Cloud SON:

A New Member of the SON Family

A Reverb Networks White Paper

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Introduction

Cloud-based radio access networks (Cloud RANs) and supporting network feature virtualization (NFV) strategies are just on the horizon, driven by several telecom industry realities. One driving force is the growing demand for mobile broadband as average revenue per user (ARPU) fails to keep pace. Another driver is mobile operators’ need to reduce capital and operational expenses (CAPEX and OPEX) while facing an exponential growth of network elements imposed by network densification. Such challenges can be addressed through shrewd use of existing network resources and the automation of network performance and optimization functions. In addition, the positioning and utilization of cells as intelligently and dynamically as possible can lead to further CAPEX and OPEX savings and ensure optimal coverage and capacity without quality degradation. The Cloud and NFV are ripe for making these aforementioned efficiencies happen.

Industry investment and developments have borne out the Cloud RAN emergence, with the China Mobile Research Institute initiating C-RAN research and proof of concept a few years ago, and Ericsson reorganizing its Networks division into two distinct units, Radio and Cloud & IP, the latter emphasizing the company’s new direction on Cloud and network virtualization. More recently, Nokia and Juniper partnered to offer operators a telecommunications cloud solution [1] based on Nokia’s Liquid Core platform, while at Mobile World Congress 2014, Huawei unveiled CloudEdge, its umbrella brand for NFV including vEPC, virtual Multi-Service Engine, and Cloud Management and Orchestration. An estimated $11.3 billion [2] will be invested in Cloud RAN by 2018, 65 percent of that concentrated in Asia, particularly China, Japan and South Korea.*

Fitting well into this largely virtualized Cloud RAN environment is the concept and practice of self-optimizing networks (SON). SON brings a set of self-configuration, self-optimization and self-healing use cases that operators can exploit to defer CAPEX and save on/control operational costs resulting from the complex radio access technologies and explosion in the number of access points in the next-generation cellular networks. A China Mobile report [3] indicates CAPEX savings of up to 15 percent and OPEX savings of up to 50 percent over 5-7 years compared with traditional RAN deployments. Alcatel Lucent Light Radio Economics

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analysis [4] indicates an overall total cost of ownership (TCO) reduction of at least 20% over 5 years for an existing high-capacity site in an urban area & at least 28% for new sites.

This white paper discusses the market drivers of Cloud RAN and NFV, and how Cloud changes the RAN architecture (and its processing and signaling methods) to enable easier implementation of the network. This paper also explores the novel ways in which SON could be introduced into the Cloud RAN topology for cost-effective network optimization & configuration.

A New Paradigm – How Cloud RAN Changes the Picture

With ARPU flat or declining and the cost of deploying and operating networks increasing, mobile network operators are struggling to find ways to deliver the next-generation services their subscribers demand while keeping CAPEX and OPEX as low as possible. Mobile broadband demand continues to rise and many operators have built out networks to accommodate peak usage periods, a strategy that can be expensive and power-consuming and potentially wasteful when network activity is low. Hence, the concept of Cloud Network is appealing as it can address the “tidal effect” of today’s network traffic by providing capacity where and when it is needed and allowing operators to turn off certain cells during low traffic periods to save power.

The Cloud RAN paradigm (Figure 1) breaks up the static relationship between remote radio heads (RRHs) and baseband units (BBUs) by dynamically creating virtual BBUs and connecting them to a mash of real (not virtual) RRHs via a reliable and intelligent transmission network known as front haul. The intelligence allows switching between one-to-one and one-to-many (DAS equivalent) BBU-RRH mappings. Here, the NFV concept comes into play with the real-time virtualization of BBUs from the

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1 In this white-paper the Cloud RAN definition is extended for including an intelligent front haul that allows reconfiguring RRH-BBU mapping [5]. The traditional Cloud RAN definition considers a pre-defined and static RRH-BBU mapping where BBUs are only virtualized.
processing capacity allocated to the physical and configurable computing resources that enable the BBU pool. In this paradigm, physical base stations (including both radio and baseband functionality) do not need to be permanently commissioned for supporting peak traffic; instead only a permanent mash of cost effective RRHs are deployed and turned into virtual base stations by assigning on-demand basis virtual BBUs from the pool (see Figure 1).

For LTE networks, the Cloud RAN architecture also simplifies the implementation of the high-bandwidth low-latency X2 interfaces connecting the geographically distributed virtual eNodeBs. This is because these X2 interfaces run within the same computing frame that hosts the multiple virtualized BBUs.

The new paradigm also allows operators to consider a *centralized approach within the Cloud* to better combine traffic load and interference management, as it is much easier to implement advanced LTE features such as Cooperative Multi-Point (CoMP) and enhanced intercell interference coordination (eICIC) by jointly processing and scheduling signals between virtual BBUs. This becomes especially important in heterogeneous networks (HetNets) involving multiple network technologies (UMTS, Wi-Fi, LTE, etc.) and overlapping macro and micro cells that share the same carrier. By contrast, in a traditional RAN deployment the gain of such features could be limited by X2 performance often forcing more sites to be built.

