SAMSUNG

The Open Road to 5G

Overview:

Mobile operators continue to build more capacity while driving down costs and looking for new service revenue opportunities. As they focus on 5G, they are exploring innovations and new operating models that will help drive fundamental changes in the economies of the new network. In this backdrop, network infrastructure products with open interfaces are critical for reducing cost and establishing a new ecosystem for service innovation. Mobile operators achieved significant success reducing costs on the core side of the network, where they created a more open and competitive hardware and software ecosystem through investments in new architectures that leverage network function virtualization (NFV) and software-defined networking (SDN). However, the radio access network (RAN) infrastructure, which accounts for the biggest share of an operator's CAPEX, remains locked into proprietary hardware and software, thus limiting deployment flexibility and choices for operators.

This paper explains how an Open RAN approach could change that and bring agility, flexibility, and cloud economies to 4G and 5G networks. It also looks at the current state of Open RAN development and will discuss critical factors that drive the widespread deployment of Open RAN in carrier networks.

What's "Open" about an Open RAN?

In many ways, operators are demanding the Open RAN architecture to break out of the limitations imposed on them by proprietary radio systems. Operators are trying to benefit from the operational savings afforded by virtual RAN (vRAN) and cloud RAN (cRAN), but the proprietary implementation of these more cost-effective options did not eliminate vendor lock-in.

60-65% of total cost of ownership of a network is in the RAN.

In the context of growing mobile data volume, virtualization of RAN network functions has been explored by many carriers to achieve better resource management (cost-efficiency) and scalability (hardware capacity). While vRAN offers multiple benefits to mobile operators, it is not "open," as it still contains proprietary purpose-built hardware and software with virtualized functions. For instance, in deployments leveraging vRAN, the remote radio unit (RRU) remains proprietary hardware, whereas the baseband unit (BBU) functionality resides on commodity hardware running proprietary software; and the proprietary interfaces (e.g., CPRI, x2) remain as they are. In such a deployment, some or all of the baseband functions operate as virtualized network functions (VNFs).

Similarly, Cloud RAN or cRAN (often used interchangeably for centralized RAN) is more about the centralized management of resources than the openness of RAN interfaces. In cRAN, BBUs from multiple base stations are centralized into a BBU pool, and baseband processes are virtualized and located in the cloud, leading to simplified network management and orchestration. A BBU pool is a virtualized cluster that may include general purpose hardware for baseband processing. The shared processing across multiple base stations enables cost savings on baseband resources, enables energy-efficient network operations, and enhances overall network performance.

As mobile operators experimented with vRAN and cRAN, they realized significant cost savings. For instance, China Telecom claims to have saved 53% in OPEX and 30% in CAPEX with cRAN.[1] However, despite such savings, scalability issues, access to dark fiber for fronthaul, and the proprietary nature of CPRI interface are among the factors that continue to keep the virtualization of RAN relatively slow compared to other parts of the mobile network (e.g., the core). The lack of an alternative to the proprietary CPRI implementations is a major roadblock to cRAN adoption. As a result, establishing open RF interfaces was identified as a critical requirement by carriers to maximize the benefits of virtualization and cloud deployments. For this to happen, carriers contend there must be more competition in the RAN market.

Open RAN is about open standard interfaces that ensure operators can deploy RRU and BBU hardware from different vendors to build a best-of-breed multi-vendor network.

[1] https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/ITU-ASP-CoE-Training-on-/session7_5G%20networks%20and%203GPP%20release%2015.pdf

Open RAN – Evolving 4G and Setting a Path for Cost-Efficient 5G

Before we look at how things will change with 5G and why Open RAN is critical for 5G infrastructure development, let's briefly discuss what Open RAN can do in existing 4G environments. Even though 5G is stealing the show for new rollouts and announcements, network operators continue to invest heavily in their 4G LTE networks to increase capacity in heavy usage areas, enhance indoor coverage, and build coverage in low-traffic areas (such as rural and remote locations). Driving new efficiencies in 4G LTE and 4G LTE Advanced networks, advancing inter-carrier interoperability, and preparing a path for 5G with virtualized and cloud-enabled Open RAN are all part of a critical need for carriers. Open RAN offers mobile operators a new opportunity to rewire their business case and deploy cost-effective networks. Operators such as Verizon[2], Telefonica, Vodafone, and Zain are doing exactly that with their Open RAN initiatives.[3]

