RF ROUTER® – THE ENABLER OF RAN VIRTUALIZATION

Dali Wireless | Whitepaper | December 2014

Introduction

Mobile data traffic is growing exponentially. This is mainly driven by video and web applications. With today's network architecture, mobile operators are forced to increase capital (CAPEX) and operational (OPEX) to address the capacity increase. However, as networks move from being coverage-centric to capacity-centric, the increased in revenue is not keeping pace with the increased in capital expenditure.

With the forecasted future mobile network capacity requirements and the decreased revenue margin, mobile operators are looking at network sharing or virtualization as a key business model going forward to handle the increased in traffic volumes while reducing future deployment and operational cost.

In this paper, we will examine how Radio Access Network can be virtualized, and the benefits RAN virtualization brings to mobile operators and enterprise users.

Radio Access Network (RAN) – Today

In a classical Radio Access Network (RAN) for 2G, 3G or 4G, a radio base station comprises a baseband unit for the processing of the radio protocols and management of data streams and a Radio Unit for transmission, reception and demodulation of the radio signal to/ from the air interface.

The Radio Unit can be collocated with the baseband unit at the location of the base station (classical compact BTS) or alternatively, it may be at a different location, closer to the actual transmit/ receive antenna (decentralized architecture) (Figure 1). Under certain conditions and for reasons of better radio performance, this constellation may be more beneficial than a collocated base station.

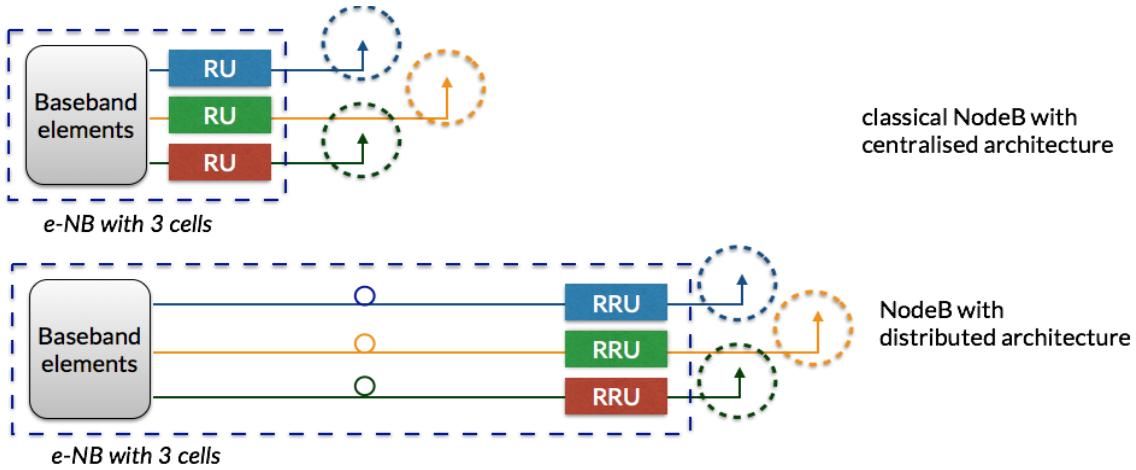


Figure 1. A classical compact BTS/a centralized architecture and a Distributed Architecture

With today's network, it's a static allocation of capacity between the base stations and the antennas. It is not able to dynamically transport network resources to where and when they are needed – each individual cell is unable to share network resources with one another. Mobile operators are still required to over-provision for optimal Quality of Service (QoS). This mean as capacity requirements increase, capital expenditure also increases.

Cloud RAN (C-RAN)

More recently, the concept of C-RAN (Cloud-RAN) has gained some media attention. C-RAN features a centralization of baseband resources at a single location, while the radio units are located remotely at the individual antenna locations (Figure 2).

