LTE-Advanced... Already?

Learn Now the Challenges It Brings to the Network

By Jan Whitacre

A deluge of media coverage has created high consumer demand and high expectations for 4G mobile technology. 3GPP's Long Term Evolution (LTE) has emerged as the leading 4G contender, and just as mobile operators begin the lengthy process of deploying and testing their LTE networks, 3GPP has published the next release of the LTE standard, known as LTE-Advanced. With performance enhancements such as peak data rates to 1 Gbps, LTE-Advanced will meet or exceed the requirements of the International Telecommunication Union (ITU) (www.itu.int) for its 4G radio-communication standard, IMT-Advanced.

In the feasibility study for LTE-Advanced, 3GPP determined that today's LTE (Release 8/9) could meet most of the ITU's 4G requirements apart from uplink spectral efficiency and peak data rates. These requirements are being addressed in Release 10 LTE-Advanced with the following features: wider bandwidths, enabled by carrier aggregation; and higher efficiency, enabled by enhanced uplink multiple access and enhanced multiple antenna transmission (advanced MIMO techniques).

Release 8 LTE itself is new and complex, introducing such features as multiple channel bandwidths, different transmission schemes for the downlink and uplink, 2 transmission modes (FDD and TDD), and the use of multiple antenna techniques (MIMO). LTE-Advanced raises the bar on performance expectations, and the new technologies will have to co-exist and interoperate with each other and with legacy 2G and 3G deployments for years to come. The challenges for the engineers who design, test, and ultimately deploy LTE-Advanced are many.

New Features for the Release

The higher requirements of IMT-Advanced are addressed in 3GPP Release 10 with the addition of the following LTE-Advanced features:

Carrier Aggregation: To achieve 1 Gbps, LTE-Advanced supports bandwidths up to 100 MHz formed by aggregating up to five 20-MHz component carriers. Contiguous and non-contiguous component carriers may be aggregated. A simple example is shown in Figure 1. Although not considered a problem for the base station, carrier aggregation will undoubtedly pose major difficulties for user equipment (smart phones and other wireless devices), which must handle multiple simultaneous transceivers. The use of simultaneous, non-contiguous transmitters creates a highly challenging radio environment in terms of spur management and self-blocking. Simultaneous transmit or receive with mandatory MIMO support will add significantly to the challenge of antenna design.

Verizon Takes LTE to 40 New Markets

Mobile Backhaul To The Rescue

Verizon Wireless recently unveiled an additional 59 markets that will benefit from its 4G Long Term Evolution (LTE) network by the end of this year. These newly named areas, added to the 39 initial markets launched in December 2010 and 49 markets announced at the Consumer Electronics Show in January, mean that consumers and businesses in at least 147 U.S. cities will have access to the fastest, most advanced 4G mobile network in America.

David Small, chief technical officer for Verizon Wireless, said, "Aggressively expanding this powerful network beyond major metro areas reflects the reality that the 4G LTE ecosystem is growing quickly. Our commitment to reach deep into medium-sized cities and smaller communities by the end of 2011 means the power of 4G LTE can be harnessed and provide advanced services to law enforcement, healthcare workers, educators, and other professionals, as well as to individual consumers, sooner than many thought possible. So whether you spend time in New York and San Francisco; or Harrisburg, Pennsylvania; Saginaw/Bay City, Michigan; Huntsville, Alabama; and Las Cruces, New Mexico, you can connect to the most advanced 4G network in the country."

In real-world, fully-loaded network environments, 4G LTE users should experience average data rates of 5 to 12 megabits per second (Mbps) on the downlink and 2 to 5 Mbps on the uplink.

In addition, Verizon Wireless is also working with rural communications companies to collaboratively build and operate a 4G network in those areas using the tower and backhaul assets of the rural company and Verizon Wireless' core 4G LTE equipment and premium 700 MHz spectrum. Already, 6 rural companies have signed on to leverage Verizon Wireless' scale for infrastructure while keeping their customers on the cutting edge of technology.

Source: Verizon Wireless, www.vzw.com

No Pressure, Really…

The Charge: Reduce OpEx AND Increase Network Capacity

Providers need to plan their network roll-outs carefully in order to reduce their costs as they increase network capacity, according to the latest report from global telecoms, media and technology (TMT) adviser Analysys Mason (www.analysysmason.com).

The combination of rapid growth in network traffic and slow growth in revenue is squeezing mobile network operators' profit margins. A well-designed radio access network reduces costs, which increases profit margins. This includes the backhaul network, which connects the base station to the core of the mobile operator's network. As a result, backhaul design is becoming an important consideration in an operator's radio access strategy.

