Evolution the way ahead in the LTE Revolution

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For a Revolution to succeed, evolution must follow! Revolutionary technologies of the recent past – Enterprise 3.0, Web 3.0, Android, attest this statement. Tablets and smartphones are new chips on the revolutionary technology block. They have triggered an explosion in video and multimedia data, increasing pressure on network infrastructure - wireless coverage, bandwidth, latency, backhaul and datacenters. The subscriber’s data consumption on the mobile has outpaced voice usage. By 2014, the average mobile data consumption per month is expected to increase from a few hundred MB of today to over 1GB. The advent of tablets and smartphones has raised the expectations of the mobile user. For instance he would want the same internet speed and experience on his mobile, as in his broadband connection. This trend is expected to put tremendous pressure on mobile networks that will be expected to handle gigabytes of traffic volumes.

Multiple optimization techniques would be needed to handle the data surge. At the operator end, one is witnessing the introduction of a cap on usage to transform the user behaviour from sporadic to responsible usage and reduce the load on the network. At the network end, Long Term Evolution (LTE-Advanced), commonly called 4G, is being hailed as the next telecom revolution due to its strong downlink and uplink throughput enabling high definition (HD) video, conferencing and gaming on tablets and smartphones, even while on the move. LTE-Advanced has high transmission bandwidth (100 MHz), peak spectral efficiency (16 bps/Hz), and least latency (50ms at control and 5ms at user), 100 Mbps downlink and 20Mbps uplink data throughput, surpassing the IMT-Advanced (International Mobile Telecommunications Advanced) requirement.

LTE-Advanced, however, today faces cost pressures to make it cheaper alongside the challenge of co-existing with 3G networks like HSPA, and achieving good performance and power efficiency in a unique macro cellular infrastructure. Evolution of LTE Advanced and related technologies is essential for LTE revolution to triumph. A dual pronged strategy, comprising of Remote Radio Head (RRH) based implementation for Macro and Active Antenna Systems (AAS) and LTE Femtocells, can help succeed in the LTE evolution.

UNDERSTANDING TODAY’S LTE-ADVANCED

In today’s LTE Advanced networks, peak data rate though used to depict user data rate performance doesn’t reflect the actual data rate experienced by users. Further, the data rate supported by a base station depends on the user location and congestion of network, influencing the degree of sharing radio resources with other users and interference levels.
The way the location and traffic load influence the user data rate is summarized in the diagram above. In a nutshell, the user data rate is determined by two factors: the Signal to Interference & Noise ratio (SINR) ratio and the share of cell resources.

A mix of the below mentioned strategies will help mobile operators succeed in the LTE revolution:
- Performance improvement of Macro network
- Denser macro network
- Heterogeneous deployment
- Internet off-loading

Macro performance can be improved by increasing spectrum, bandwidth transition from 10MHz to 20MHz, carrier aggregation (CA), usage of multiple antennas (MIMO), improved processing and coordination. On the other hand, a dense macro deployment would mean reduction of Inter Site Distance (ISD) from 500 meters to 300 meters. However, both these deployment strategies meet with limited success due to economic factors.

As a result, most telecommunication companies will move towards heterogeneous or distributed base station architectures with remote radio head (RRH) capabilities to balance the limited availability of new spectrum and leverage existing spectrum. These implementations are driven by a need to lower CAPEX and OPEX for the service providers.

**HETEROGENEOUS BASE STATION ARCHITECTURE**

Efficient distributed base station architecture would comprise of a base station server transmitting RF data using Open Base Station Architecture Initiative (OBSAI) or Common Public Radio Interface (CPRI) to the RRH (remote radio head) and Adaptive Antenna System (AAS).

