451 Research | PATHFINDER REPORT

Open RAN Transitions for Established Providers

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About this paper

A Pathfinder paper navigates decision-makers through the issues surrounding a specific technology or business case, explores the business value of adoption, and recommends the range of considerations and concrete next steps in the decision-making process.

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Eric Hanselman is the Chief Analyst at 451 Research. He has an extensive, hands-on understanding of a broad range of IT subject areas, having direct experience in the areas of networks, virtualization, security and semiconductors. He coordinates industry analysis across the broad portfolio of 451 Research disciplines. The convergence of forces across the technology landscape is creating tectonic shifts in the industry, including SDN/NFV, hyperconvergence and the Internet of Things (IoT). Eric helps 451 Research's clients navigate these turbulent waters and determine their impacts and how they can best capitalize on them. Eric is also a member of 451 Research's Center of Excellence for Quantum Technologies.

Executive Summary

The wave of new Radio Access Network (RAN) technologies that leverage virtualized and cloud-based resources can transform wireless delivery and operations. One of the most important aspects is the shift to open models of development that let providers blend software and equipment to become more adaptable and agile in how they approach markets and engage with their customers. Open RAN initiatives seek to allow the independent development of hardware and software in the wireless world. They leverage the virtualization of functions that have historically been bound within physical appliances to create opportunities for innovation.

Growth and competition in existing 4G networks and the transition to 5G technology have dramatically increased pressure on operators to become more efficient. The journey to a more decomposed mobile edge for existing environments can seem daunting from both the operational and technical perspectives, but recent advances in the industry have opened up routes that can help achieve the full benefit and smooth the transition. The result is the ability to build capacity with greater flexibility and agility, which can dramatically improve new services. While some have seen this only as a greenfield opportunity, there are advantages to putting the approach to work for operators in all stages of deployment.

Key Findings

- **RAN transitions offer critical benefits for operators** – Increasing 4G density is already straining operational models in ways that open approaches can address, while also building foundations for 5G.
- **Open approaches to RAN deployments offer flexibility** – Simpler interoperability gives operators smoother paths in complex technology and vendor transitions.
- **Progress in virtualizing RAN functions is leading to greater efficiency and operational simplicity** – Virtualization allows faster deployment with lower effort, reducing risk in operations.
- **Open approaches enable innovation – Opening the RAN with standardized internal interfaces creates opportunities for a wider community to integrate new technologies, approaches and algorithms. The same innovation that has driven other open source communities can be unlocked in the radio world.**
- **Real-time operating systems are needed to meet the performance requirements of today's infrastructure** – Deterministic performance is needed to assure network quality for 4G architectures today and 5G going forward. Expectations of lower latency and improved performance place greater demands on operating system performance.

Transitions in RAN

Much has been made of the transformative powers of 5G and the impact that it will have on the world. While one can debate the scale and scope of the broader impacts, 5G technologies offer a dramatic set of changes for network operators. The cellular industry finds itself at another cusp of significant technological change, one that presents an opportunity for providers to raise the level of their value to customers beyond the basic movement of data. These technologies are valuable not only for 5G deployments, but are also valuable in the existing 4G world, as demands for density increase and market pressures push for more efficient operations. Services that can support the needs of industrial IoT, gaming, e-sports and vehicle interconnection are a path to greater potential for those that can master the capabilities required to deliver them.

One of the most powerful technology transitions available to operators is the shift to open interfaces within the RAN environment. The disaggregation that started in other parts of operator networks with network functions virtualization (NFV) has taken longer to reach the radio world, but it's finally arrived. The virtualization of significant parts of the RAN can simplify deployment by separating functional elements from their supporting infrastructure. This allows operators to more efficiently deliver capacity where it's needed, with greater ability to respond dynamically as needs change. It also reduces the work required to bring in new technologies, whether for 4G or 5G. Opening the interfaces between these elements allows innovation to happen independently within different areas of the RAN. This paper explores the benefits that are possible and examines paths to achieving them.

