White Paper
Transporting 5G from Vision to Reality

As the race to deploy 5G gathers speed, the reality of building out new and different network architectures presents a variety of complex issues for service providers to address. Foremost among these challenges is the development of a robust optical transport network to support 5G radio access at the edge, creating the solid foundation that will enable service providers to deliver new profitable services. New 5G networks need greater scalability, reliability and performance – from the first mile through the last, and to the edge – in order to meet the speed, latency and density requirements of diverse and demanding 5G services.

Fujitsu is working closely with network service providers to help them plan, design and deploy transport networks that will not only position them to be first across the finish line with commercial 5G services, but also help them maintain forward momentum for the long-haul. Building on this real-world experience, this paper examines 5G transport challenges, evolution of the radio access network (RAN) architecture, best practices for design and deployment, early business model opportunities and a vision for the future.

To the Edge and Beyond

With the promise of extremely high throughput and gigabits of data offered by enhanced mobile broadband (eMBB), 5G is expected to revolutionize economies and societies through hyper-connectivity, enabling innovations in automotive, manufacturing, energy, utilities and healthcare sectors, among others. As network architectures transition to cloud-based connectivity and software-defined networking (SDN) control, service providers can enable new 5G use cases ranging from massive Internet of Things (mIoT) services, machine type communications (MTC) and fixed wireless access (FWA), to connected cars and smart homes.

5G networks will need to be dynamic enough to support low latency, cloud-based applications, while maintaining co-existence with current 4G and LTE technologies. The introduction of new antenna technologies such as massive Multiple Input Multiple Output (MIMO) will stretch capacity to the limits, resulting in a 5G transport rate more than ten times greater than 4G. In order to successfully achieve this evolution, service providers need to build out robust transport networks capable of scaling to support billions of connected devices and an exponential increase in capacity, while significantly reducing latency at the edge.

The transport network for 5G is much more than just backhaul; it's the critical backbone connecting the core network all the way to the service layer at the edge via the midhaul and fronthaul. Sufficient capacity, reliability and scalability to enable differentiated 5G services in the future will be dependent on the fiber transport network deployed now. But in the evolved 5G architecture, transport network planning presents additional complications due to interdependencies with RAN deployment and the network operator's service strategy. Deployment plans for the backhaul, midhaul and fronthaul segments of the transport network (i.e., X-Haul) will be highly dependent on the varying capacity needs and latency sensitivities of the use cases to be supported, as well as overall CapEx budgets. Therefore, planning and design of 5G transport networks requires careful consideration of many different factors to optimize efficiency and ensure that capacity is effectively delivered where and when it's needed.

Evolution to Virtualized RAN

To handle the tsunami of device-to-device communications expected with 5G, next-generation networks will require denser RAN architectures with distributed intelligence. This increasing densification means more advanced topologies in the access part of the transport network, such as mesh or ring configurations, as well as evolved fronthaul and backhaul interfaces. In addition to connecting physical radio sites, tomorrow's mobile networks need to support virtual network functions in order to enable network slicing and connect subscribers to cloud-based applications.

As the 5G RAN (NG-RAN) is increasingly virtualized, service providers are able to dynamically support a range of use cases with varying demands using SDN control and orchestration. Moreover, with the advantage of running virtualized network functions (VNFs) on open hardware, service providers can be free of vendor constraints, helping to keep both OpEx and CapEx costs in check. Therefore, a key benefit of this new ecosystem is the opportunity to disaggregate the optical transport network.

Ensuring a smooth evolution to an integrated 4G/5G network requires scalable, modular and disaggregated platforms that are highly programmable. With open application programming interfaces (APIs) and standards-based protocols such as NETCONF/YANG, network operators can build more affordable vendor-neutral networks that are dynamically controlled via SDN technology, allowing them to be first to market with new services.

Fixed on the Horizon

While the potential future opportunities for 5G are nearly limitless, the first use cases will be limited by default, as the market awaits delivery of new 5G devices and handsets. There are many technical hurdles yet to be overcome in the 5G consumer device market, including form factor, battery life, beam tracking and higher MIMO. For that reason, fixed wireless access (FWA) is the first use case to see widespread adoption; a "low hanging fruit" for service providers. We expect this to be a particularly prevalent option for delivery of broadband services to residential subscribers and small to medium businesses, and these services are already beginning to take shape.[1]

Fixed wireless access can be enabled through network densification overlaid on the existing 4G network with accompanying fixed location devices in the home or enterprise. This creates an early advantage for network operators and new mobile market entrants to leverage the new 5G radio interface (NR) in the short term, while working to extend fiber reach and address last mile challenges that are critical to 5G deployment.