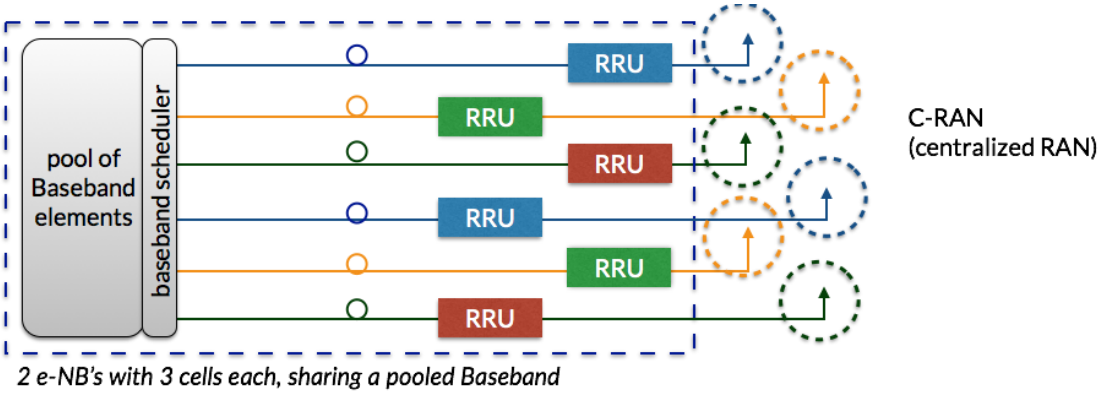


Figure 2. A C-RAN Architecture

The pooling of baseband resources in C-RAN constitutes a first step of virtualization. Without concrete proof or evidence from a C-RAN deployment, we believe that the C-RAN concept can only provide benefits in operational costs and improved network manageability.

However, since the monetary proportion of the baseband unit as part of the total base station costs is significantly less than that of the radio unit, the commercial benefit of a virtualization solution on the scope of baseband is expected to remain limited.

A more comprehensive and impactful approach to virtualization of a RAN must therefore also include the radio units, thereby significantly improving the efficiency and utilization of the deployed resources, in particular that of the most scarce and valuable resource -- frequency spectrum.

RAN Virtualization

Mobile operators need to address the expected growth in mobile traffic volume today and minimize the waste of valuable network resources, while maximizing OPEX and CAPEX-savings. Legacy RAN infrastructures provide coverage and capacity with a fixed allocation of baseband and radio resources. While C-RAN does hold some potential, operators are right to mull over the long-term implications and costs of such an overhaul to their networks. RAN virtualization empowers operators to remotely reconfigure and redistribute the radio coverage and capacity from the core to the antenna. It's a solution with more immediate benefits than those of C-RAN without requiring a complete adaptation of the radio network infrastructure.

RAN virtualization involves sharing antennas/base stations across multiple network operators with either separate spectrum resources or shared spectrum resources. This means that both the baseband processing power and the radio resources are virtualized and shared. The virtulization of the entire cells allow for efficient usage of the most precious resource – spectrum.

RF Router™ - The Enabler of RAN Virtualization

RF Routing is an innovative architecture which creates a radio distribution network that in fact virtualizes the entire radio access network (RAN) and ultimately puts an end to systematic over-provisioning.

The basis of Dali's RF Router lies in its unique "end-to-end" digital RF signal processing and software configurability. Dali's RF Router platform consists essentially of two components, the Headend (Host) and the Radio Remotes. The host unit interfaces with the feeder base stations via an RF interface or a digital baseband interface (BBI), using the industry standard CPRI protocol (Figure 4). The host unit converts the received data streams to digital addressable packets so radio capacity can be routed from any source to any destination point within the network, irrespective of the underlying physical distribution network (Figure 5).

