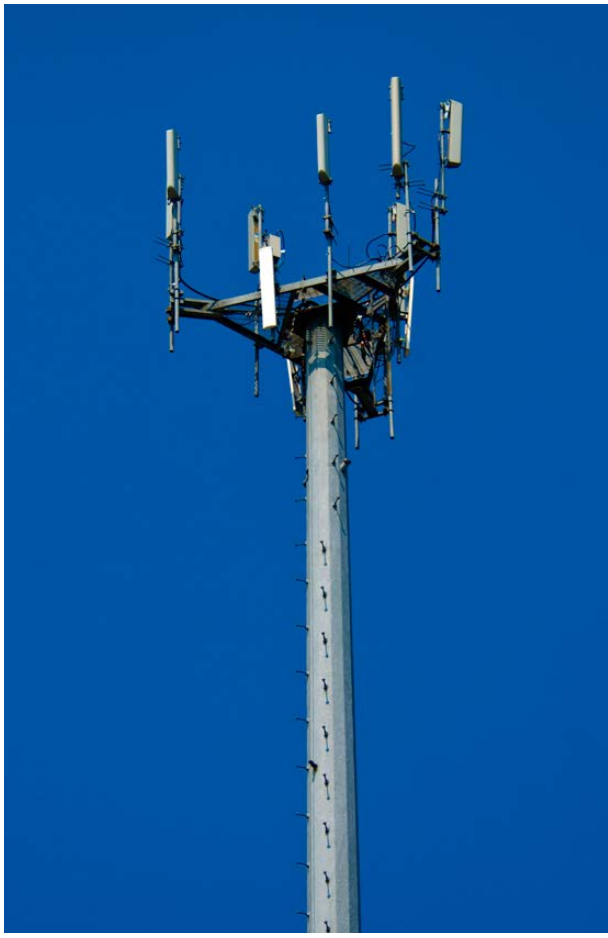
ANY-G TO 4G

The Top Five Considerations for Migrating to 4G LTE

Preparing for Sunsets

In the consumer market, the 4G LTE standard continues to gain favor as the preferred network for phones and tablets, thanks to its increased data speeds. Consumers might not give much thought to the differences between generations of cellular technology, but engineers and network professionals who manage remote commercial and industrial equipment are, naturally, very focused on the nuances and distinctions that can affect their short- and long-term plans. As many carriers announce their plans to sunset their legacy networks, managers of corporate wireless networks must prepare for the migration from legacy 2G and 3G networks to 4G LTE.



This migration, which is already well underway in North America, Western and Northern Europe, Japan and South Korea, is driven by the pursuit of three fundamental and worthy benefits:

Speed

Over the past year, more companies have stepped up their adoption of 4G LTE in bandwidth-intensive applications such as retail store backups, IP cameras and digital signage. 4G LTE provides unsurpassed download and upload speeds (theoretical speeds as high as 300 Mbps) and very low latency.

Total Cost of Ownership

4G LTE technology allows network operators to do more with less, thanks to increased spectral efficiency. Simply put, 4G LTE lets carriers support more customers and more devices with fewer towers.

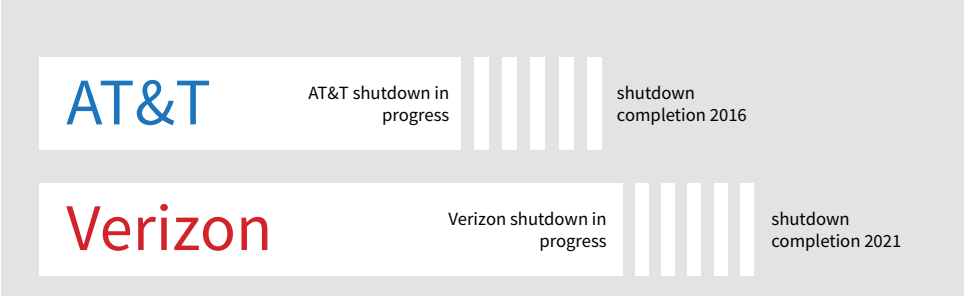
Longevity

While consumer wireless devices typically have a 12- to 36-month refresh cycle, M2M network professionals need a longer-term horizon – typically five to 10 years. Companies are viewing 4G LTE as their strategic platform for the next decade.

“Over the next four years, 10-12 million 2G M2M devices will need to migrate to 3G or 4G LTE networks.”

