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5G: Network Agility Comes of Age

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Self-driving automobiles require that network delay or latency be reduced to less than a millisecond. Streaming 3D video and new immersive applications require massive bandwidth. Multi-millions of IoT devices will require spectrum beyond what is currently accessible. Dramatic increases in data use at events and public venues will exacerbate already existing swings in capacity demand. A proliferation of devices will intensify the need for densification of base stations — the ability to deliver more and more capacity within the same space.

The demands placed on mobile networks by the 5G air interface will be complex, varied and strenuous. While current networks effectively support today's requirements, delivering on the dramatic increase in demand, density and diversity of network requirements associated with 5G will require a very different approach, as today's networks are simply inadequate. The limitations of fixed point-to-point architecture, of a dependence on traditional dedicated hardware, and of legacy technology have saddled operators with networks that cannot flex, adapt or scale to meet future needs. Current networks, by design, are rigid and rather limited.

Creating Agile Networks Through Virtualization

The approach of 5G is driving a shift toward a new kind of network architecture, an agile architecture that can enable key innovations, such as network slicing, wherein a single virtual network can be architected to function as multiple networks — each with its own specifications, for its own use case. To accommodate the complex and high performance requirements of 5G services, network operators need to find a way to bypass the limitations inherent in existing networks. To that end, new network architectures are combining network virtualization with an end-to-end perspective.

Virtualization is the process of creating a "virtual" rather than "actual" version of the network. This is done by moving network functions that traditionally reside within dedicated hardware to a 'virtualized' or software-based environment to produce a virtual version of the network components. Once defined in software, the network components can be easily pooled, shared and accessed simply via interfaces. Virtualizing the network also opens the door for network fine-tuning and adaptations that are simply not possible with a traditional network such as demand dynamic allocation and the partitioning of resources among different users.

Virtualizing the Base Stations

Base station resources, once virtualized, can be centralized and their capacity allocated dynamically according to network load. This increased efficiency potentially lowers the overall base station requirement of the network resulting in a smaller footprint and in turn, reduced operating expenditures from lower rental and electricity costs. As virtualized base stations can use generic commodity hardware instead of dedicated equipment, capital equipment costs can also be reduced.

The ability to manage virtual base station functions centrally through software makes network resource management quicker, easier, and more flexible. It also opens the door to automation. New services are created by sequencing one or more virtualized network functions and adding an application layer, producing a packaged combination of telecom and IT resources that can be provisioned as one entity and efficiently orchestrated and automated using network function virtualization.

Extending Virtualization Through the Network Fronthaul to the Radios

The greatest advantages of virtualization can only be realized once the virtualization extends end-to-end; not just the base stations of the network, but rather extending the virtualization through the fronthaul to include the network radio resources. The following diagrams present two different approaches to an end-to-end virtual radio access network or virtual RAN. In the first, an integrated accelerator in the virtual base station facilitates the CPRI/ORI transport over fiber through the fronthaul interface and remote gateway to the remote radio units. The Fronthaul Interface and Remote Gateway elements intelligently aggregate and route the digital signals to wherever they are required.

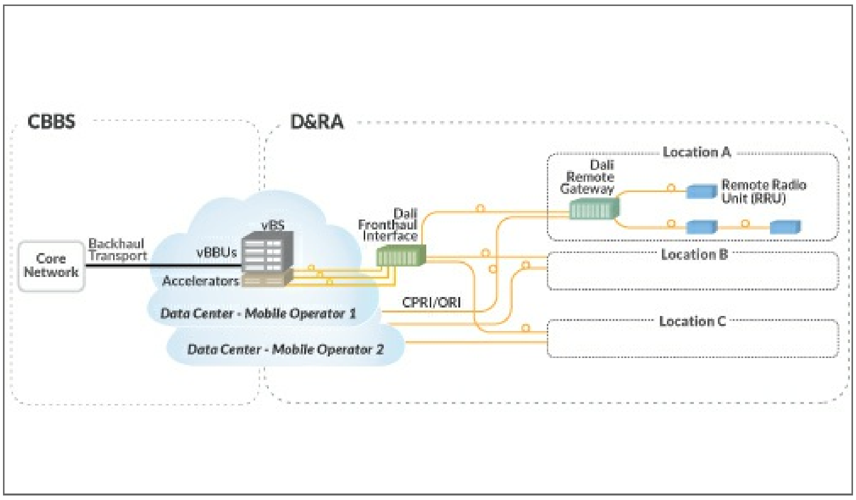

Fig. 1 - Virtualization Through the Fronthaul

In the second diagram, we illustrate an Ethernet-based virtual RAN, which is particularly well suited to long-distance deployments. Here, digital signals are sent from the virtual baseband unit through an Ethernet switch to a remotely based Accelerator, which then converts the signals to CPRI for intelligent distribution to the Remote Radio Units by the Fronthaul Interface.

