C-RAN, a Nextgen Access Network

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C-RAN is a centralized, cloud computing based new radio access network architecture which supports 2G, 3G, 4G system and future wireless communication standards. The name C-RAN is coined from the four 'C's in the main characters of C-RAN system, which are "Clean, Centralized processing, Collaborative radio, and real-time Cloud Radio Access Network" i.e. Cloud-RAN, sometimes also referred as Centralized-RAN.It is a new cellular network architecture for the future mobile network infrastructure which was first introduced by China Mobile Research Institute in April 2010 in Beijing, China. It is based on many existing technology advances of wireless communication and optical technology as well as IT technology. In the era of mobile Internet, mobile operators are facing pressure on ever-increasing capital expenditures and operating expenses with much less growth of income. Cloud Radio Access Network (C-RAN) is expected to be a candidate of next generation access network techniques that can solve operators' puzzle.

CRAN applies recent Data Centre Network technology to allow a low cost, high reliability, low latency and high bandwidth interconnect network in the BBU pool. It utilizes open platform and real-time virtualization technology rooted in cloud computing to achieve dynamic shared resource allocation in BBU pool and support of multi-vendor, multi-technology environment. A baseband unit *(*BBU*)* is a unit that processes baseband in telecomm systems. A typical wireless telecom station consists of the baseband processing unit and the RF processing unit (remote radio unit - RRU).CRAN allows hundreds of thousands of remote RRH (remote radio head)connect to a centralized BBU pool.

Remote radio head is a remote radio transceiver that connects to an operator radio control panel via electrical or wireless interface. Any BBU can talk with other BBU within the BBU pool with very high bandwidth (10Gbit/s and above) and low latency (10us level)·This is enabled by the interconnect of BBU in the pool. This is one major difference from BBU Hoteling, or base station hoteling. In the later case, the BBU of different base stations are simple stacked together and has not direct link among them to allow physical layer co-ordination. This is different from the traditional base station built on proprietary hardware, where the software and hardware are closed-sources and provided by one single vendor. C-RAN BBU pool is built on open hardware, like x86/ARM CPU based servers, plus interface cards to handle fiber link to RRH and inter-connection in the pool. C-RAN can be viewed as an architectural evolution based on the above distributed base station architecture.

C-RAN Architecture

C-RAN architecture has the following characteristics that are different from other cellular network architectures:

i. Large scale centralized deployment
ii. Native support to Collaborative Radio technologies
iii. Real-time virtualization capability based on open platform
iv. Centralization is back into consideration, driven not only by the need to improve performance, but also by pragmatic and strategic motives that are embodied in Cloud RAN.

C-RAN small cells can be most broadly defined as having a centralized baseband that is pooled across a large number of distributed access points. This provides significant management and self-organizing network benefits compared to a cluster of standalone small cells. Some C-RAN small cells go support the key attributes such as Coordination between radios,. Baseband pooling, Ethernet front haul and Single cell operation. Cloud RAN is based on two tenets: centralization and virtualization of base station baseband processing. Centralization is a mean to improving performance. Driver for centralization is very pragmatic: operational cost reduction. Virtualization, aims at reducing capital expenditures by applying network function virtualization (NFV) to the radio access network. But virtualization has another attractive feature such that can switch between base station vendors at the click of a button! In fact, there are two issues to resolve. The first

issue is front haul which is an impediment towards centralization. Virtualization could spread at the 'micro' level, while the technology and economic challenges are resolved for the 'macro'