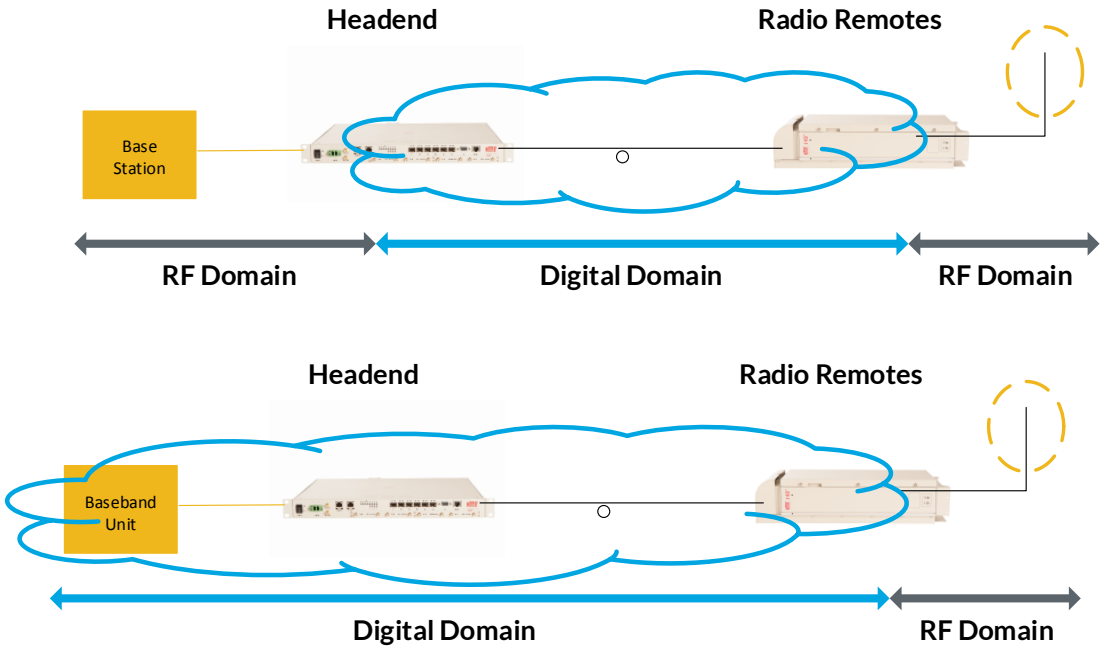


Figure 4. The RF Router system interfaces with the base station via an RF interface or directly to a digital baseband interface (BBI).

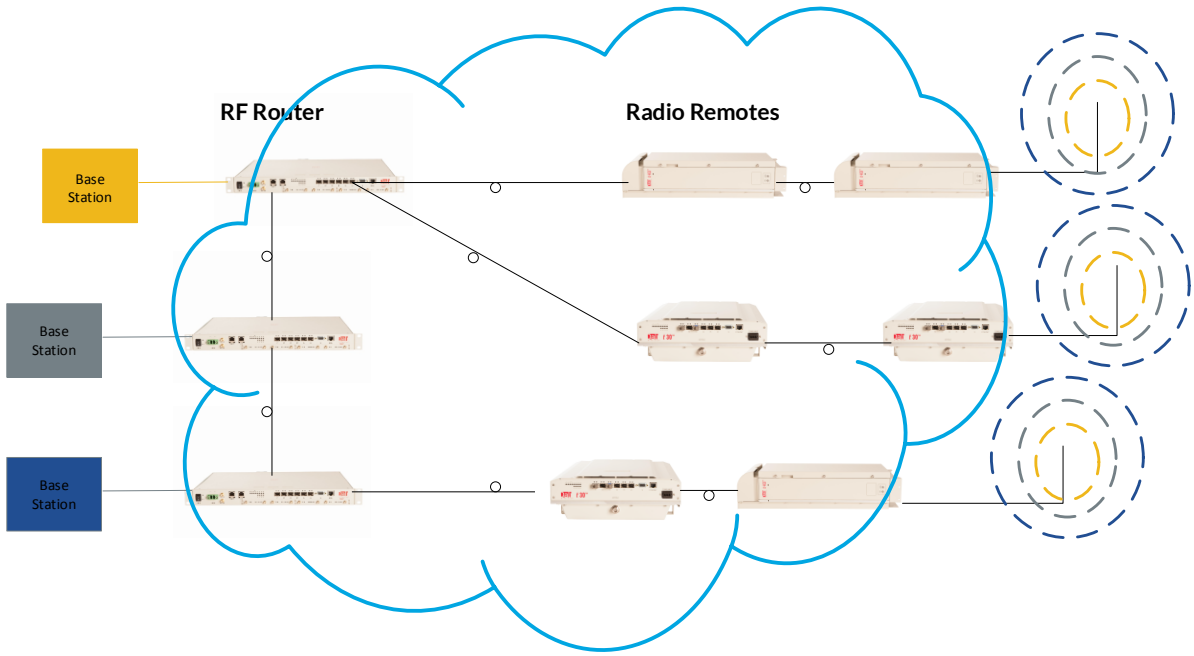


Figure 5. Irrespective of the underlying physical transport network – whether a star topology or a chain topology, a logical network is formed that enables RF signals to travel from any source to any destination points. RF Router enables the virtualization of radio resources.