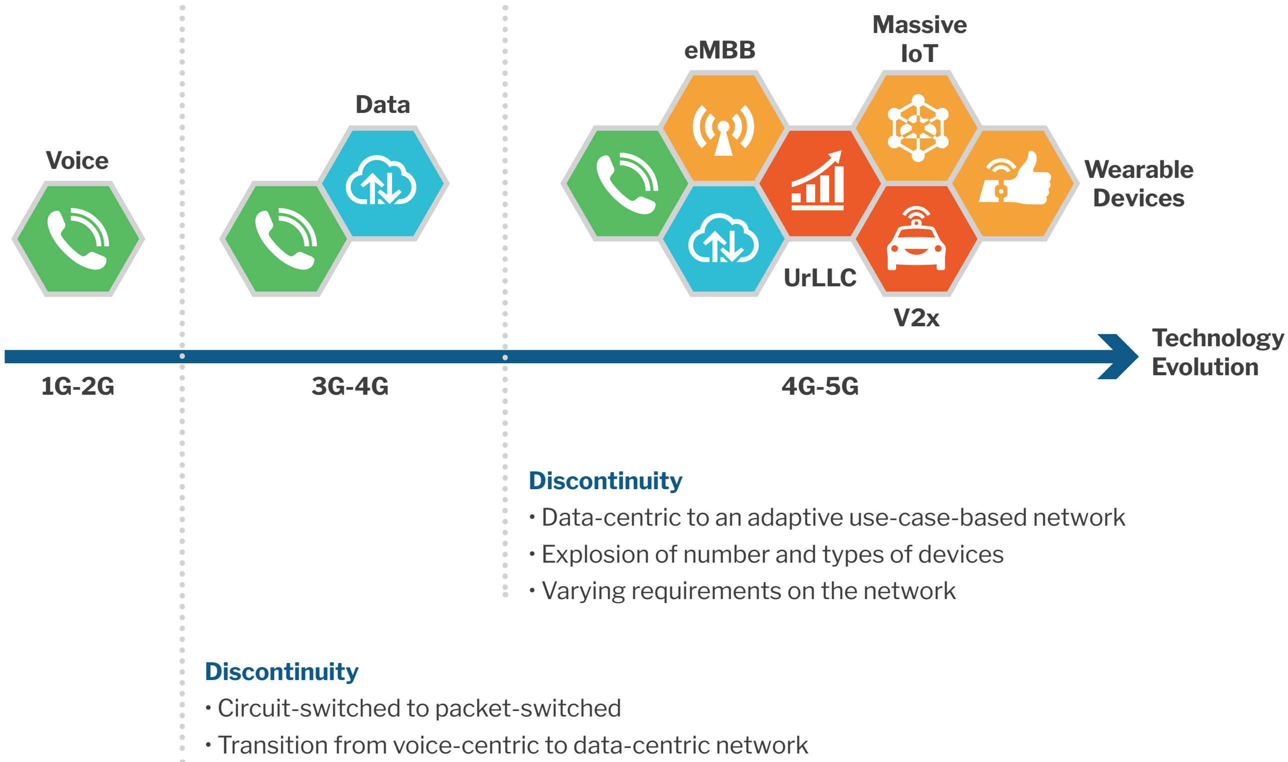
Demands on RAN

To reach this level, operators' networks must be able to support multiple types of competing, and often conflicting, usage types and performance requirements. These requirements come with an expectation of adaptability and responsiveness that is well beyond the demands placed on existing networks. They also come with expectations that can strain traditional business models.

There are opportunities for operators that can transform development, deployment and operational aspects of their businesses. The need for greater density and more capable supporting infrastructure is the most visible driver for RAN transformation. This is a need that exists in most 4G networks today as well. Operators that are able to embrace these changes have the opportunity to transform their internal capabilities, as well as their services. The architectures of these transformed networks will have to be flexible enough to support a wider range of use cases within their operational scope. They'll have to do this for the many existing uses and also be ready to adapt to those that we have yet to identify. Figure 1 presents a snapshot of some of the varied requirements for some of the early use cases targeted for 5G.