Fujitsu is actively working with leading service providers to help them create innovation and unique differentiation with 5G, including fixed wireless access solutions. Fujitsu has developed a number of technologies aimed at increasing capacity and spectral efficiencies in 5G NR communications, such as integrated ultra-high density distribution antenna systems and low-power millimeter wave circuits. As shown in Figure 1, these systems can connect directly to existing backhaul, reducing costs and allowing service providers to get up and running quickly with fixed wireless services.

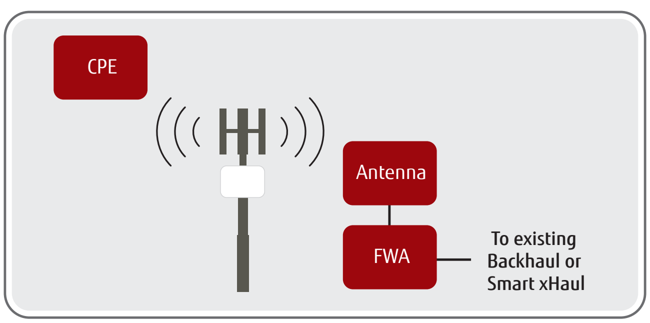

Figure 1: Fujitsu Fixed Wireless Access Solution

Likewise, Fujitsu offers an xHaul transport solution that can be connected to fixed wireless access systems from third-party vendors in an open networking configuration, as depicted in Figure 2 below. The Fujitsu Smart xHaul solution offers CPRI, eCPRI and gigabit Ethernet at 1G and 10G rates, which can be integrated into the C-RAN transport.

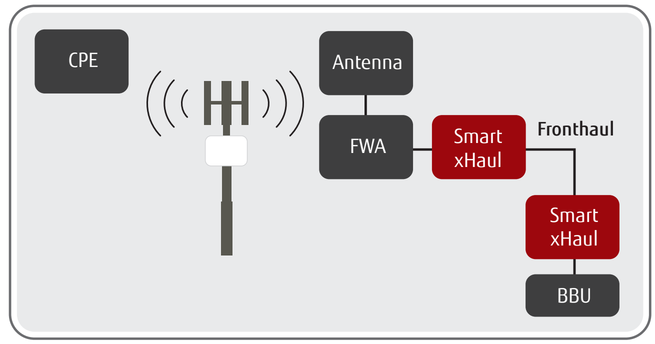

Figure 2: Third-Party Fixed Wireless Access w/ Fujitsu Fronthaul

Fast-Moving Future

Once network operators have begun to realize return on new 5G investments with fixed wireless access, the next step for most service providers will be to enable the types of mobility use cases more closely associated with 5G. Planning and deploying a mobile network to support a myriad of 5G applications will be no easy feat, considering the complexities of these new architectures and the interdependencies between the RAN and transport network. For this reason, working with a supplier like Fujitsu, that offers end-to-end transport and radio solutions that complement each other, can offer significant advantages.

As shown in Figure 3, the three key building blocks of the NG-RAN architecture are the centralized unit (CU), distributed unit (DU) and radio unit (RU). Together, these three main functional modules make up the 5G base station (gNB). While the functions of the CU and DU were combined in the 4G baseband unit (BBU), 3GPP 5G specifications introduce a functional split to the previous BBU design as a way to lower transport costs, thereby offsetting the significant increase expected with 5G transport rates.