By virtualizing the radio resources through RF Routing, spare capacity sitting idle in one part of the service area can be dynamically routed within the system to another part that may be in need of additional capacity, such as to cover a temporary peak in use. This ensures that no usable capacity is wasted, allowing network operators to maximize QoE and QoS for every device and user on the network. Re-allocating radio resources to where they are needed and when they are required removes the need to over-provision by intelligently adapting to the capacity of users in a certain region of the service area. Additionally, RF Routing is fully software-configurable and software-controlled, empowering network operators to manage and maintain the networks remotely without having to deploy technicians into the field.

In addition, Dali Wireless' RF Router solution provides a platform that enables the connection of any of the incoming data streams (cell feeds) of one or more base stations (2G, 3G or 4G) to any of the connected radio nodes. This constitutes a full virtualization of the base stations and enables a true any-to-any routing between cell feeds and antennas.

The RF Router works with any base station of any vendor or any Operator, on any frequency band within the 3GPP specification series and with any technology and radio modulation used in GSM, UMTS, HSPA and LTE networks. It is fully agnostic towards all these attributes which makes it universally usable in any configuration of radio networks (Figure 6).

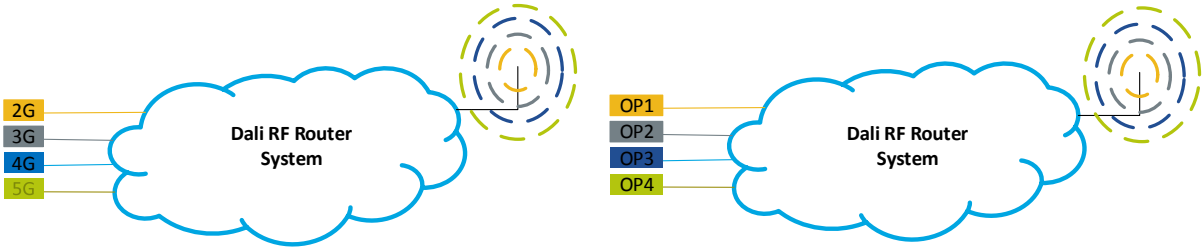


Figure 6. RF Router supports any frequency band, and is technology- and operator- agnostic.

Furthermore, the RF Router can dynamically allocate the different cell feeds coming from the base stations to different antenna points in the radio network. The dynamic capacity allocation is fully controlled and performed by software via the remote network management system (NMS). This full "any-to-any routing" between cell feeds and antennas provides a layer of virtualization across the entire set of base stations, including their radio units (Figure 6). Clearly, the scope of virtualization of a Dali RF Router solution is broader than that of a pure C-RAN, which only encompasses the base band processors of the base stations and has no handle on the capacity allocation between the associated radio units. By virtualizing both the baseband processing power, and the radio resources – spectrum, RF Router enables RAN virtualization (Figure 7).