Figure 1: RAN Technology Evolution

Source: Altiostar and 451 Research



The architectures and technologies that are in place for many operators were built with design ideas that were adequate and acceptable at the time, but face difficulty in handling the dynamic environment in which they find themselves today. The amount of risk tied to change in monolithic, dedicated and brittle systems holds operators back from being able to innovate or even accelerate fundamental operations. Operators can put the lessons that fueled the evolution of the IT industry to work in their own environments to both enhance their operational effectiveness and hold off competitive threats:

- Creating a platform for services – Building systems that are extensible
- Embracing open interfaces internally and externally – Enabling larger ecosystems
- Transforming from integration-led to innovation-driven – Expecting continuous change

Aspects of Change

The main aspect of change is the shift to software implementations of functionality that has historically been delivered in dedicated hardware. The idea that software is eating the world is often echoed, but that trivializes the impact of this shift. Software implementations impact how functionality is developed by reducing the integration effort required to package it with hardware. It's decoupled from the hardware system on which it eventually runs, and that frees the developer of those concerns. The shift to software implementations is also seeing a transition in how functionality is delivered. It's maturing from models that simply took the full software environment from dedicated hardware and fit it into a virtual machine (VM) toward approaches where the architecture of the software is adapted to entirely new models. Early efforts optimized virtual instances, and later ones began to decompose monolithic designs. As in other areas of software design, this change has progressed to more fully deconstruct the functional elements of designs. The decoupling of development efforts can create greater agility.

In telecommunications, the decomposition of designs created the opportunity to make specific functional elements independent of the hardware that supported them. The transition to network functions virtualization (NFV) allowed operators to deploy hardware resources that could support a range of virtualized network functions (VNFs) that don't depend on the specific characteristics of that hardware. VNFs could be dynamically deployed where they were needed, and the capabilities of the network could be adapted without the need to change its physical configuration.

The progression to virtualization has brought with it the ability to transform the relationship between vendors and operators. As vendors are able to package functions in more lightweight vehicles, it has opened the door to greater decomposition of functions and the need for interoperability between those functions. For RAN technologies, the traditional deployment model tightly coupled the various functions of the radio environment. There have been some efforts at RAN decomposition, such as the Common Public Radio Interface (CPRI) that allowed radio transceivers and base stations to be separated. It required high-performance links to bridge the separation, and that made it costly to deploy, limiting the situations in which it could be used. It was an early step that showed what was possible.

The Shift to Open

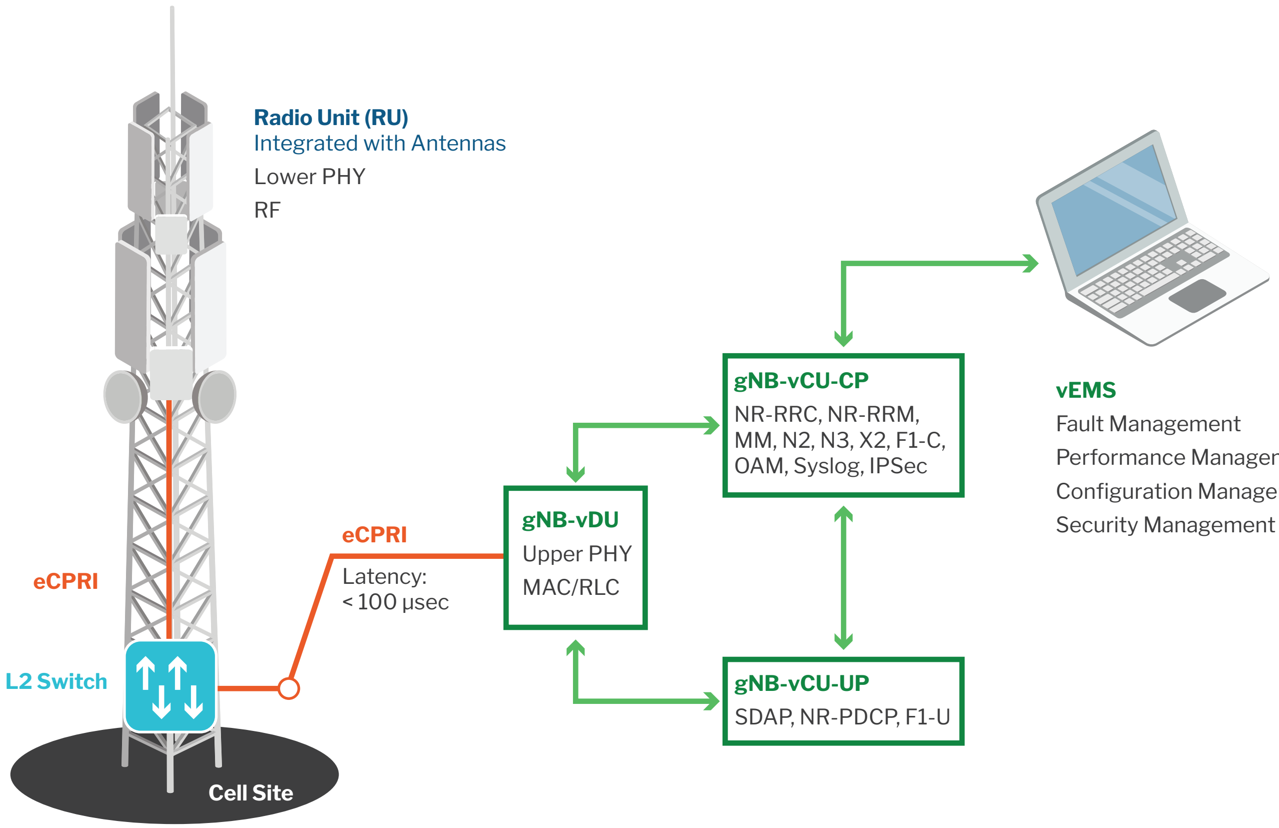
The expanding use cases for 5G networks are driving fundamental changes in the way operators are building them. This has led to architectural changes that are pushing initial efforts to decompose and virtualize radio functions much more aggressively. The diversity of 5G uses effectively demands larger numbers of cell sites that are closer to users. It creates the need to scale up functional density and to do it across a broader set of resource capacities to meet these varying needs.

