ANY-G TO LTE AND 5G

THE TOP FIVE CONSIDERATIONS FOR MIGRATING TO 4G, 5G AND BEYOND

PREPARING FOR 2G AND 3G SUNSETS

4G LTE and 5G standards continue to gain favor as the preferred networks for phones, tablets and an increasing number of commercial, industrial and transit applications, thanks to increased data speeds. Developers and network professionals who manage commercial and industrial equipment, SCADA systems, business networks or municipal transit and traffic operations, are now rapidly migrating to next generation networks for operational efficiency and reliability. Many carriers have announced plans to sunset their legacy networks, which means network managers must prepare for the migration away from legacy 2G and 3G networks.

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

SPEED

To support better operations, companies are increasing adoption of next-generation networks for bandwidth-intensive applications such as retail store backups, IP cameras and digital signage. 4G LTE and 5G networks provide unsurpassed download and upload speeds (up to 2,000 Mbps) and very low latency.

TOTAL COST OF OWNERSHIP

New network technology allows operators to do more with less, due to increased spectral efficiency. That means carriers can support more customers and more devices with existing towers.

LONGEVITY

While consumer wireless devices typically have a 12-to-36-month refresh cycle, companies developing IoT solutions need a longer-term horizon — typically five to 10 years. Companies are viewing 4G and 5G as their strategic platform for the next decade.

> "Millions of 3G M2M and IoT devices need to migrate to LTE or 5G. Otherwise, the devices will fail when those networks sunset."

In the U.S., carriers are moving inexorably to shut down older network architectures. For instance, AT&T and Verizon are decommissioning 2G networks now and 3G decommissioning will be complete in 2022. As a result, their 2G and 3G investments and maintenance activities have decreased dramatically, resulting in service degradation or complete loss of service. In most cases, 2G and 3G activations have halted. Carriers are no longer allowing 2G and 3G light-ups as they decommission these networks and repurpose them for 4G LTE and 5G. Clearly, moving to an LTE or 5G platform is the best choice for carriers — and, by extension, enterprises, governments and systems integrators must migrate all development and deployment efforts to LTE and 5G as well.

YEAR	2018	2019	2020	2021	2022	2023
VERIZON	No new 2G or 3G activations				**3G sunset** December 31	SHUT DOWN COMPLETE
AT&T	No new 3G activations				**3G sunset** February 22	SHUT DOWN COMPLETE
T-MOBILE					**3G sunset** April 1 **2G sunset** December 31	SHUT DOWN COMPLETE

2G/3G CARRIER SUNSETS

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 earlier, it's more cost-effective for a carrier to operate an LTE network than a 2G or 3G network. What, exactly, do we mean by migration? Those who are evaluating next steps for 2G and 3G have the option to migrate to LTE devices or leap-frog over LTE and migrate to 5G. Note that Digi can help you determine the right strategy. Contact us for assistance.

THE TOP FIVE MIGRATION CONSIDERATIONS

Advocates emphasize the improved speeds that are possible with new network architectures, but there are other important factors to consider. Developers designing and building IoT applications with advanced devices must now include these additional factors in their 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 and IoT network operators and administrators should keep in mind as they contemplate migration from 2G/3G to next generation networks.

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). Companies migrating from CDMA and EVDO networks likely are not using SIM cards. In an LTE network, a SIM card authenticates the LTE device and identifies the data services it will use.

The key consideration for product developers and systems integrators building systems with newer cellular networks is that devices on a CDMA network don't require a SIM card. In migrating to LTE, engineers must make some determinations regarding SIM cards and the resources for integrating them. The key design considerations include:

- Determine which SIM form factor is best suited for the application
- Factor in the SIM card in the product specifications
- Identify the time and resources for placing SIMs in every device

Note that Digi offers a range of application development, kitting and SIM services to support rapid deployment. See our Professional Services site for additional information.

2. Dual Antennas

In 3G HSPA and EVDO networks, routers are frequently deployed and configured with two antennas to achieve "antenna 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 multi-path 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 multi-path interference.

Conversely, LTE and 5G use 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 cause 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.

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 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 is why it is 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, as shown in the following table.

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 LTE, operators can take advantage of three additional metrics to help indicate when the device has received a “good” LTE signal:

- Reference Signal Received Power – RSRP 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.

For example, a 4G modem might report an RSSI of -68 dBm, but less favorable values for other metrics.

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 from the LTE transmitter. Or something could be interfering with the signal, such as a building or other obstruction between the device and the tower.