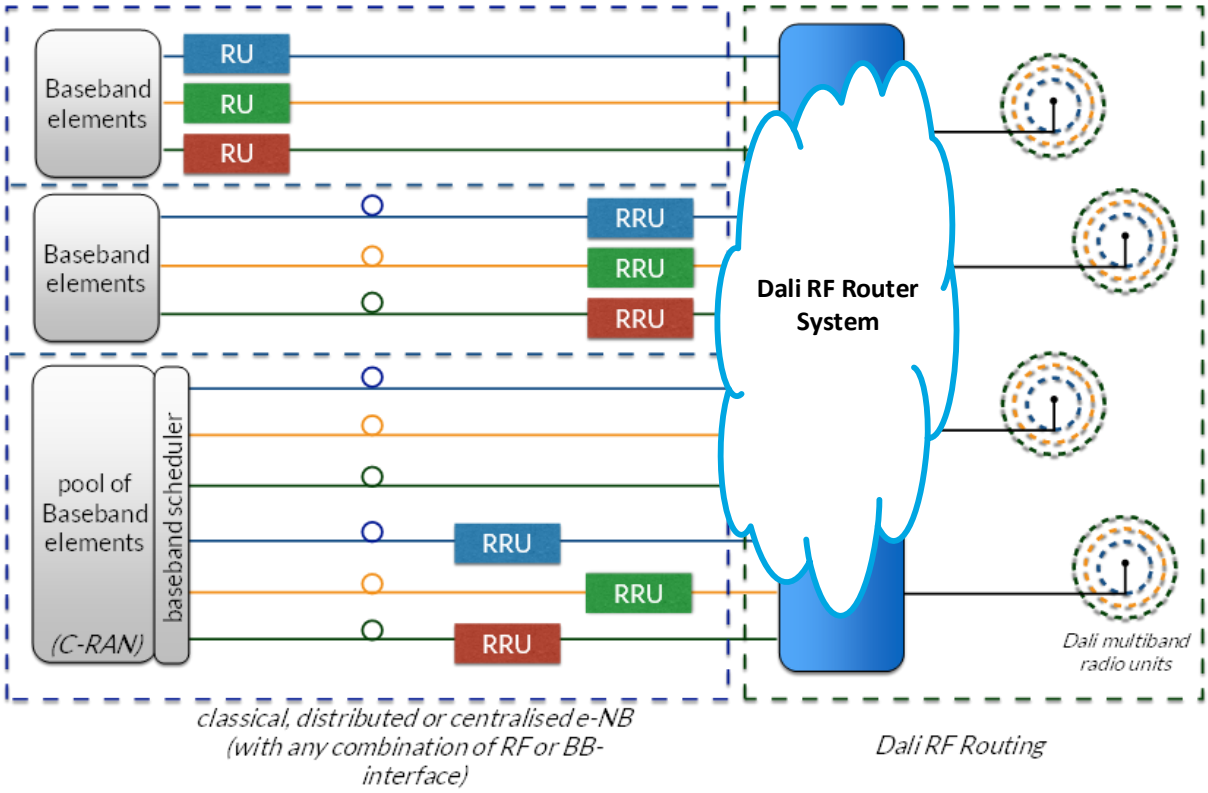
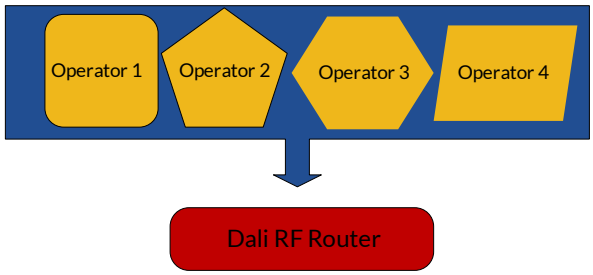
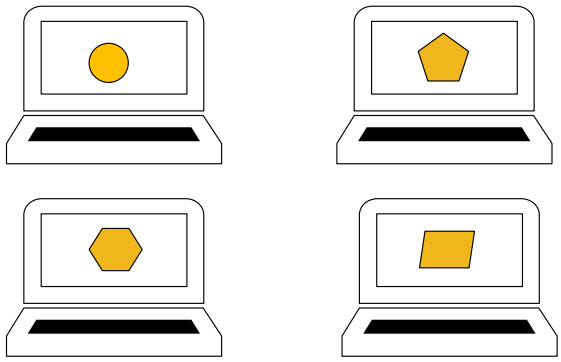


Figure 7. Dali's RF Router can deliver immediate benefits to an operator without a major overhaul to their network. It works with existing centralized architecture, distributed architecture and C-RAN.

