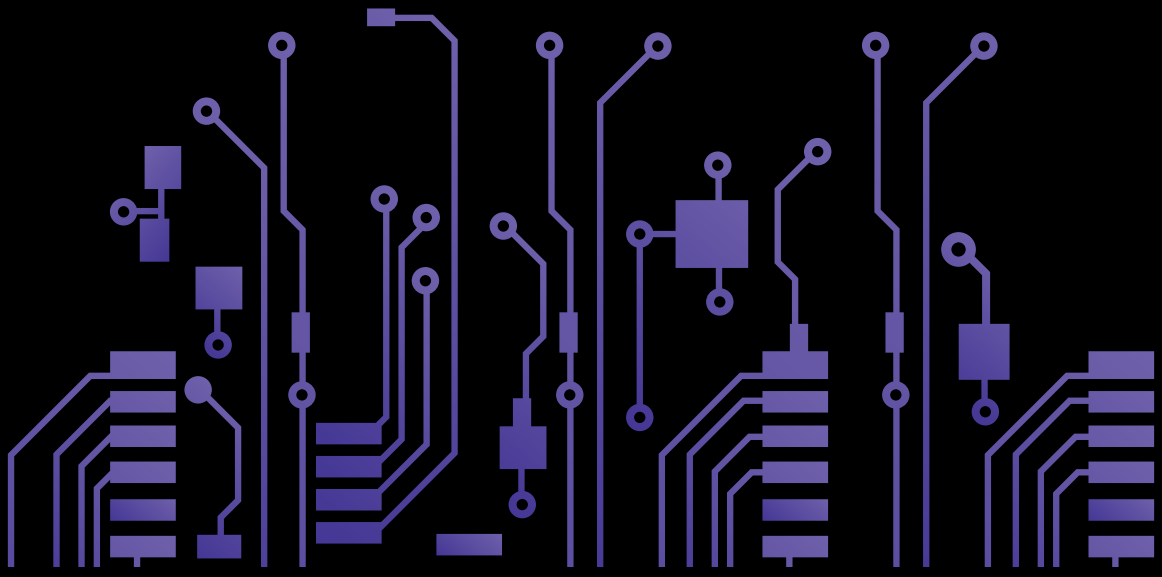
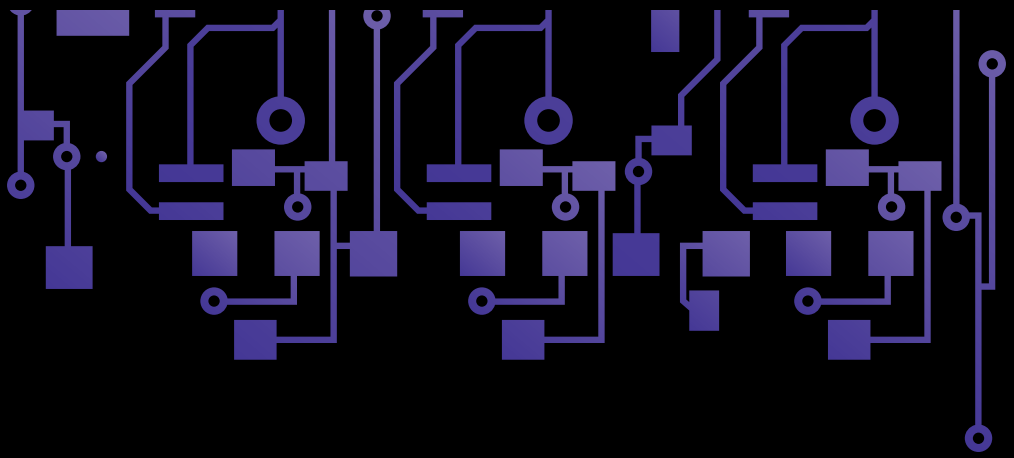


2G, 3G, 4G... OMG!
What G is Right for M2M?



Aeris
COMMUNICATIONS

Introduction

Every M2M deployment has four things in common:

1. M2M applications need long-range communications capability.
2. The data gathered by remote devices is sent to a system, person or other machine automatically.
3. Managers must be able to control and manage a device from far away.
4. It needs a network and services for long-range communication.

Over the years, connectivity has been accomplished with many technologies, beginning with phone lines and radio signals and later, satellite and cellular. The overwhelmingly logical choice for a wide-area network ("WAN") for M2M applications, particularly for mobile devices, is cellular wireless data services.

If you have chosen cellular for your M2M application, then the next step is to select the cellular radio and wireless data service that is right for your application. If you have turned on a television or opened a newspaper in the last few decades, you have been barraged with information about cellular network speeds for personal handsets. In general, if you have a smart phone and use your device for sending and receiving data, then we can all agree that more is better: the faster speeds and greater bandwidth provided by 4G LTE is the best choice. When considering M2M deployments, however, this does necessarily not apply.