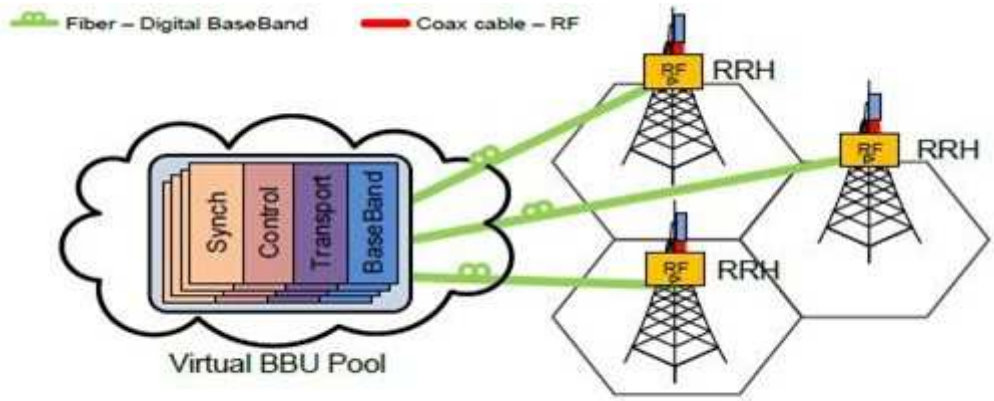

Figure1.C-RAN Architecture

Front haul is the link between the baseband units and the remote radios. Fronthaul capacity, delay and synchronization requirements are stringent. A single 20 MHz 2x2 MIMO LTE channel requires about 2.5 Gbps. This capacity adds up quickly when tens even hundreds of baseband modules are collocated in a data center. A fiber network is required to connect the sites to the data centers which not all operators possess. The cost of fiber breaks the business case for operators without their own fiber assets. But operators recognize the need for fiber and there has been a strong drive by many operators to acquire and build up their fiber assets. The second challenge centers on virtualization of the physical layer (PHY) which involves real-time processes and high computational load functions.

General purpose processors are less efficient in running these functions for commercially scalable networks than dedicated processors resulting in high power consumption. Dedicated processors can have as much at 10x the performance per Watt of general purpose processors for PHY functions. A possible solution is to offload real-time and computationally expensive functions to accelerators. But there are other solutions. The fronthaul and virtualization challenges are coupled in a manner that a solution to both can be arrived at by judiciously choosing the functional split between centralized and distributed functions. For example, it is possible to place the physical layer at the remote radio while placing higher layers in the data center. This significantly reduces fronthaul capacity and timing requirements, and consequently the cost of fronthaul, but also reduces the performance gain over traditional distributed architecture. Since it is possible to draw the line between distributed and centralized functions along different points in the protocol stack, we are set to witness a proliferation of Cloud RAN implementations. While the industry works at resolving the above challenges in Cloud RAN, small Cloud RAN systems are set to emerge. Such systems would be targeted at venues, for example, a stadium or a convention center, and deployed in a similar way to distributed antenna systems (DAS). More than eight different solutions are in development with various vendors, so the hype cycle is beginning.

Small Cloud RAN systems could eventually disrupt the wireless industry with virtualization moving up into ever larger deployments – a familiar path taken by disruptive technologies in other fields ranging from steel to excavation equipment. Another indicator of the promise of Cloud RAN is manifested in the current thinking around 5G networks. While capacity was a major requirement for 4G, 5G complements this with emphasis on scalability and energy efficiency (as much as 90% of power consumption of mobile operators is due to the radio access network). HetNets are a central feature of 5G networks which imposes requirements for simplification of all aspects of network operation and management. These facts combined point to the importance of virtualizing the radio access network and formulating a Cloud RAN architecture and deployment scenarios that leverage the benefits of Cloud RAN.The trends in wireless network evolution indicate that we are currently at the cusp of bifurcation in network architecture and technologies, and even commercial practices. Operational processes remain rigidly entrenched. Operators will have to look for new means to meet the demands placed upon them by customers and investors more efficiently and effectively.

About two thirds of a network's cost of ownership is in operational costs including site rental, energy, and support and maintenance expenses. Also, operators realize further cost reduction from pooling and virtualizing baseband processing because we no longer need to provision for peak capacity on a per-site basis: it is possible to reduce processing requirements by as much as 75%. Cloud RAN has the elements to provide flexibility necessary in future wireless networks, and in the indoor market, emerging solutions may break new ground toward low-cost, high density mobile infrastructure.