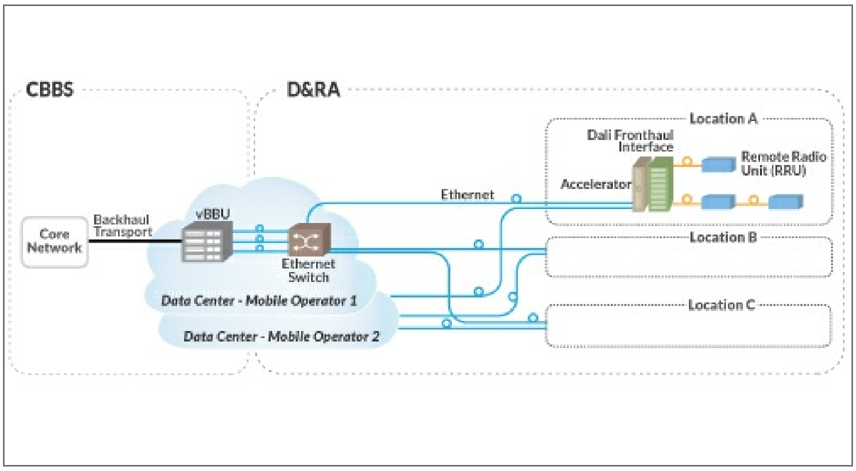

Fig. 2 - Virtual RAN

As with the virtual base stations, virtual fronthaul elements can be remotely configured using software, and allocation can be dynamic and elastic. The network can also be easily scaled by adding new bands, radio resources and operators incrementally. Adopting fully digital distribution in the fronthaul also eliminates the need for point of interface (POI) units yielding lower equipment, space, and energy requirements resulting in reduced capital and operating expenditures.

Multipoint-to-Multipoint Changes Network Dynamics

5G is expected to generate a dramatic increase in capacity demand, which will put a strain on limited spectrum resources. However, that strain is mitigated when the radio resources of a network are virtualized. Because the fronthaul and routing of the digital radio signals are now defined in software, signals can be routed intelligently and dynamically. Whereas traditional networks are limited by the hardwired point-to-point architecture of their radio distribution components, the innovative software-defined radio routing architecture makes it possible for the virtual distribution network to function as a virtual multipoint-to-multipoint distribution network. This eliminates the need for overprovisioning to meet peak demand, as network resource are allocated dynamically where needed and when needed.

This fundamental change is the foundation for dramatic increases in network efficiency and bandwidth management, in managing the Quality of Service (QoS) and hence, the user experience, which is critically important for driving revenues and customer retention. This change is also a critical enabler of network slicing.

The Network Slicing Alternative

Perhaps one of the most exciting developments in anticipation of 5G is that of dynamic network slicing. Only possible when a network is fully virtualized, network slicing effectively "slices" the application layer of the virtual network to create multiple application layers. Each new layer can then be configured independently of the others to provide different levels of performance, spectrum, latency and power, as required for its own specific service or use-case i.e. for IoT, RFID, cellular; and is managed dynamically based on analytics.

While a proliferation of IoT devices, such as connected homes and inventory tracking systems require network service, they do not require the millisecond latency and ultra-high level of reliability necessary for self-driving vehicles or other mission critical IoT. Likewise, neither is expected to require the massive data rates needed for video streaming and immersive technologies.

By implementing network slicing, an operator can effectively address widely varying application requirements without prohibitively expensive options, such as having to build a single network that meets all of the most extreme application criteria, or deploying multiple independent physical networks.

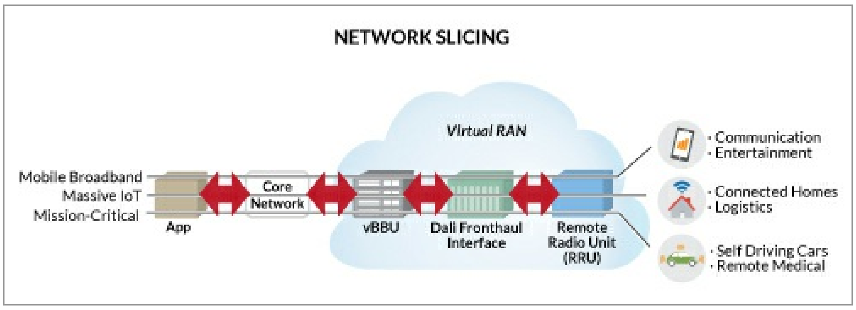

Fig. 3 - Network Slicing

Within network slicing, as shown above, the unique capability of the virtual network's Fronthaul Interface to dynamically allocate spectrum also presents new opportunity for operators in terms of business models. Slices can be designed as different service tiers, each with its own suitable charging model. Capacity can also be shifted for a specific period of time to accommodate large events or other high-demand situations, and sold as such. Operators also have the ability to provide different data rates to different enterprise customers, for example, and to charge accordingly. In other words, network slicing provides operators with an innovative and cost-effective means of delivering a breadth of services.

Evolving Networks for 5G

From a network perspective, 5G represents a 1000x increase in capacity, significantly higher data rates and signal quality, as well as lower latency — all far beyond what traditional fixed point-to-point networks could provide. At the same time, 5G invites increased complexity and service fragmentation, and a proliferation of new applications and use cases, each of which will represent highly diverse requirements in terms of spectrum, bandwidth, latency, and power. This will make implementation of 5G a challenge in terms of designing and deploying comprehensive and adequate 5G network solutions.

Network slicing offers a compelling long term approach for 5G deployment with a level of flexibility that operators have not seen before. As operators work towards 5G, they can gain significant benefits when transitioning to virtualized networks that interoperate with existing legacy equipment: increased efficiency and cost savings, improved network resource management, and the flexibility, elasticity and scalability that comes with software-configurable resources.