turn off the power of unused cells give a significant opportunity to reduce the overall power consumption of the RAN.

Open RAN security can be made more robust using the automation and intelligence of SMO by monitoring for security anomalies and enforcing standardised security controls.

4.2. Underlying enablers of SMO in mature Open RAN

Compared to initial Open RAN with SMO, mature Open RAN deployment allows connections between SMO and other components through standardized interfaces, which in turn allows advanced optimization features such as Near-RT RIC to be fully utilized.

O1 interface between the SMO and multi-vendor NFs and Near-RT RIC is used by the SMO to provide OAM functions such as fault, configuration and performance management. It allows the SMO to collect various types of data such as performance management (PM) counter, fault management (FM) data and trace management (TM) data from the NFs. SMO can also use O1 interface to apply configuration settings, which are optimized by the rApps in the Non-RT RIC, to the NFs.

A1 interface between Non-RT RIC in SMO and Near-RT RIC allows Non-RT RIC to provide policies, ML model management and enrichment information to Near-RT RIC for intelligent RAN optimization.

O2 interfaces (O2dms/O2ims) provides communication between SMO and O-Cloud, of which the latter contains deployment management services (DMS) and infrastructure management services (IMS) functions. O2 interfaces will allow operators to manage O-Cloud infrastructure resources and perform NF life cycle management in multi-vendor environment via SMO, whereas operators with initial Open RAN architecture based solution need to understand APIs from different virtualisation platform providers to perform such management tasks.

In addition, R1 interface between Non-RT RIC framework and rApps is used to exchange data and control signalling information. Multi-vendor rApps can consume or produce the R1 services without being limited by specific SMO and Non-RT RIC framework implementations. Similarly, Near-RT RIC APIs are the interfaces that connect Near-RT RIC framework and xApps. Near-RT RIC APIs enable the hosting of xApps from the Near-RT RIC vendor as well as from third parties. With mature Non-RT RIC and Near-RT RIC frameworks, operators will be able to freely choose best-of-breed rApps/xApps that utilize advanced technologies such as AI/ML. This breaks the monopoly that each radio provider currently has for resource management and optimization capabilities within its environment, opens the door for third party rApp/xApp providers and creates competition that currently does not exist, whose main purpose is providing customers with the best possible experience in using the operator mobile network.

A well-defined decoupled SMO architecture decomposes the SMO into a combination of specified sub-functions and interfaces. It is important to define RAN NF OAM within SMO which terminates NFs and provides services such as performance data collection, fault data collection and provisioning via O1 interface and Open Fronthaul M-Plane interface. This will improve multi-vendor interconnectivity and give operators more flexibility to select an optimal combination of solutions rather than having fixed vendor dependent NF/EMS combinations. Vendors will have more opportunities to offer NFs and other SMO services regardless of whether operators have deployed the vendors' EMS or not. In addition, new players specialized in OAM functions will be more likely to enter the market.

4.3. Attaining the mature Open RAN scenario

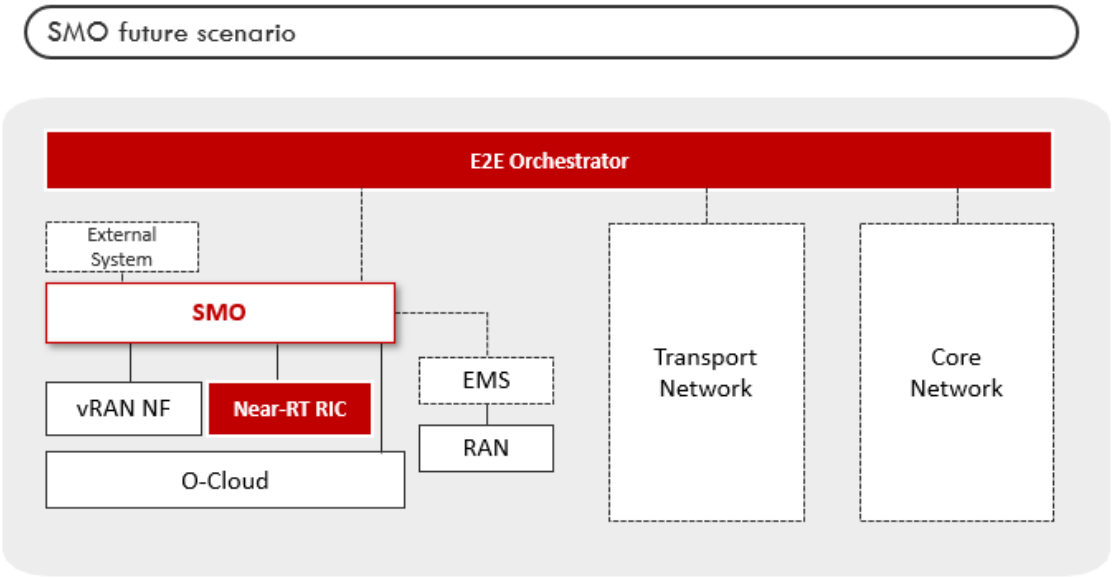
It is not beneficial for operators and vendors to be held back in the transitional initial Open RAN SMO architecture for longer than necessary because the industry will not be able to enjoy the aforementioned benefits. In addition, important strategic benefits will be delayed for SMO – complete openness and disaggregation to allow operators to mix and match the optimal solution, supply chain diversity, reduced

entry barriers for increased competition and quicker innovative to create new Open RAN capabilities. It is recommended that a mature scenario is attained as quickly as possible to avoid a prolonged vendor and operator lock-in in the transitional phase.