"Growth in the take-up of devices and technologies that offer an improved user experience, such as smart phones and tablets, will increase the amount of data that customers consume," says Terry Norman, Principal Analyst at Analysys Mason and author of the report *The cost of capacity: mobile backhaul worldwide*. "Operators will be able to keep up with their customers' demand for data in the short term, but thirty-fold growth in data volumes by 2015 will drive most operators to increase their backhaul capacity. Operators can achieve this in 2 ways: by leasing dedicated lines from incumbent (and some alternative) operators, or by building their own fiber or microwave backhaul."

Backhaul costs are forecast to increase by a factor of 10 by 2015, which could significantly reduce operators' profit margins. Furthermore, capacity constraints in the backhaul network are threatening to constrict the flow of data to and from the customer.

These trends are driving operators to review their backhaul strategies and equipment suppliers to develop transmission network technologies that address these issues.

"There is no universally applicable backhaul solution. Operators must review their backhaul improvement strategies on a region-by-region and country-by-country basis to identify the optimal solution for each market," says Terry Norman, who also leads Analysys Mason's *Wireless Networks* research program. "The initial cost is not the only -- and often not even the overriding -- factor. Variables such as security, return-on-investment timescale, traffic growth rate, and the availability of local infrastructure must contribute to the overall backhaul strategy. Operators must calculate a fair and accurate 'total cost of ownership' model for backhaul costs."

The report *The cost of capacity: mobile backhaul worldwide* offers a unique view of this issue by considering how regional variations will influence operators' backhaul strategies.

Source: Analysys Mason, www.analysysmason.com

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Figure 1. Aggregation of contiguous component carriers.

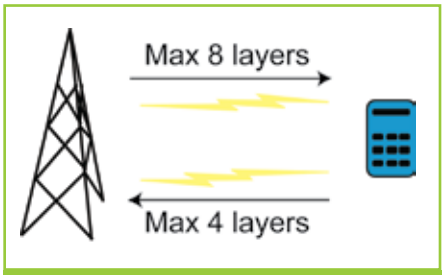

Figure 2. LTE-Advanced Release 10 maximum number of antenna ports and spatial layers.

Enhanced Uplink Multiple Access: LTE's uplink is based on single-carrier frequency division multiplexing (SC-FDMA), which allocates carriers across a contiguous block of spectrum, thus limiting scheduling flexibility. LTE-Advanced introduces clustered SC-FDMA in the uplink, which allows frequency-selective scheduling of component carriers for better link performance. The PUCCH and PUSCH can be scheduled together to reduce latency. However, clustered SC-FDMA increases peak-to-average power ratio, leading to transmitter linearity issues, and the presence of multi-carrier signals increases opportunity for in-channel and adjacent-channel spur generation.

Advanced MIMO: To improve single-user peak data rates and meet spectral efficiency requirements, LTE-Advanced specifies up to eight transmitters in the downlink (with the requisite eight receivers in the UE) enabling 8x8 spatial multiplexing in the downlink. The UE supports up to 4 transmitters allowing up to 4x4 transmission in the uplink when combined with 4 receivers in the base station. (See Figure 2.)

MIMO increases the number of antennas in the system, and MIMO antennas have to be de-correlated. A major challenge will be designing multi-band MIMO antennas with good de-correlation to operate in the small space of an LTE-Advanced UE. New methods are required for predicting actual radiated performance of an advanced MIMO terminal in an operational network, so 3GPP is considering ways to extend MIMO over the air (OTA) testing for LTE-Advanced.

Other performance enhancements are under consideration for future 3GPP releases, even though they are not critical to meeting 4G requirements:

- Coordinated multipoint transmission and reception (CoMP)
- Relaying
- Support for heterogeneous networks
- LTE self-optimizing network (SON) enhancements
- Home enhanced-node-B (HeNB) mobility enhancements
- Fixed wireless customer premises equipment (CPE)

Deploying LTE-Advanced

Industry-supported field trials are already demonstrating the viability of many of the technical concepts in LTE-Advanced. Additionally, operators are showing considerable interest in the higher data rates and spectral efficiency improvements. However, the timing of LTE-Advanced deployment is difficult to predict and will be dependent on industry demand and the success of today's Release 8 and 9 LTE rollouts. LTE-Advanced represents a big increase in system and device complexity, and it will take time for the industry to respond.

When the Release 10 features of LTE-Advanced are initially deployed in the field, it is expected that the major challenges (beyond those already posed by LTE) will center around interference problems and spurs. In the challenging RF environment, high-performance handheld tools such as Agilent's FieldFox RF analyzer will be invaluable for monitoring the spectrum and identifying interference signals.

Jan Whitacre is LTE Program Lead for Agilent Technologies. She has more than 20 years of experience in wireless testing. For more information, please email jan_whitacre@agilent.com or visit www.agilent.com/find/.