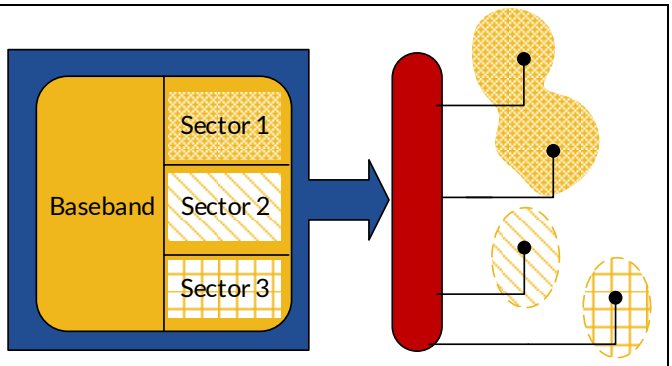
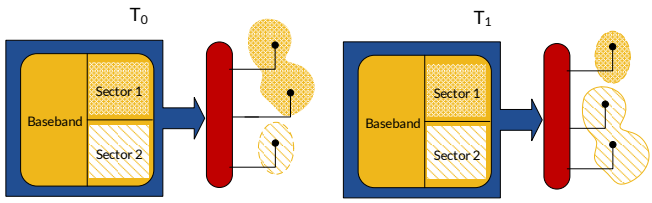
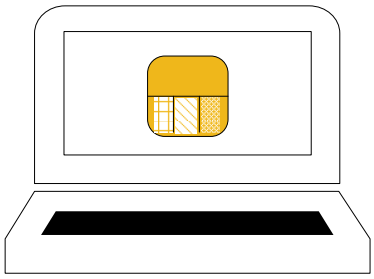
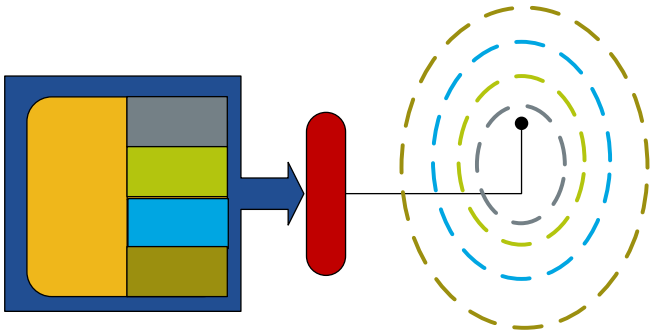
RF Router - Virtualization Characteristics

Existing networks are not designed to support dynamic re-configuration required for timely and efficient sharing of resources. With RF Router, re-configuration is no longer a manual task. With this software configurable multipoint-to-multipoint platform, operators and enterprises can easily scale the number of frequency bands, technology and standards – a truly future-proof solution.

Characteristics of virtualization and software defined RAN include sharing, isolation, dissection & aggregation and elasticity[1]. Additionally, we have identified two additional characteristics that enhances RAN virtualization. This includes ease of management and economies of scale. Dali's RF Router fulfills all of the characteristics and is illustrated in the table below.

Sharing: The system can be used by multiple operators in parallel. The capability of the virtual radio access network (v-RAN) is shared by all operators utilizing the system.	
Isolation: The usage of the system by one user does not impede usage by other users. Resources allocated to one user are exclusively used by this user without disclosure of contents to other users. Each operator has the ability to monitor and regulate the power allocation on a per operator basis using the network management system (NMS). This ensures precise and accurate power allocation.	

[1] In November 2013, the IEEE Communications Magazine also published an article on „Network Virtualization and Software Defined Networking for Cloud Computing: A Survey http://www.comsoc.org/ctn/network-virtualization-and-software-defined-networking-cloud-computing-survey

Dissection & Aggregation: The total capacity of the system can be split across several participating nodes or be aggregated into fewer nodes as needed.	
Elasticity: The system allows more or less capacity to be allocated towards a single node as needed (based on data traffic).	
Ease of management: The allocation of capacity is managed remotely and fully by software from a centralized network management system (NMS).	
Economies of scale: New frequency bands and/or RF carriers only need to be deployed at the central feeder station, avoiding costly upgrades across the entire network.	