To accelerate this transition, operators should make an increased effort in owning, leading and facilitating the standardisation and deployment of mature Open RAN services with SMO. This is because it is operators, not vendors, who are ultimately responsible for providing the Open RAN services to their customers.

The industry needs to accelerate the standardisation of the interfaces between SMO and NFs, with leadership and vendor facilitation by operators. The discussion of decoupled SMO architecture functions should also be accelerated with increased operator involvement and facilitation. Vendors whose products have already been in service will have to address the O1 and Open Fronthaul M-plane interfaces between the NF and SMO without going through their own EMS, which may require additional work. Operators therefore need to express their strong willingness to use SMO that can manage NFs from multiple vendors and encourage vendors to support it. A continued effort in system integration between as many differing vendors as possible, including the alignment of interface optionality and data models, will become important to achieving a plug and play Open RAN, akin to personal computers in the 1990s – this needs to be led by operators. Interoperability of SMO and many vendors' NFs must be proactively validated in community labs such as OREX Shared Labs provided by NTT DOCOMO. In order to achieve the aforementioned benefits, operators should put pressure on the industry to evolve toward mature Open RAN as described above.

5. SMO future scenario



Even after the architecturally mature Open RAN deployment has been realised throughout the industry, the SMO will continue to evolve to meet the continually growing operational and functional requirements.

Although 5G is yet to be deployed in some countries, 6G is expected, serving a massive number of huge heterogeneous network slices and multiple network domains. The management architecture will expand to allow the SMO to control traditional RAN, and improve coordination with other domains beyond the radio access network with end-to-end orchestrator (E2EO).

In addition to controlling O-RAN ALLIANCE specified vRANs in an open multi-vendor environment, it is expected that the expanded architecture will provide the same level of control for traditional RANs by adaptation via EMS. The evolving architecture will also enable fault, configuration and management data to be collected from the entire RAN and analysed, with recommended actions from the analysis results reapplied to the network – a key role for the RIC to perform.

E2EO is envisioned to provide monitoring and network control for orchestration and intelligent operation across multiple network domains, including RAN domain, Transport Network domain and Core Network domain. E2EO will be linked to the RAN domain via an interface with the SMO, hence it is important that Open RAN architecture with SMO interfaces be mature and fully open. The ability to monitor and control multiple network domains from a single E2EO platform can enable a

more robust and faster fault detection and response while performing data collection and network optimisation across domains. It enables the automation of maintenance, operation (zero-touch operation) and deployment/construction/ orchestration (automatic and scalable resource management). It is expected to automate the operation of increasingly complex networks, reducing the burden on operational workforce while improving overall service quality.

For future study, a more detailed analysis of SMO is required and is being considered. This analysis should discuss specific use cases, and underlying functionalities which can enable these use cases. It is hoped that such analysis can provide a basis for discussion between stakeholders within the Open RAN community.

6. Conclusion

The complexity introduced by 5G and beyond makes it essential to realise more intelligent and automated management and orchestration of networks.

O-RAN ALLIANCE's SMO framework makes an important contribution to operators running 5G networks - it provides intelligent automation to simplify the complexity operators encounter in deploying, running and maintaining the network. SMO can enable operators to automatically provision and deploy services (e.g. Zero Touch Provisioning), manage RAN optimisation intelligently and automatically, reduce energy consumption and more.

While today's SMO is providing operators with certain important use cases, its evolutionary potential has yet to be achieved. The pressing challenge for the industry is to realise a mature Open RAN architecture in which the SMO interfaces are industry aligned and open, thereby laying the groundwork for a positive ecosystem evolution and transformation on SMO, in step with RAN. The ambition is to include SMO as part of this evolution so that both SMO and RAN together can enjoy strategic benefits such as - complete openness and disaggregation, supply chain diversity, reduced entry barriers, increased competition and more.

O-RAN ALLIANCE and industry are actively specifying SMO interfaces towards a mature architecture (with a focus on decoupled SMO functions), but this will take time. Until the industry aligns on open SMO interfaces, vendor proprietary extensions will be required to interconnect vendor functions with SMO, excluding SMO from the positive evolution.

It is in the interest of operators and vendors to accelerate industry alignment and standardisation towards a mature and open SMO interfaces. Operators can play a central role by maintaining pressure on the industry and keeping stakeholders aware of current and emerging value of full SMO standardisation and implementation. Both Vodafone and NTT DOCOMO will continue to collaborate towards a timely evolution and successful deployment of SMO.