The 5G New Radio (NR) specification redefines the functional splits into Central Unit (CU), Distributed Unit (DU) and Remote Radio Unit (RU). This has created an opportunity to increase the flexibility with which operators address the capacity demands of their networks. The O-RAN Alliance was formed to foster the creation of open and interoperable interface definitions that would allow operators to deploy independently developed functions across their networks.

The combination of these efforts and the move to virtualization has fostered considerable work around creating virtual RANs (vRANs) that can take advantage of the agility of VNFs and the efficiency of general-purpose hardware in radio environments. The O-RAN Alliance is looking to give operators the flexibility to work with interoperable functionality from different vendors. The goal is to enable the efficient tailoring of deployed technologies to network requirements and encourage innovation in a rapidly evolving world.

Figure 2: The Virtualized RAN

Source: Altiostar and 451 Research



Wireless networks have always had difficulty dealing with dynamic changes in demand, and open interfaces are a path toward fixing this complex problem. Capacity management was always challenging, and 5G's flexibility makes it worse. Rapid changes in user density or service consumption could overwhelm a region that normally saw low utilization, leaving operators with significant overprovisioning as the only practical means of dealing with this situation. 5G amplifies this problem with the need to accommodate changing ratios of RAN functional elements as different capabilities are utilized by different services and user requirements.

Capacity management within an area extends the requirements of LTE in that different sectors are carved up to form cells, each requiring supporting DUs. Layering on the latency demands of a new class of applications using the network requires tighter functional alignment. New antenna locations will be created more rapidly, requiring the rebalancing of associated DUs and CUs. Spectrum use will vary by location and environment. Network slicing further complicates the distribution and associations of elements to match throughput and latency for services that can be overlaid on shared infrastructure.

All of these factors have driven a requirement for 5G infrastructure to be far more adaptable. Open designs give operators the ability to mix and match the right spectrum radios with appropriately dense back ends to tailor infrastructure to the customer demands of the moment. Most importantly, the flexibility of virtualized infrastructure will ensure that VNFs can be spun up to meet the on-demand expectations of customers. The transition to 5G is a multi-stage process with many intermediate steps. There are specialized adaptations, such as NB-IoT and LTE-M, that focus on IoT and other low-power wide-area requirements that must be supported.

As has been amply demonstrated in the broader IT marketplace, an open ecosystem can not only increase the adaptability and competitiveness of an operator, but can also foster innovation, a key factor in making operators' existing 4G networks more competitive and making them ready to capitalize on the opportunities that the 5G transition presents. Open systems allow operators to build capacity and advance to new technologies in ways that more closely match their needs. 5G presents a broad range of options for service portfolios, and operators must be able to define their operations on their own terms.