In the U.S., the sunset plans have been announced and carriers are moving inexorably to shut down older network architectures. For instance, AT&T has announced it will decommission its 2G network as of January 1, 2017. As a result, their 2G investments and maintenance activities have decreased dramatically, and many 2G customers have already reported service degradations. Verizon has also announced plans to sunset its 2G and 3G networks entirely by 2021.

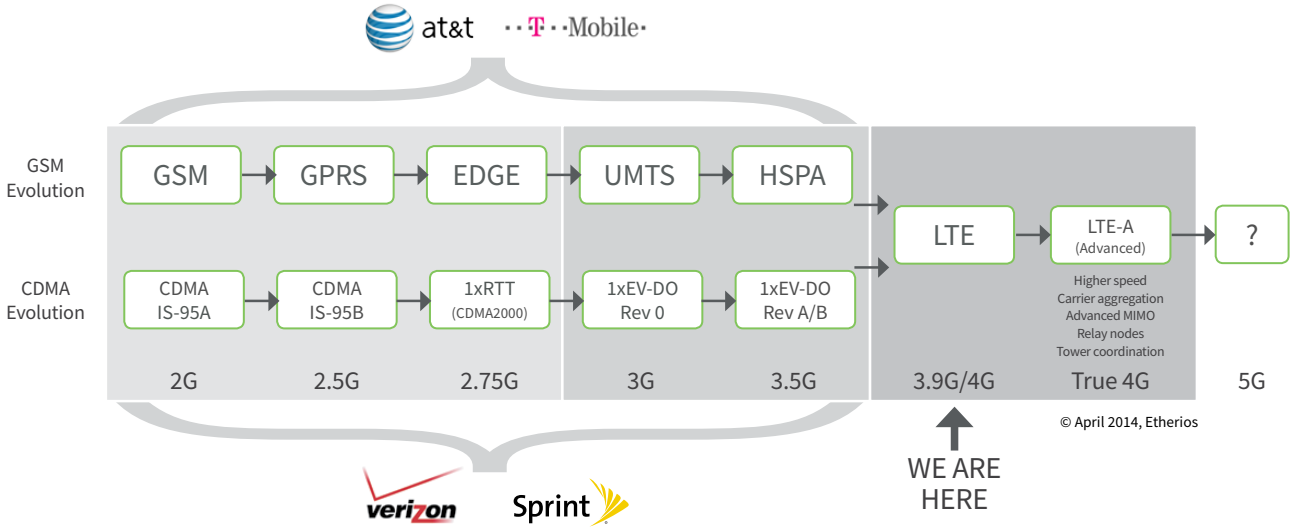
2G Carrier Sunsets



Source: Raco Wireless

In many cases, the migration away from 2G/3G is driven by a desire to repurpose spectrum for more efficient LTE data traffic. As mentioned above, it’s more cost-effective for a carrier to operate a 4G LTE network than a 2G or 3G network. What, exactly, do we mean by migration? As the graphic below describes, LTE represents the confluence of the GSM and CDMA evolutions.

Cellular Technology Evolution



The Top Five 4G LTE Migration Considerations

Advocates emphasize the improved speeds that are possible with 4G LTE, but there are other important factors to consider. Operators of machine-to-machine (M2M) networks considering 4G LTE routers must now factor into migration plans SIM cards, dual antennas, new signal-quality metrics and new frequency bands. In the following pages, we review the top five considerations that M2M network operators and administrators should keep in mind as they contemplate migration from 2G/3G to the 4G LTE platform.

1 SIM Cards and APNs

Companies that currently leverage GSM GPRS, EDGE or HSPA networks use subscriber identification module (SIM) cards and access point names (APNs). But SIM cards are a new concept for those companies that are migrating from CDMA 1xRTT or EVDO networks. A SIM authenticates the LTE device and identifies the data services it will use.

An APN is a private network. Instead of going to a tower and then switching to the public Internet, the packet goes to the tower and stays on the carrier's private network. LTE carriers also use APNs (just as they did with GSM). The APN, which is either automatically downloaded to the LTE module or manually entered in the device configuration, works with the SIM to determine IP addressing, whether this device will be on a public or private network, and similar security and routing parameters.