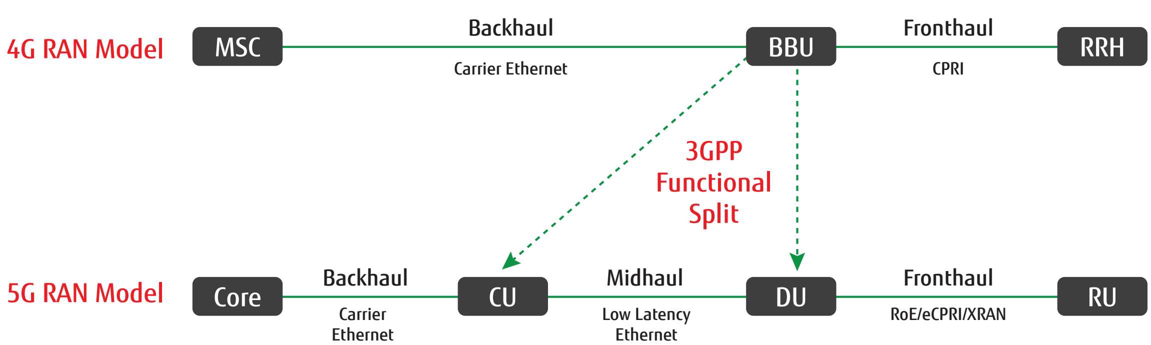

Figure 3: 4G to 5G RAN Architectural Contrast

This split in gNB functions means that the three main functional modules can be deployed in multiple combinations, with various scenarios yielding tradeoffs in RAN performance and cost. The key, therefore, is to determine which RAN topology is optimal for your network. This section will review three use cases for general performance and cost tradeoffs, as shown in Figure 4.

Dual Split RAN Architecture

The dual split RAN architecture is similar to the 4G BBU where DU resources are centralized in a pool for connectivity to RUs at multiple cell sites. In this configuration, fronthaul provides connectivity from the DU to RU. Since the DUs are centralized, their resources can be pooled across multiple cell sites over the fronthaul spans. This pooling capability enables the service provider to engineer performance demand for the RAN based on the region within this group of cell sites, instead of based on individual cell sites. Individual cell site performance engineering is very inefficient, since the dedicated DU cannot be dynamically scaled when greater performance is needed.

Conversely, if dedicated DU capacity is underutilized then it becomes an expensive dedicated resource. In this NG-RAN architecture, centralized DU resources also offer cell site aggregation. Cell site aggregation enables multiple cell sites to simultaneously address demand for an individual mobile user, as compared to a single cell which can become saturated during peak loading hours when supplying demand to an individual mobile user. Pooling and cell site aggregation provide the service provider with a blend of high performance and dynamic radio network operation per capital expenditure, along with the lowest scalability OpEx.

Cell Site RAN Architecture

The Cell Site RAN architecture offers dual functionality providing low latency and centralized operation. The DU, RU and local CU user and control plane (CU-UP and CU-CP) functions as well as a possible multi-access edge computing (MEC) functions are collocated at cell sites to support latency-sensitive applications and a second CU-UP at the edge site for centralization benefits. To achieve dual functionality, the DU resources are sliced to offer a fixed allocation of resources to each of the two CU-UPs.

The cell site local elements support the ultra-low latency applications such as autonomous vehicle and tactile Internet operation. The edge site CU-UP optimizes mobility applications offering centralization enabling efficient resource pooling and high performance cell site aggregation to the cell sites they serve.

In addition to enabling these next-generation applications, this architecture helps reduce costs by potentially eliminating the fronthaul transport segment.

IDU Cell Site RAN Architecture

The integrated DU (IDU) Cell site RAN architecture along with UPF or MEC functions, integrates the DU and RU elements, offering similar low-latency and centralization benefits as the Cell Site RAN architecture while providing an additional level of capital and operational cost reduction. Since the DU and RU are integrated, service providers can realize CapEx savings in fiber optics and cabling that is internal to the integrated device. Operationally, there are fewer devices to turn-up and interconnect, resulting in decreased OpEx as well as expedited service delivery.

Integrating the DU with the RU is the lowest cost implementation architecture option, offering a next step in the evolution of the 5G NG-RAN.