Benefits of New Modes

Managing Expenses

There are many benefits that open and virtualized approaches can deliver. One of the most clearly established in the broader technology market is the amount of choice in balancing capital expenses (capex) and operating expenses (opex). Virtualization in enterprise IT has freed organizations from the need to tie workloads to specific hardware. The telecom world has had more stringent performance requirements that have held back virtualization of RAN functions, but advances have now opened the door to RAN VNFs. That means that operators have the ability to deploy physical systems that can support a wide range of logical functions, and they can deploy those functions dynamically as the needs of the network change. The traditional model of deploying physical implementations of integrated RAN stacks meant that operators had to take the risky and expensive path of placing capacity where they expected it was going to be needed. Any change in requirement from the expected caused, at best, stranded capacity and, at worst, broken services. Virtualized functions enable tighter alignment of capacity and demand.

Another benefit of NFV is the automation that comes along with it. While service orchestration in the traditional model focused on the configuration and operation of fixed physical devices, NFV handles not only configuration but also the placement and integration of the functions it's managing. This can seem like a subtle change, but it has dramatic impacts on operations. Changing cell capacity with physical devices required a truck roll to move or add capacity or capabilities. With NFV, if a network slice requires lower-latency performance, for example, a CU/DU stack can be provisioned closer to the radio head with automated tools, performed remotely, and no truck is roll required. As needs change, capacity can be reallocated just as simply. This combination of benefits gives operators more control over capex outlay, and reduces opex simultaneously.

The Nimble Operator

Another operational benefit of the shift to open and virtualized infrastructure is the decoupling of functional capabilities from supporting hardware and their dependent elements. This allows operators much greater operational and deployment flexibility, while reducing risks in introducing new services. The operational revolution that has been sweeping the hyperscale world with DevOps and continuous integration and continuous development (CI/CD) is now accessible to operators. NFV lowers the cost of deploying new versions of functions. That lets operators experiment and innovate with lower risk. New versions can be rolled out with incremental changes that can be rolled back just as rapidly, if needed.

Open interfaces within RAN components give operators the flexibility to bring in new methods to enhance service and capacity. 5G's expanded radio architectures represent one area where this can offer advantages. Massive MIMO (Multiple Input Multiple Output) expands antenna density, but innovations like Coordinated Multi-Point (CoMP) require linking radio control across cells to optimize coverage. That can require the dynamic provisioning of RAN elements to realize the benefits it offers. NFV-based systems can make this a reality. The delivered value for operators is better spectrum utilization and capacity management, and the nimbleness to capture new opportunities.

Challenges in Existing Environments

Network operators face hurdles in deploying 5G technologies in their existing environments. The nature of those hurdles can be broken down into three areas: the limits of existing equipment with multivendor interoperability, the fragility of their existing operations and the rigidity of operational systems. The combination can make for what appear to be daunting obstacles.

Equipment Constraints

Most operators are moving forward with the non-standalone (NSA) deployment model of 5G, which requires the integration of 4G with the new 5G RAN. There have been concerns that getting equipment from different vendors in these two realms to interoperate will be complex, if it's achievable at all. The core of the issue is the X2 interface, over which connection handoffs occur, which has been seen as having proprietary elements in its implementation by different vendors. Interoperability is a key functional part of NSA deployments. This has raised the idea that only single-vendor deployments would be possible. For many operators, that could require existing 4G equipment to be replaced – a costly, time-consuming and risky prospect.

Operational Fragility

Any operational environment is at risk for the intrusion of dependencies that accumulate over time. In many cases, these come with simplifications that take advantage of shortcuts or proprietary functionality. That can make operations sensitive to changes in equipment types, vendors or even configurations. What could be expected to be small changes wind up with outsized impacts when the ramifications are fully realized. Operators can be hesitant to make changes as a result, due to the fear that dependencies aren't fully understood and that the only way to detect them is through a resulting failure. That concern can seriously hamper innovation.