The heterogeneous deployment of the Macro layer with the Pico Base Transceiver Station BTS, Remote Radio units (RRU) and Relays help improve coverage and cater to a non-uniform and realistic usage density. A heterogeneous network can be seen in 3 levels of deployment -
- a) wide area site which is today’s macro deployment ISD of 500m and less than 5watt output power
- b) medium area site with RRH for a denser deployment ISD of 100m and 1 to 5W power output
- c) local area sites with Pico cells and Antenna adaptation System for a deployment ISD of less than 100m and power output of less than 500mW. Interspersed in the local area will be Femtocells with deployment ISD of 10 to 100m and a power output of less than 100mW.

Spectral efficiency is needed as it will help reduce cost, improve power efficiency and performance of LTE networks. For a given service and grade of service, spectral efficiency determines the required amount of spectrum, number of base stations, sites and maintenance as well the consumer pricing and affordability. At the macro level, RRH which packets high-performance, efficient, and frequency-agile analog functions, digital interfacing and processing functions, into a light-weight (10Kg) device with a small mechanical footprint, can achieve spectral efficiency.

However, today, LTE networks face the problem of dense pockets of users where achieving spectral efficiency is fast becoming a challenge. An adaptive antenna system that is
a miniature version of the remote radio head at the macro level could resolve this bottleneck which is more concentrated in nature. AAS comprises of multiple antenna elements of transmission and receiving communication chain where the signals are processed adaptively to exploit the spatial dimension of the mobile radio channel. AAS systems improve the link quality, hereby enhancing the quality of service to the end user. It also provides benefits of increased range/coverage (due to beamforming gain), increased capacity as it improves SINR (this can be used for dense population sections of the cell), reduction in power dissipation and cost of deployment/maintenance, and increased spectral efficiency.

**COMPLEXITY OF IMPLEMENTATION:**

Today, RRH and AAS systems implementations have grown in complexity. The multi standard support requirements like GSM, HSPA and LTE-A, make the digital signal processing blocks in the RRH system very complex, which in turn demands a high end ASIC implementation. The Tx and Rx paths are implemented with either custom logic or DSP elements. For quicker product launches, FPGA based solutions are deployed. The FPGA approach is apt for the prototype stage/small scale implementation as it is flexible on the hardware and software side. However, the approach has limitations in scaling up. The DSP approach, on the other hand, provides scale needed for a large implementation and flexibility on the software side, making it a preferred approach for large but evolving implementations.

Adding to the complexity of RRH and AAS implementations are support requirement for high speed upto 10Gbps and optical interfaces like CPRI/ OSAI/ OBRI. The Antenna design for Multi-mode AAS system also make implementations complex. As a result, RRH and AAS system are transitioning into ‘Smart Antenna Systems’. This increases the level of silicon integration, but brings down overall cost of RRH and AAS implementations.

**CAPACITY OFF-LOADING OF MACRO NETWORK – LTE FEMTOCELL**

Another bottleneck on the LTE network front is fluctuating wireless experience depending on the loading of the network. A user would typically have access to wireless LAN at office and LTE outside. A seamless switch between the two can improve spectral efficiency on congested networks and ensure optimum utilization of resources. This capacity crunch can be overcome by offloading a large portion of the traffic to complementary wireless access networks depending on different user experience. Hence, it could be offloaded via LTE Femtocells, Wi-Fi or RNC offload using deep packet inspection and other techniques. Femtocell that plugs into existing broadband line can act as a cellular transmitter and receiver to connect to the wireless operator's network and improve efficiency. Femtocell is a viable approach for service providers to subsidize, but still charges the customer for the usage.

**HOW FEMTOCELL WORKS?**

Unlicensed nature of spectrum, commodity hardware and presence of WiFi radio in all new smartphones, tablets and consumer electronic devices planned for LTE make WiFi traffic offloading an equally viable alternative to resolve the capacity crunch LTE networks will experience in 2014 and beyond.

In a nutshell, there is no ‘One Size, Fits All’ solution to resolve the LTE-A jigsaw puzzle. Various combination packs are being tried and tested to help service providers sufficiently manage the inevitable data explosion of the future. Only time will tell which one succeeds!

**REFERENCES**

Paper on “Heterogeneous networks – increasing cellular capacity” by Ericsson