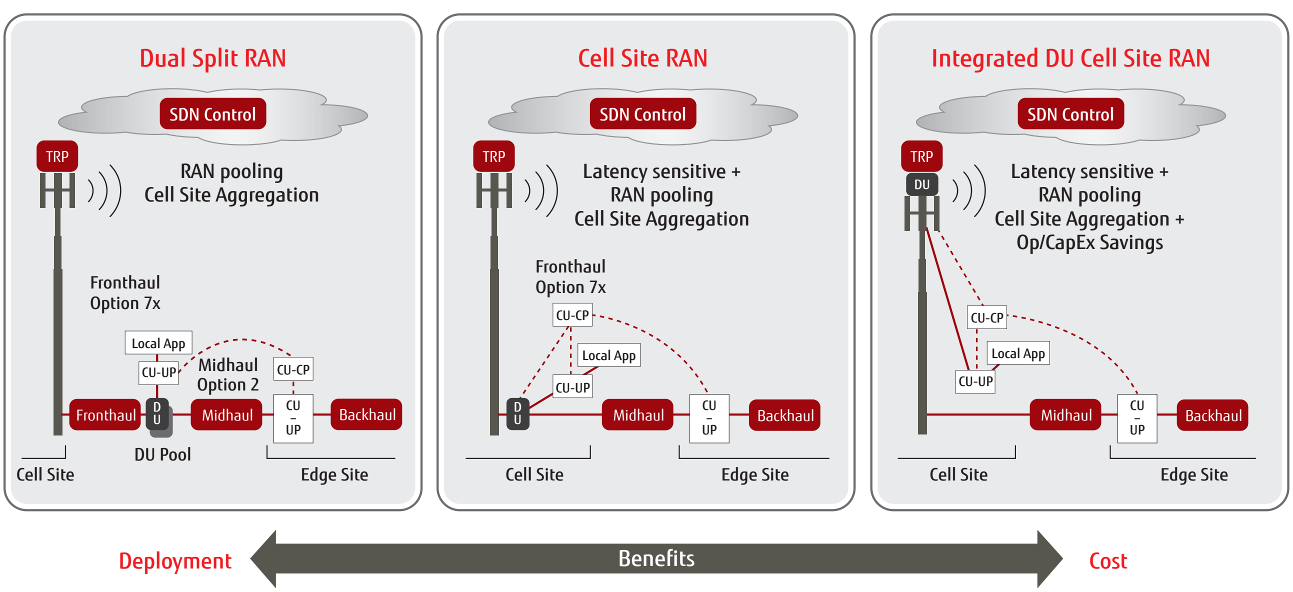

Figure 4: 5G RAN xHaul Use Cases

Planning for the Long-Haul

In an effort to ensure wide interoperability of network infrastructure and devices, 5G NR specifications and frequencies are being defined on a global basis. However, there are bound to be regional deployment differentiations due to the very short propagation nature of the 5G millimeter wave (mmWave) spectrum and its susceptibility to interference.

For example, regions of the world where large populations are concentrated in dense urban areas will benefit from deployment scenarios that make use of millimeter waves with beamforming and beam tracking, taking advantage of the wider bandwidth to deliver spectral efficiencies and support the promised high throughput. On the other hand, rural or sparsely populated areas would be difficult to address with such millimeter wave deployment; therefore, these deployments would be better served by sub-6GHz spectrum bands.

A comprehensive transport network architecture designed to address varying deployment conditions will be invaluable in the 5G era. And the key to ensuring this infrastructure can dynamically respond to changing network conditions on demand will be deployment of open and programmable transport networks with virtual DU/CU elements that enable greater automation and more efficient operations.

Expertise Built on Experience

To fully realize the promise of the next generation, Fujitsu has built an open ecosystem of products that will allow service providers to seamlessly and securely deliver services over wireless, wireline and cloud end-to-end, meeting subscribers' expectations for 5G. Fujitsu offers a range of solutions, from RAN products that enable mmWave and sub-6GHz services, to a portfolio of disaggregated optical transport solutions including the Smart xHaul family and the Fujitsu 1FINITY platform.

Moreover, because Fujitsu transport and radio access solutions complement each other, service providers benefit from faster deployment, streamlined support and interoperability.

Offering significant communications technology expertise, including a focus on RAN and optical transport, Fujitsu delivers more efficient packet switching economics, innovative RAN technologies and open interfaces, reducing costs while simplifying network deployment challenges. With an end-to-end approach enabled by a comprehensive RAN transport network, service providers can overlay 5G networks and use cases atop existing 4G transport infrastructure with ease, allowing them to go to market quickly with enticing new services that leverage Gigabit speeds and intelligent automation.

Fujitsu's unified service platform, open-source automation framework and MicroApplications Practice offering facilitates end-to-end activation and delivery of differentiated services across technologies. Cloud delivery services are available as infrastructure as a service (IaaS), platform as a service (PaaS) or software as a service (SaaS). In addition to mobility and IoT solutions, Fujitsu also co-creates fixed wireless access solutions with customers to help them go to market quickly with 5G, leveraging our 28GHz Fixed Wireless Access solution that offers automated delivery of bandwidth-on-demand and zero touch provisioning of 5G fixed wireless devices on an edge cluster for a seamless customer experience.