Operational Rigidity

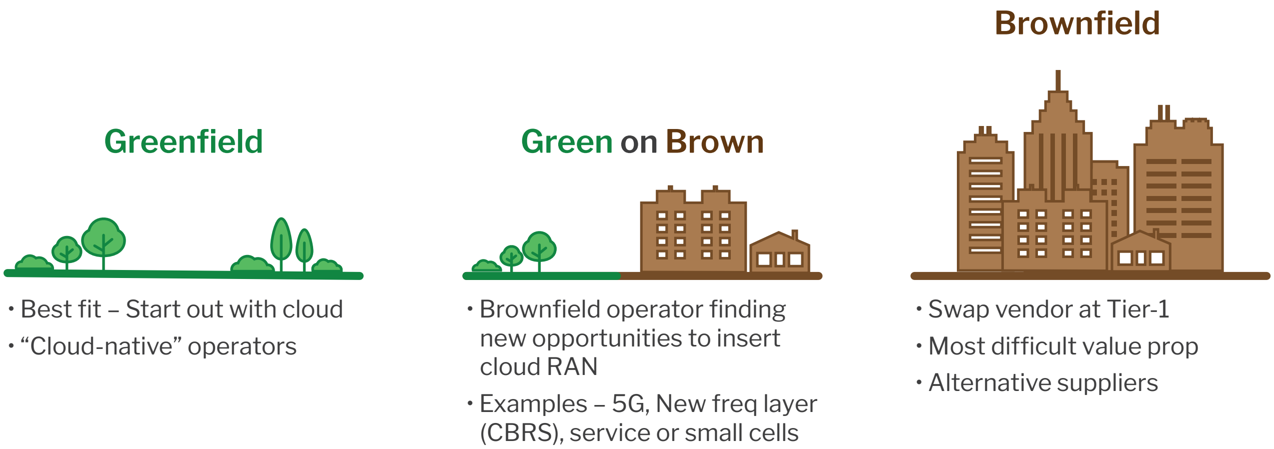
Alongside the perceived fragility of operational systems can be concerns about their rigidity, which come from systems that are built with expectations around how functionality is implemented and will be operated. If there's a tight coupling between business processes and supporting infrastructure, it can be difficult to modify those systems without changing the business aspects. While this type of issue is less common, operators can expect that business processes will be more complex to adapt and be more resistant to change.

Paths Forward

The various aspects of each of the challenges we have outlined can be addressed to deliver successful outcomes. Operators need to begin the journey to better capabilities or risk being eclipsed by their competitors and new entrants into the market. This is a transition that can bring existing environments up to levels of performance that can rival greenfield capabilities. The change requires consideration of the foundation of the infrastructure and the cooperation of vendors, both existing and new.

Figure 3: Deployment Models

Source: Altiostar and 451 Research



Architectural Enablement

One of the first steps in opening infrastructure to the benefits of more open models is to ensure that there is a solid foundation on which to build. For most operators, that will begin with the installation of NFV infrastructure to support the deployment of VNFs. One of the advantages of virtualized environments is the ability to have more granular deployment of supporting physical systems and to deploy them closer to where they're needed, often at the edge of networks. Virtualization allows just those functions that are required for current network needs to be consuming resources, and has the potential to reduce the size and power demands at individual locations. Operators examine the potential for deploying in smaller increments of compute and storage to take advantage of these benefits.

There should be careful consideration around the capabilities and capacity of the supporting systems put into place. They need to deliver not only the computational power needed but also deterministic performance to meet the needs of RAN operations. This is a requirement that goes beyond the simple needs of a more basic virtualization infrastructure. To deliver predictable responses, virtualization platforms are required to provide low-jitter and low-latency data handling, and offer controls to manage and prioritize resource delivery to optimize performance. Generally this will require real-time operating systems and configurations that allow for the tuning of operational parameters.

Platforms that can support a variety of virtualized workloads and target resource allocations to optimize performance can deliver RAN functionality that scales to meet needs across an operator's network.

Vendor Collaboration

Historically, many operators felt that maintaining a predominant relationship with a single vendor would simplify their operations. While there may have been some truth in that years ago, today's reality is that maintaining such a stance can constrain the options available to address a much more complicated future. Operators must have flexibility if they're to remain competitive. Vendors have come to realize that it's in their best interests to work with operators to address an expanding set of needs that may extend beyond their own product suite. Operators should approach the transition to 5G with an expectation that vendor collaboration is mandatory. One way to measure that collaboration is to understand the extent to which vendors are addressing and integrating open standards across their offerings.