In terms of 5G, the biggest change that we will see is the explosion of bandwidth that will result from peak download speeds of up to 20 Gbps, a reliable 100 Mbps user experience data rate in urban areas, all coupled with latency requirements that are significantly less than LTE networks.[4] To achieve the peak throughput that 5G promises with the mmWave spectrum, mobile networks will need a much higher base station density and higher data processing capabilities. As such, operators will need heavy investments not just in RRU and baseband but also in fronthaul. For instance, in the current cRAN architecture, the fronthaul network uses CPRI over fiber links for data transmission between RRH and BBU. The CPRI links require a higher amount of bandwidth to transmit IQ data of the baseband signals. As an example, an LTE base station that supports 150 Mbps of downlink bandwidth will require more than 2 Gbps of optical bandwidth to send its IQ samples over the CPRI interface.[5] This bandwidth essentially means that fronthaul becomes the biggest CAPEX element of a 5G network. Participants in Open RAN expect that the open fronthaul specifications that provide for functional splits (with well-specified control, user and management plane interfaces) will enable a substantial reduction in fronthaul capacity requirements that traditional CPRI links command. The savings will be in addition to the substantial decrease in capital outlay that operators can achieve with a wider choice of vendors for key RAN elements if they could deploy more general-purpose hardware in the RAN. For instance, Deutsche Telekom has stated that an Open RAN architecture will likely reduce its 5G CAPEX bill by at least 50% compared to 4G.[6]

[2] https://www.samsung.com/global/business/networks/insights/news/samsung-selected-as-a-4g-lte-open-ran-provider-on-verizons-4g-lte-network/

[3] https://www.fiercetelecom.com/telecom/tip-summit-vodafone-telefonica-plow-forward-openran-pilots

[4] https://www.gsma.com/spectrum/wp-content/uploads/2018/11/5G-Spectrum-Positions.pdf

[5] http://dl.ifip.org/db/conf/ondm/ondm2017/1570337472.pdf

[6] https://rethinkresearch.biz/articles/open-ran-platforms-move-closer-to-reality-but-no-common-network-in-sight/

Open RAN Economies Promises to Bring New Innovation

While cost savings and eliminating vendor lock are certainly the key drivers for Open RAN, the ultimate goal of Open RAN is to bring intelligent software-defined networking and automation to wireless networks. With the growth in automation, machine learning, AI, and other latency-demanding applications, wireless networks will become increasingly complex. Network operations need to become autonomous and programmable, just like self-driving cars. We can no longer afford to exclusively rely on traditional human intervention to operate, scale, and troubleshoot networks. Thus, to enable a robust and flexible architecture, every element in the network needs to be modularized, software-controlled, and programmable, as well as to use standards-based open interfaces to communicate with the rest of the network – a key toward achieving cloud-scale economies in RANs.

An Open RAN will fundamentally change the landscape of wireless network deployments.

Healthier Competition will Drive Healthier Innovation:

By eliminating the dependence on a single vendor for all key components of the RAN infrastructure (the RRU, BBU, CPRI fronthaul), the operators will not only have the flexibility to build a best-of-breed network of their choice. It will foster a more competitive marketplace for RAN equipment and is already encouraging innovation in the RAN market.

Improved ROI will Drive Service Innovation and New Operating Models:

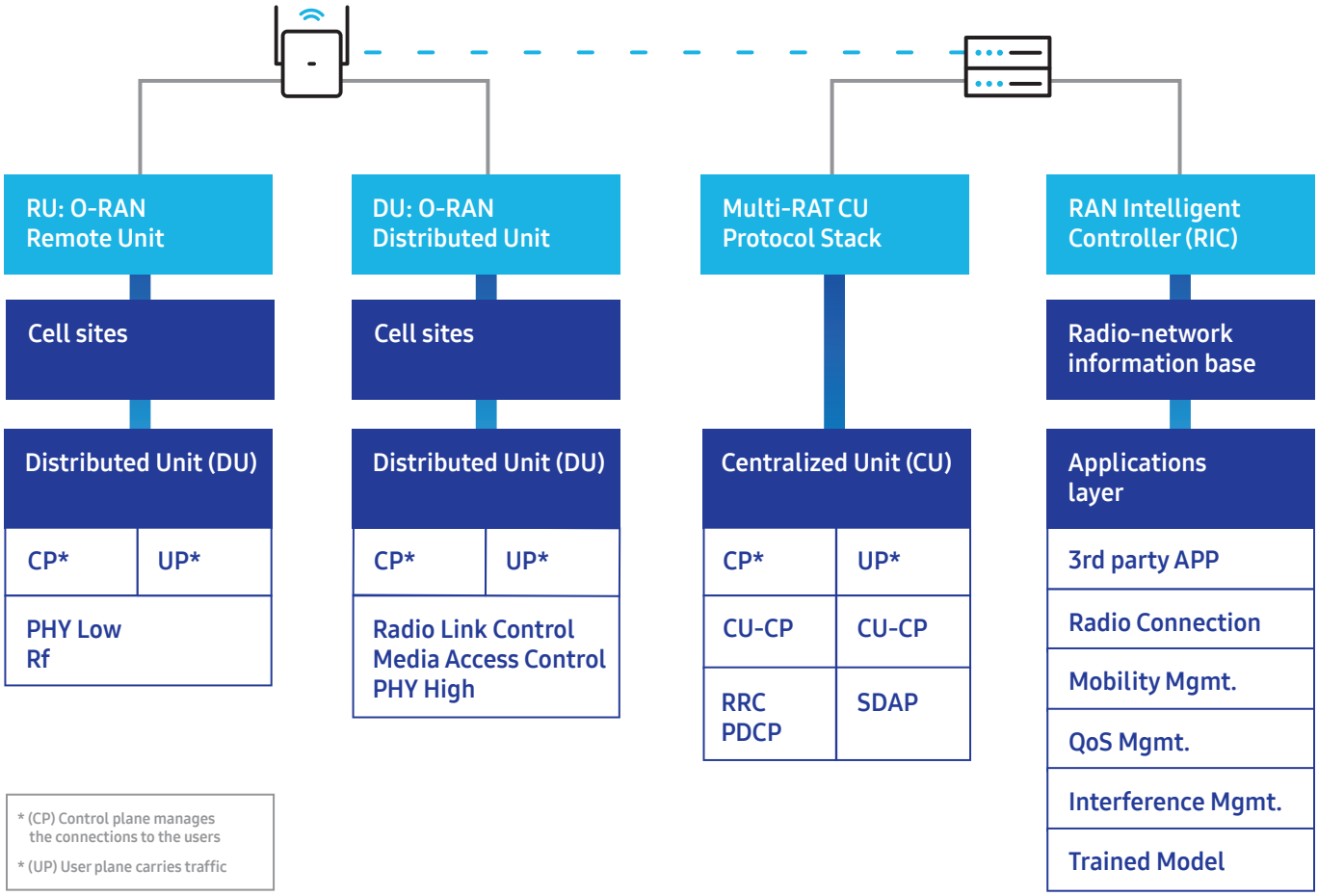
5G and Open Networks will be a catalyst that enables network operators to expand business models. Operators will have an opportunity to address the connectivity needs of enterprise customers in a more innovative manner. Mobile operators can build cost-effective private enterprise networks that are tightly integrated with their macro network to provide the best of indoor, local area, and wide area coverage to enterprise customers.

New feature development in the proprietary RAN world is a slow, time-consuming process. With open architectures, we also envisage a scenario wherein operators can open their RAN to collaborate with independent software developers to build new RAN features that augment RAN capabilities as well as enable deployment of new services and applications.

With Open RAN (combined with shared spectrum) the neutral host model will be economically viable, and mobile operators with large nationwide footprints will have the opportunity to partner with smaller players for 5G coverage especially in areas where a single operator owned 5G network may not be viable, but a shared one can make sense. And as the operators save on CAPEX / OPEX, they can focus more on network value creation by offering applications and services.

Private enterprise networks with large regional, national and international footprints currently have a business case challenge, largely because of the lack of RAN flexibility, the lack of HetNet interoperability and standards, and immature automation/virtualization.[7] A lower RAN CAPEX, combined with vendor flexibility and the use of unlicensed and shared spectrum, is likely to drive innovation in enterprise networks and make private enterprise networks and neutral host business models viable.

[7] http://www.5gamericas.org/files/9815/3547/3006/195_SC_siting_challenges_final.pdf



Carriers at the Helm

The carrier community is the primary driver of Open RAN initiatives. The earliest standards-based initiative toward an Open RAN was taken by AT&T, Deutsche Telekom, and SK Telecom, who formed the xRAN Forum in June 2016. The xRAN Forum described itself as "a consortium dedicated to promoting a software-based, extensible radio access network (xRAN) and to standardizing critical elements of the xRAN architecture." The group focused on developing fronthaul specifications. Later that year, the C-RAN Alliance was formed with the goal of building virtualized and open-interface radios. Both of these groups merged (with AT&T, China Mobile, Deutsche Telekom, NTT DoCoMo, and Orange as founding members) in February 2018 to form the O-RAN Alliance with the goal of bringing greater intelligence, cloud-scale economies, and agility to the RANs of the next-generation wireless system.