Managing all these elements in one ecosystem requires a robust SDN control platform based on open-source technology. Fujitsu enables unique resource control of multi-vendor systems with multi-domain orchestration via the Virtuora Network Control Solution. Plus the Fujitsu Services team offers turnkey support for design, configuration, deployment, integration and management of 5G networks from end to end, based on years of experience with legacy RAN and transport network deployments.

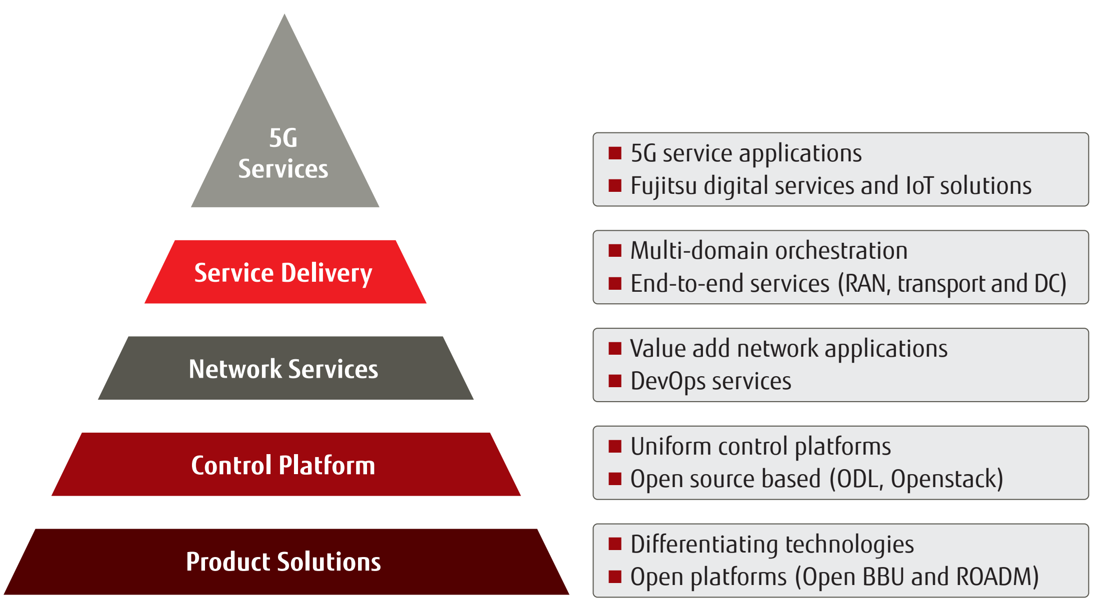

Figure 5: The Fujitsu 5G Ecosystem

Race to the Finish

Despite all the hype around 5G, industry experts agree that the potential for significant future revenue is very real. In fact, a recent study by Juniper Research projects that annual revenues from 5G connectivity could reach nearly $300 billion by the year 2025, representing an annual growth rate of 163 percent over the first six years of commercial operation.[2] In order to capture that revenue, however, network service providers need to fundamentally rethink how they design and deploy next-generation networks.

To transform the vision of 5G into reality, it's crucial that network operators deploy programmable, cloud-based RAN transport architectures designed to be agile, cost-efficient and flexible enough to deliver services faster, while simplifying their networks for future expansion. In this way, the transport network is able to adaptively handle multiple open radio interfaces, network latencies and virtual infrastructures to support a plethora of devices and applications, delivering the full 5G experience.

Smart, disaggregated transport solutions will allow service providers to quickly realize return on their 5G investment with use cases they can monetize immediately, and fuel growth well into the future. Contact Fujitsu to discuss how we can help you deliver on the promise of 5G.

References

[1] Verizon Wireless, October 1, 2018: "Verizon launches 5G Home" www.verizonwireless.com/5g/home/

[2] Advanced Television, November 5, 2018: "Study: 5G billed service revenues to reach $300bn by 2025" www.advanced-television.com/2018/11/05/study-5g-billed-service-revenues-to-reach-300bn-by-2025

Fujitsu Network Communications, Inc.

2801 Telecom Parkway, Richardson, TX 75082
Tel: 888.362.7763

us.fujitsu.com/telecom

1.0/01.19