The first stages of collaboration can be as simple an ensuring that VNFs are supported on a range of infrastructure options. That can be as part of formal certification efforts or partnerships across vendors. Operators must plan for the resources to evaluate and measure interoperability or work with partners who can aid them in that task.

Operators should expect to work with vendors in more integrated ways to manage the amount of internal change required. The co-creation of new services or functionality can help operators to leverage vendor capabilities while driving the development of their internal skills. This can be effective with existing vendors, and operators should also consider new vendor partnerships where they bring in competencies that the operator requires. Open interfaces allow the participation of new market entrants, as deployment risk is lowered, making experimentation easier and opening the door to innovation. Operators should initiate greater outreach to research and startup communities to capitalize on this potential.

Open Source Software Engagement

As part of the movement to more open architectures, operators will also have the opportunity to work with open source software projects that may form the foundation of some of the technologies that are delivered as part of their vendor ecosystems. Operators can also look to leverage open source projects on their own, to meet their requirements directly. The engagement model that works best will depend on an operator's environment, staff and base of skills. Taking on the integration of an open source project directly requires significant skill levels and resource commitments. This is especially true with operating systems, orchestrators or other critical pieces of an operational network. In a direct model, the operator must be able to maintain their integration and work with the project community to manage the delivery of defect resolution and security updates.

For those that have well-developed software teams with open source experience, the direct model can offer a useful path. For most operators, that effort can dwarf any potential gains, and they prefer an indirect model where they work with a trusted intermediary who provides curated open source distributions. The advantage of the indirect model is that operators get access to open source innovation with the risk reduction of a committed maintainer. It can also offer longer-term support that better fits the longer deployment and lifecycle patterns familiar to operators.

Staged Decomposition

The transition to the more flexible environments needed to support 5G involves the decomposition of monolithic RAN implementations. It's not a change that has to be undertaken in a single event. Functional partition of the 5G RAN allows higher-level elements, such as those of the CU, to be gradually virtualized as there is capacity to support them. Operators can work with vendors to identify the transition and ensure that it happens in manageable steps. The operational changes between each stage of decomposition can be taken in steps that minimize disruption and manage risk. An orderly transition can be achieved with a modicum of planning.

Simplifying Operations

The antidote to many of the operational complexities that operators face is strategic rethinking of how they are serving the business. A comprehensive revamp is impractical, but addressing those areas that are key to unlocking service flexibility can yield visible results quickly. RAN virtualization can tackle one of the most problematic areas of capacity management. It's also a large component of the transition to 5G, and an area where there is high likelihood of additional operational churn, as vendors revise early product implementations and standards mature. Virtualization can be rolled out in increments in the RAN in ways that are more complicated closer to the network core.

Conclusions & Recommendations

The transition to 5G is inevitable, and operators have the opportunity to engineer that change in ways that can deliver far-reaching improvements to their operations and infrastructure. The operational nature of their RAN environments can be transformed to become nimbler and offer greater choice and flexibility in the way in which new services and technologies are introduced.

There are a set of basic steps that operators at any level of maturity can put to work:

- **Identify an entry point** – Finding a specific service or element is that crucial first step in starting the journey. For greenfield deployments, this can be new service infrastructure. For brownfield deployments, this can be a functional element or a region.
- **Build the ecosystem** – Getting vendors engaged is important, and operators must identify areas where they can put the advantage of co-creation to work.
- **Identify process transformation** – New processes and methods are part of the transformation and key to ensuring success. Building open requirements into request processes is a necessary first step.
- **Plan insertion** – After validating a service or function, commercial insertion is the realization of the new capability.

Operators must get started today if they want to maintain their competitive position. The greatest challenge can be taking the first step. Keep in mind that significant transformation is a long-term process, one that has to be seen as a continuing journey, not a one-time event. Leveraging open interfaces to integrate new options and speed transformation can be a competitive differentiator. The future is there, and intelligent network operators will take the initiative to embrace it on their own terms.

About 451 Research

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