2 Dual Antennas

In many 3G HSPA and EVDO networks, routers are frequently deployed and configured with two antennas to achieve "receive diversity." (The primary antenna transmits and receives while the secondary antenna is receive only.) With this configuration, the router is better able to cope with multipath interference that occurs when signals bounce off obstructions (e.g., buildings, trees or airplanes) and arrive at the antenna out of phase. Two receive antennas, placed where signals can be best received and combined, can help counteract multipath interference. Conversely, LTE uses multiple input/multiple output (MIMO) where both antennas transmit and receive. While it is possible to use one antenna (and operate the device in SISO mode), two antennas are a better choice for optimum performance. Using one antenna will case bandwidth to vary based on the RF conditions at the operating site. Application performance will also suffer, sometimes cutting bandwidth as much as 50 percent. Regardless, best practices call for using directly attached antennas.

Consider both signal strength AND quality in your assessment.

3 Evaluating Your Signal

In 2G and 3G networks, signal strength was best understood using the received signal strength indicator (RSSI), measured in dBm. That value alone only provides a measure of the total signal including noise, and, of course, noise degrades the performance of a cellular connection. For example, a cellular router installed in an electric substation may pick up a strong cellular signal – but it will still perform poorly due to electromagnetic interference. That's why it's important to understand not only the strength of the signal, but also its quality.

Most 2G/3G CDMA and WCDMA (i.e., UMTS/HSPA) devices also report Ec/Io which is a better indicator of signal quality. However, this metric is less commonly used and not as well understood as RSSI.

For 3G cellular connections, RSSI and Ec/Io determine signal quality:

RSSI	Signal Strength
> -70 dBm	Excellent
-70 dBm to -85 dBm	Good
-86 dBm to -100 dBm	Poor

Ec/Io	Signal Quality
0 to -6	Excellent
-7 to -10	Good
-11 to -20	Fair to Poor

With 4G LTE, operators can now take advantage of three new metrics to help indicate when the device has received a "good" LTE signal:

- **Reference Signal Received Power** – RSSP indicates the signal strength and is roughly analogous to RSSI.
- **Reference Signal Received Quality** – RSRQ describes the signal quality and is similar to Ec/Io.
- **Signal to Interference and Noise Ratio** – SINR (also called SNR) indicates the throughput capacity of the channel. As the name implies, SINR is the strength of the signal divided by the strength of any interference.

These parameters may vary depending on the technology being used. The table below describes the RF conditions that each value range represents.

RF Conditions	RSRP (dBm)	RSRQ (dB)	SINR (dB)
Excellent	>=-80	>=10	>=20
Good	-80 to -90	-10 to -15	13 to 20
Mid Cell	-90 to -100	-15 to -20	0 to 13
Cell Edge	>=-100	>=-20	>=0

For example, a 4G LTE modem might report an RSSI of -68 dBm, but:

RSRP = -102 dBm

RSRQ = -16 dB

SNR = -1.8 dB

In this case, the signal quality is actually very poor. This could be due to the device being some distance away from the LTE transmitter. It's also possible that something is interfering with the signal, such as a building or other obstructions between the device and the tower.

Ultimately, poor signal quality equals poor performance due to issues such as retransmissions. Not only does poor signal quality degrade performance, it also adds cost to monthly data plans.

How Does One Get the Best Possible Signal?

- Move the cellular device to a location where it can receive the best possible signal and use directly attached antennas.
- If that's not possible, use two identical external antennas with the shortest possible cables. Consider using dual-element antennas that reside in one enclosure. These are well suited for mobile applications but can also work in stationary settings.

4 Frequencies and Bands

When it comes to frequencies and bands, LTE adoption can involve some subtle complexities. For 2G cellular networks it was possible to have a single, worldwide SKU that operated on four bands between 850 MHz and 1,900 MHz. 3G added two bands at 1,700 MHz and 2,100 MHz, resulting in a total of six bands in a single worldwide SKU.

4G LTE - Challenges

Bands

2G: 4 bands (800, 900, 1800, 1900)

3G: 6 bands
(850, 900, AWS, 1800, 1900, 2100)

4G: 40+ bands and counting
(some overlap)

SKU Proliferations

No worldwide LTE module

More supported bands =
higher cost, larger device

LTE module SKUs by region

LTE module SKUs by carrier

Due to the exponential growth in cellular devices, 4G LTE now has more than 40 bands defined, at frequencies between 700 MHz and 3,700 MHz. This results in a few benefits, but also creates challenges.