Benefits of RAN Virtualization for Operators

The benefits of a virtualized RAN (v-RAN) for Operators include

- **Capacity-driven requirements planning**: Operators no longer need to plan for maximum capacity ("worst-case") at each individual antenna point, but can plan based on average capacity usage across a larger cluster and distribute capacity dynamically between the antenna points, where and when needed.
- **Economies of scale**: New frequency bands and/or additional mobile operators only need to be deployed at the central feeder station, avoiding costly upgrades across the entire network and service disruption.
- **Better utilization of resources**: Less resources are required in a shared cluster compared to a non-shared layout. This in-turn saves CAPEX and OPEX.
- **Flexibility in multi-vendor and multi-technology scenarios**: The agnosticity of Dali's RF Router system makes it ideal for deployment in environments involving multi-operator, multi-vendor or multi-technology networks. The flexibility in configuration of the systems is unmatched in the industry.
- **Cost efficiency**: The system requires less units per service area this means lower unit production costs for equal user experience or –alternatively - better user experience at same cost levels
- **Configuration flexibility**: The ability to dynamically change the configuration of base stations connected to a service cluster allows a smooth cut-over between different scenarios without downtime of the system, e.g. during band reframing activities, during upgrading or modernization of the network or when introducing a new technology.
- **Software Controlled**: The full control and configurability of the system via Network Management System allows operators to offer self-provisioning of services for enterprise users, similar to current provisioning capabilities in cloud-based IT systems.

Benefits of RAN Virtualization for Users

The benefits of a virtualized RAN (v-RAN) for Users include

- **Cloud**: Enterprise user can now receive tailored telecom services leveraging the flexibility, scalability and elasticity of virtual solutions, similar to cloud-based offerings in the IT domain.
- **Lower cost:** A v-RAN solution provides better cost efficiency, therefore users can expect lower cost of services at same user experience or –alternatively – a better user experience at same cost levels as with the current non-virtualized networks.
- **Better user experience:** v-RAN provides a better and more consistent performance; thereby,

enhanced user experience. Systematic capacity bottle-necks is no longer an issue, since capacity can be scheduled or dynamically re-allocated between the participating nodes to cater for variable capacity demand.

Conclusion

Legacy RAN infrastructures provide coverage and capacity with a fixed allocation of baseband and radio resources and with a price – high TCO and the amount of spectrum resources required. Static allocation of resources means that systematic over-provisioning is needed in order to meet peak demands at any time. RF Routing virtualizes entire cells (including the baseband and the radio resources), allowing for efficient use of the most precious resource: spectrum. Even with more budget, operators cannot add spectrum because it's a finite resource. By making radio signals route-able, RF Routing makes better use of the limited spectrum resources which is a priceless commodity.

RF Routing will allow operators to dynamically allocate network resources of multiple virtualized cells. By routing coverage and capacity to where it's needed, when it's needed in a service area, operators are in a position to meet demand with optimum efficiency of spectrum usage by allocating both baseband and radio resources in response to dynamic traffic conditions. RF Routing helps operators avoid over-provisioning, ultimately reducing TCO while keeping the QoE up.

Virtualizing the RAN through RF Routing is an appealing opportunity for operators to handle the forecasted deluge of mobile data traffic while at the same time, increasing ROI of the deployed radio infrastructure. RAN virtualization covering both the baseband and the radio part of the cells can offer a more comprehensive and flexible approach – today.

About Dali Wireless

Founded in 2006, Dali Wireless is a global provider of an all-digital RF Router, a new concept which transcends the features typically associated with traditional Distributed Antenna Systems (DAS) to deliver more data throughput and value at a lowest Total Cost of Ownership. With its patented dynamic capacity allocation technology, mobile operators and enterprises can dynamically allocate capacity to where and when it is needed. This is achieved through Dali's proprietary signal processing algorithms that transform any radio signal into addressable frames/data packets, enabling Radio Distribution Network (RDN) of "any-to-any" connections between sources and destination points– a software defined network. This unique architecture allows on-demand routing of radio capacity utilizing flexible simulcast ratio to avoid challenges associated with conventional RAN architecture: link budget, interference and handovers. The Dali RF Router can improve useable capacity by over 20 percent as compared to conventional small cells.