Since its merger, the alliance continues to add new carriers (like Verizon, Reliance JIO, and TIM) and vendors including Samsung.[8] It made significant progress with standards and trials on many different aspects of Open RAN. The alliance has drafted and developed a reference architecture for Open RAN. The alliance released its first Open RAN standard, the Open Fronthaul Specifications, comprised of control, user, synchronization, and management plane protocols in February 2019. These specifications aim to eliminate the monopoly that incumbent RAN vendors have over fronthaul via proprietary CPRI or eCPRI. The lack of an open fronthaul standard has been one of the biggest roadblocks to an open radio architecture or, for that matter, large-scale vRAN deployments.

[8] https://news.samsung.com/us/samsung-joins-o-ran-alliance-advance-open-innovation-networking-technologies/

Besides driving open fronthaul specifications for 4G and 5G networks, the O-RAN Alliance has several workgroups working on multiple aspects of Open RAN. These workgroups focus on overall architecture and use cases, RAN Intelligence Controller (RIC), interoperability profiles for F1/ X2/ Xn/ E1 interfaces, virtualization and cloudification enhancements, white-box hardware reference designs, and software reference designs for Digital Unit (DU) & Radio Unit (RU). These initiatives are leading towards the standardization of all RAN interfaces, the simplification of multi-vendor interoperability, and the deployment of commodity hardware platforms in all parts of a RAN deployment.

The Vodafone, Intel, Telefonica, and Facebook-backed Telecom Infra Project (TIP) is the second major group working toward creating an Open RAN. Recently, TIP also announced a new project group named Open RAN 5G NR led by Sprint and Vodafone. The group will initially focus on the development of sub-6 GHz 5G NR small cells for outdoor and indoor use cases. The project group aims to develop an open reference design that leverages general-purpose hardware and open-source software for creating a flexible modular 5G NR platform.

While efforts by O-RAN alliance and TIP are directly focused on opening RAN interfaces, there are several other open-source networking communities (such as Linux Foundation, ONUG, ONF, and others) that are driving the overall concept of "open networking" in the wireless ecosystem.

Open RAN Mass Adoption

For Open RAN to deliver its promises to the operators, both the vendor and operator communities will have to partner on multiple critical functions. Some of the critical factors that will define the success of Open RAN include the following:

Strong industry partnerships and ecosystem:

It's critical to focus on building an ecosystem that has breadth and depth. It's unlikely that operators will go for an open RAN product – whether it is RRU or baseband – if they don't have enough options to consider. A robust ecosystem will encourage mobile operators and give them more confidence in the viability of Open RAN and speed up its adoption.

Multi-vendor interoperability:

The concern for interoperability is one of the major reasons that many operators stick to a single-vendor strategy to ensure tight inter-cell coordination and avoid any impact on network performance. A truly multi-vendor best-of-breed open network demands interoperability between different RAN vendor equipment to be as smooth as they are in a single-vendor network.

Addressing employee concerns around added network complexities:

It is noteworthy here that even though carriers want to avoid vendor lock-in and build multi-vendor networks, they have concerns about complexities that a multi-vendor network will bring in.[9] Because of concerns around added complexities to network operations, operators may also face resistance from employees as well.[10] It is critical to have proper training programs for employees to understand and align with the long-term benefits of Open RAN.

Addressing system integration challenges:

Similar to interoperability, the success of Open RAN will depend on what kinds of system integration capabilities operators have access to when it comes to building a multi-vendor network. Operators are unlikely to buy an RRU from one vendor, fronthaul from another, and baseband from a third one if they lack skills or find it difficult to integrate them all tightly. Besides good system integration capabilities and skills, the cost should be reasonable enough to make Open RAN solutions appealing.

Cooperation Among Vendors and Carriers

Collaboration between operators and vendors will be key to ensuring that Open RAN developments follow a path that supports the current and future needs of the carriers. Given the hyperdynamic nature of mobile networks where a single small outage can cost millions of dollars in lost revenue and reputation, it will also be critical to ensure system stability, reliability, and performance. Joint developments and trials can speed up the resolution of critical gaps in interoperability and coordination between different radio network elements.