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

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

There are many ways to improve cellular 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 significantly increased the number of available bands.

4G - CHALLENGES AND OPPORTUNITIES

BANDS

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

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

4G: 80+ 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 introduced more than 80 bands worldwide at frequencies between 700 MHz and 5,900 MHz. This results in several benefits, but also creates challenges.

On the positive side, lower frequencies broaden the service area and improve building penetration. But there are additional factors and considerations:

- More bands mean more aggregated bandwidth, resulting in a higher capacity as well as higher per-device throughput.
- However, more bands mean a more expensive and complex device. Many manufacturers have found it impossible to build 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 with products certified in the region where you need coverage. Digi offers some cellular products in single global SKUs, such as Digi IX20.
- The wider frequency range also requires more complex antennas. An antenna that is efficient at one frequency may be less efficient at another frequency. 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 to 2,100 MHz. Most North American 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 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 new and advanced networks, the conversation has largely focused on faster download and upload speeds. For the most part, that focus is understandable. Another benefit for IoT is that LTE and 5G technology offer much lower latency than 3G, getting closer to wireline latency, which is critical for certain M2M polling applications like SCADA and asset monitoring.

Real world speeds can vary widely from the published range. 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 cellular tower or 5G cellular infrastructure. For example, a location next to a freeway will likely see slower speeds at rush hour vs. at 2 a.m. This is one example of a factor that cannot be helped by improving signal quality. Even the best antennas cannot counteract a busy, potentially overloaded network.

A CLOSER LOOK AT WIRELESS STANDARDS

There are multiple choices today for low-power wide-area (LPWA) connectivity. These include NB-IoT, a 3GPP standard that improves system capacity and spectrum efficiency, and LoRaWAN, which provides connectivity without the need for Wi-Fi.

LTE-M is another 3GPP standard for the LPWA market. Like NB-IoT, LTE-M is optimized for lower bandwidth applications using devices that sleep and report their data periodically. It supports multi-year battery life with extended ranges and better penetration of buildings and obstacles for devices deployed in hard-to-reach places.

Each of these standards supports long-range, low-power applications and therefore long battery life, but they have different ideal use cases. NB-IoT is at it's best in applications that don't require high refresh rates, such as smart metering. LoRaWAN is ideal for remote asset tracking and monitoring, such as smart supply chain applications. Finally, LTE-M is great for mobility and voice use cases such as smart security.

All three of these standards will continue to develop with the rollout of 5G networks.

TECHNOLOGY	PEAK DATA RATE	TYPICAL DATA RATE	TYPICAL LATENCY	APPLICATIONS
2G	**237 kbps**	**< 100 kbps**	**250–1,000 ms**	• Data logging, metering • SCADA apps polling small bits of data
3G	**42 Mbps**	**1–10 Mbps**	**100–250 ms**	• Small remote-site backup • Retail/POS/kiosk/lottery • SCADA apps that need higher bandwidth
4G	**2 Gbps**	**10–100 Mps**	**50–100 ms**	• Larger remote-site backup • Video surveillance/IP cameras • Interactive media • Digital signage • Transit Wi-Fi • Medical applications
5G	**20 Gbps**	**50–2,000 Mps**	**25–50 ms**	• Mass transit communications • Connected vehicle/autonomous vehicle • Industry 4.0 manufacturing automation • Video streaming services • AI and machine learning • Business, retail and branch networking

CONCLUSION

Today, applications that still deploy 2G and 3G devices must migrate to 4G or 5G solutions, which will support the extensive and growing number of IoT applications across all industries for many years to come. 4G LTE presents excellent speed and longevity benefits today. 5G networks are growing, and share the same bands as LTE, which means both 4G and 5G devices are an excellent investment. With careful planning, organizations and municipalities will be in a better position to capitalize on the signal strength, speed and greater capacity that LTE and 5G architectures provide.

ABOUT DIGI INTERNATIONAL

Digi International (NASDAQ: DGII) is the IoT and 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, an IoT device configuration and management platform 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 supports customers across the globe in planning, building, deploying and monitoring devices across the enterprise, industrial and transportation sectors. Contact us to start the conversation.

KEY TAKEAWAYS

- Those building or deploying 2G and 3G-based applications must migrate to 4G or 5G devices ahead of network shutdowns.
- Network engineers and administrators can capitalize on the advantages of 4G, 5G, NB-IoT, LoRaWAN and LTE-M.
- LTE and 5G use more frequencies and bands, so it's important to work with a manufacturer that supports the LTE technology in your region.

Contact a Digi expert and get started today

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