**Cloud RAN Front Haul Options**

The front haul is the transport network that carries signaling and traffic data between RRHs and BBUs. The available standards are CPRI [6] and OBSAI [7] and the physical bearer could be fiber, microwave, or any other high bandwidth technology. Operators can choose between two Cloud RAN deployment options, each having its own pros and cons in terms of network flexibility and front haul requirements.

The **full centralization** model is very flexible but demands high bandwidth for the front haul. The BBU supports Layer 1, Layer 2 and Layer 3 traffic and signaling as well as operations and maintenance (O&M) functionality. Full centralization has the benefits of multi-
RAT support (RRHs are RAT-agnostic allowing operators to dynamically switch the Radio Access Technology if needed), maximum resource sharing, and optimum architecture for CoMP. The challenge with this approach is the aforementioned high bandwidth required mainly for transporting the digitized L1 signals.

The **partial centralization** option (see Fig. 3) is less flexible in regards to the supported RATs but has the advantage of lower bandwidth required for the front haul. BBUs support only Layer 2, Layer 3 and O&M support, with Layer 1 residing at the RRH level, hence, the lack of flexibility. The benefit is the significant reduction in the bandwidth required for the front haul (only 2%-5% of the bandwidth required by full centralization).

Cloud RAN could be static or dynamic. In the first case, virtual BBUs (v-BBUs) are created in the Cloud and statically (permanently) associated with RRHs for creating operational virtual network elements, the only physical component being the RRHs. In the second case, network elements are instantiated dynamically, based on traffic load and distribution, by dynamically creating one-to-one and one-to-many BBU associations, while also considering scenarios in which some RRHs are not being used. Virtual BBUs could come with virtual D-SON features.

**Cloud SON and Cloud RAN**

As defined currently, SON is associated with known and existing network access points. For example, D-SON modules are located at a network element and optimize its radio performance by using local knowledge (e.g. SON-specific reports from UEs, the network element and its neighbors). On the other end, C-SON resides at the network management level and optimizes the overall network performance by changing the configurations of the existing and operational network elements. In summary, current SON (distribute, centralized or hybrid) optimizes network performance by changing the radio configurations of the access nodes in an ossified network, therefore not fully matching the needs of Cloud RAN.

Cloud SON is the next step in SON evolution representing a solution that not only supports the specifics of SON for a virtual network but also redesigns in real time the network configuration;
i.e. what RRHs to be used for increasing capacity (network densification) and which to be used for coverage. In the case of densification, one-to-one BBU-RRH associations are created and the required resources are allocated to each virtual BBU. In the case of coverage, one-to-many BBU-RRH associations are created for providing ubiquitous coverage similar to how DAS systems do it these days. In the near future, dynamic Cloud RANs will very likely be deployed for islands of small cells and for HetNets, which will serve as a test bed for full Cloud networks.

A bit further out in the future, networks will most likely be a mix of physical stand-alone network elements (legacy deployed macro cells) and Cloud RAN islands (Figure 4). Distributed SON platforms will run at stand-alone and virtual network elements, hybrid/centralized SON platforms will run at the network level while each Cloud RAN island will have its own Cloud SON platform. This brings the need for extra standardization work for the proper operation of Cloud SON within the Cloud RAN and for coordination with legacy SON components in the whole network.

Figure 4: SON in the Cloud
Conclusion

With network feature visualization (NFV) paving the way, Cloud RAN will enable operators to run smarter, more efficient wireless networks. The Cloud RAN is a disruptive RAN architecture that replaces a collection of expensive-to-operate-and-own stand-alone access nodes with a mash of very inexpensive physical RRHs that are real-time associated to software-defined BBU virtualized on the fly from a common pool of computation resources. Such a flexible architecture provides many benefits going from (i) 50 percent increase in both supported traffic and usage of computational resources in the BBU pool versus a traditional architecture, (ii) better performance gains of advanced features like CoMP and eICIC due to enhanced signal synchronization and reduced signal latency as a result of concentrating all communication signals processing and routing in single piece of hardware.

The Cloud SON together with Cloud RAN define the next-generation network architecture, allowing operators to deliver the large data volumes needed for mobile broadband with good quality of experience (QoE) while controlling OPEX and CAPEX. Starting with LTE, SON becomes a key component of any present and future network deployment, and the industry can expect to get more advanced SON accompanying advanced network features.

Sources

[7] OBSAI (Open Base Station Architecture Initiative): Hyundai, LG Electronics, NSN/Nokia, Samsung, ZTE

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About Reverb Networks

Reverb Networks is a pioneering provider of automated, customer-centric and value-based SON solutions. The company’s InteliSON product suite enhances the networks of mobile operators through frequent and proactive self-optimization, improving network coverage and capacity and increasing spectral efficiencies. Headquartered in the United States, Reverb Networks has presence in the Americas, Europe, Middle East, and Asia, and offers support across the globe.

For more information, visit www.reverbnetworks.com.