1. On the positive side, the lower the frequency the larger the service area and the better the building penetration.
2. More bands mean more aggregated bandwidth, resulting in a higher capacity as well as higher per-device throughput.
3. However, more bands mean a more expensive and complex device. It is no longer economically feasible to have a single, worldwide SKU of a product. Most products are therefore offered in regional variants, with the Americas, Europe and APAC being the most common geographical split. When comparing vendors, compare down to the band-level and if you have a global business, select a partner that has products in the region where you need to have coverage.
4. The wider frequency range also requires more complex antennas. An antenna that is efficient at one frequency may be less efficient at another frequency. 4G LTE antennas are therefore typically more expensive, and for optimal performance two antennas are recommended.

For the most part, 2G/3G GSM and CDMA networks have operated primarily within a narrow band of frequencies: from 850-2,100 MHz. Most North America cellular carriers use 850 MHz (called the cellular band) and 1,900 MHz (the PCS band). In other regions of the world, carriers use 900 MHz and 1,800 MHz, with some use of 1,700 MHz and 2,100 MHz AWS bands worldwide.

In addition to these frequencies, 4G LTE also uses spectrum below 800 MHz and above 2,100 MHz. Many LTE carriers are using the 700 MHz spectrum. LTE radios and carriers are now using "bands" to represent which frequencies are used.

5 Speed and Latency

When it comes to 4G LTE, the conversation has largely focused on faster download and upload speeds. For the most part, that focus is understandable. Another benefit for M2M is that LTE technology typically provides much lower latency than 3G, getting closer to wire-line latency, which is critical for certain M2M polling applications like SCADA and asset monitoring.

While the theoretical upload and download speeds are said to be in the 300+ Mbps range, real-world speeds are typically far less. In some cases, a mobile device (e.g., a Digi TransPort® router) might see 40+ Mbps, but the same device in a different location might get less than 10 Mbps. Why? There are many factors that influence cellular data performance, just as they do for any wired or wireless network, including:

- Distance from the serving cell site
- Obstructions such as hills, buildings and trees between the end device and the serving cell site
- Interference from electric devices such as electric motors, transformers and lighting ballasts
- The type and quality of antennas and antenna cables and the number of antennas. As noted previously, two antennas will provide much better performance than just one.
- The load on the local tower and network attached to that tower. For example, a location next to a freeway will likely see slower speeds at rush hour vs. at 2:00 a.m. This is one of the only factors that cannot be helped by improving signal quality. Even the best antennas cannot counteract a busy, potentially overloaded network.

Technology	Data Rate (peak)	Data Rate (typ)	Latency	Applications
2G	Kbps	100-400 Kbps	300-1,000 ms	• Data logging, metering • SCADA apps polling small bits of data
3G	Mbps	0.5-5 Mbps	100-300 ms	• Small remote-site backup • Retail/POS/Kiosk/Lottery • SCADA apps that need higher bandwidth
4G LTE	Gbps	1-50 Mps	<100 ms	• Larger remote-site backup • Video surveillance/IP cameras • Interactive media • Digital signage • Transit Wi-Fi • Medical applications

Conclusion

For forward-thinking M2M operators, 4G LTE will continue to emerge as an increasingly important standard. Network professionals will need to acknowledge and plan for the many subtleties that will affect their long-term adoption plans as 4G LTE takes center stage and migration strategies take shape. To capitalize on the speed and longevity benefits that 4G LTE presents, it's essential to account for a variety of factors – from SIM cards and antennas to bandwidth selection. With careful planning, companies will be in a better position to capitalize on the signal strength, speed and greater capacity that 4G LTE architectures can provide.

About Digi International

Digi International (NASDAQ: DGII) is the M2M solutions expert, combining products and services as end-to-end solutions to drive business efficiencies. Digi provides the industry's broadest range of wireless products, a cloud computing platform tailored for devices and development services to help customers get to market fast with wireless devices and applications. Digi's entire solution set is tailored to allow any device to communicate with any application, anywhere in the world. Digi has shipped nearly half a million cellular M2M routers to 95 countries over the last decade.

Key Takeaways

- ✓ It will be increasingly difficult, and eventually impossible, to rely on 2G devices for M2M applications.
- ✓ Network Engineers and Administrators need to understand the differences between 2G/3G and 4G LTE.
- ✓ 4G LTE uses more frequencies and bands, so it's important to select a device that supports the LTE technology in your region.

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