Such collaborative efforts among vendors and carriers are already accelerating the adoption of Open RAN beyond specifications and lab trials. Many carriers are directly working with RAN vendors to build Open RAN systems. For instance, Samsung has been collaborating with Verizon to advance their 4G LTE Open RAN initiative by supplying RRHs and BBUs, which will allow Verizon to interwork with other vendor products in its network. [11]

Recently several leading operators including AT&T, Bharti Airtel, China Mobile, China Telecom, Deutsche Telekom, KDDI Corporation, KT Corporation, Orange, SK Telecom, SoftBank Corp., Telefónica, TIM, Verizon Communications Inc., and vendors including Samsung jointly announced they would adopt the O-RAN Alliance fronthaul specifications. The operators plan to test or introduce O-RAN-compliant products in commercial 5G networks.[12]

[9] https://img.lightreading.com/downloads/HR-Open-RAN-Survey.pdf
[10] https://www.lightreading.com/mobile/fronthaul-c-ran/vran-tech-hits-resistance-at-sk-telecom/d/d-id/741230
[11] https://www.samsung.com/global/business/networks/insights/news/samsung-selected-as-a-4g-lte-open-ran-provider-on-verizons-4g-lte-network/
[12] https://www.nttdocomo.co.jp/english/info/media_center/pr/2019/0222_00.html

Unlocking Innovation

Mobile operators have long been stuck in a cycle of flat revenue growth despite the big investments in networks and the huge growth in data traffic. The current operator enthusiasm around Open RAN is driven by a strong belief that it will lead to significant transformational changes to the way networks are built and managed and that it will benefit them in multiple ways.

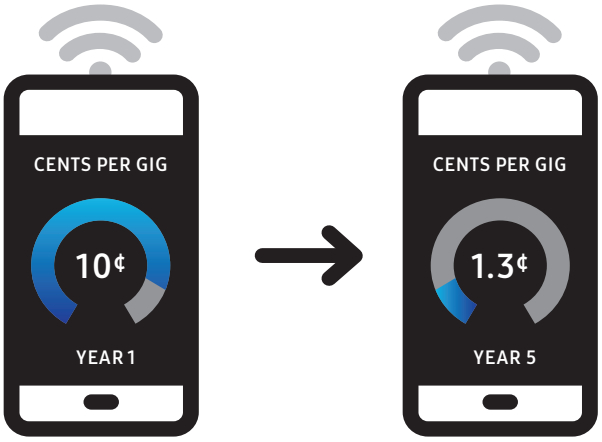
Samsung shares similar enthusiasm and belief in Open RAN initiatives. Open RAN will play a critical role in evolving carrier networks by offering flexibility to build a best-of-breed network, bring agility in developing new innovative services, create new operating models, and enable new cost economies.

While it's still in its early days, Open RAN evolution is gaining momentum and showing real benefits. A stronger ecosystem and collaboration are critical for creating wider acceptability of Open RAN, and to convince both operators and vendor communities that Open RAN systems can be as reliable and stable as the proprietary radio networks.

The key to unlocking the power of 5G networks lies in investing in open standards and an open network that lays the foundation to introduce new and exciting business models. Combining advancements in technology, spectrum availability and a shared desire to foster rapid innovation in how the world communicates information encourages investment while delivering a healthy return to profitability that network operators have needed.

The push for Open RAN is not about network turf wars. It's about accelerating the deployment of infrastructure necessary to help 5G reach a critical mass. Without reaching this critical mass, the benefits offered by 5G technologies may take longer to realize. Telemedicine and remote health monitoring will remain stifled. Autonomous cars will remain in the showroom, leaving human error as the leading cause of traffic accidents. And rookie firefighters will have to train in real fires instead of using virtual reality tools to learn best practices before facing dangerous circumstances. Open RAN is good for everybody because 5G benefits individuals and businesses. Samsung is committed to seeing the deployment of 5G happen as quickly as possible, simply because people, businesses, and communities will experience a better quality of life with the advances it will bring.

Samsung is an established pioneer in mobile networking technologies, from 2G to 4G LTE and 5G NR. Through this evolution, Samsung is committed to fostering innovation through openness and partnering with carriers and suppliers in the Open RAN community to help design standards that will optimize present and future networks and to meet the increasing demands of next-generation users.



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1301 E Lookout Dr.
Richardson, TX 75082

Sales: 1.877.556.9469
Service & Support: 1.800.737.7008

samsung-networks.com