The available cellular technology choices are confusing. You may have already asked questions like:

- Which cellular technology shoul I select?
- What are the 2G and 3G data speeds?
- All the operators are talking 4G LTE now – should I start using 4G LTE?
- If I pick a 2G or 3G technology, what is its longevity?

Unfortunately, there aren't any simple and easy answers, so let's dig in.

Which G is Right for M2M?

The answer is: It depends!

The choice depends on a number of factors. In the following pages, we will review these factors to help you make the best decision on the cellular technology to use for an M2M application deployment.

M2M vs. Traditional Consumer Cellular

Let's begin with a discussion of the differences between personal and M2M cellular devices and their deployments. These comparisons also illuminate some of the many differences between traditional, consumer cellular operators like AT&T, Verizon and Sprint, and an M2M service provider like Aeris, which was made for machines and only transports M2M data.

Devices

The cellular handset is simple – relatively speaking, of course! – compared to M2M devices. Most handsets fall into a few general categories: some are basic cellular phones for making voice calls and sending text messages, and some are smart phones for sending and receiving data – e-mail and web surfing – in addition to voice calls and text messages.

M2M devices, on the other hand, are usually very unique. With the exception of a few self-contained cellular modem products (for example, from MultiTech Systems), every M2M device is usually "designed from scratch" for a specific purpose.

An M2M device generally contains (depending on the specific application):

- A cellular radio, called a "Module".
- A processor that runs the program ("firmware") for the M2M application.
- Volatile and non-volatile memory for the firmware and data storage.
- Sensors and I/O, as needed, for the specific data gathering functionality.
- Analog-to-Digital and Digital-to-Analog converters, if required.
- Global Positioning System ("GPS") chips for determining location.
- Power conditioning circuits for noisy electrical environments.
- Cellular and GPS antenna and power connectors.
- Batteries, if required.

The size of M2M devices vary: some are as small as a handset, others may be comparable to a tiny notebook, or they can be larger than a laptop case. It is important to note that devices installed in mobile applications may require special construction for vibration and environmental issues. Boards and components are usually encased in material to avoid shock and vibration effects. The operating temperature ranges for normal operation may need to be wider than standard handsets, etc. depending on the environment of your application.

Cellular Applications

The uses of cellular service fall roughly into two categories: "traditional" and "varied."

Traditional

The major operators like AT&T and Verizon created their networks for traditional handset wireless data applications, like:

- Handsets for text messaging, e-mail, surfing the web and a few business applications.
- Laptops and notebooks with wireless data cards for the same purpose.

Unfortunately for companies that need cellular support for M2M, traditional operators often adapt consumer technologies and processes for more complex M2M applications. Their M2M service was not built from the ground up with needs of business and machines in mind.

Varied

M2M applications have a much broader and more complex set of uses, like:

- Tracking trucks on highways for location and dispatch.
- Sending driver logs to central locations.
- Checking cargo loads in trailers and reporting when they are loaded and ready for pickup.
- Reporting automobile theft and tracking them when stolen.
- Sending an Automatic Crash Notification ("ACN") when an air-bag deploys.
- Sending fire and burglar alarms for residences and businesses to monitoring stations.
- Transmitting blood pressure readings to a doctor's office.
- Reading an electric or gas or water meter remotely.
- Reporting a jammed irrigation system to send out repair technicians.
- Reporting failed heating and air-conditioning equipment in commercial buildings.

Usually, the data is sent from machines (M2M devices) to other machines (host systems, databases, etc.) without human intervention. In these M2M applications, the firmware is different – the program code, frequency of data transmissions, quantity of data, alarm conditions, information encoding methods, retry algorithms on failures, etc. are usually different in each device.

Network Coverage

Personal Handsets Don't Roam Much

Traditional operators have enabled their consumers to roam freely and make voice and data calls throughout their coverage areas, as well as in other carrier markets through roaming agreements. Yet, most handset users do not actually roam outside their home market often. For the vast majority of handset users, their phone registers in one market and stays registered in that market for long periods – days to weeks to months (perhaps never leaving it!). This allows traditional operators in the US to be remarkably successful, with deployments that cover markets sufficiently well for their customers to receive good coverage and good service.

M2M Devices May Move a Lot

Unlike consumer handsets, M2M devices may move from market to market quite often. For example, a long-haul truck may drive through many markets in a single day, operating on dozens of switches, and, often on more than one or two operators. The trucks may need to send and receive data in areas where smaller cellular operators do not provide coverage, or where a small carrier may not have a roaming agreement. If the cellular technology used in that M2M device is not available in a particular market or region, then that truck is not able to send or receive data when in that area. It may need to buffer the data and wait until it is "in coverage" to send the information. If the time that the truck is outside coverage is long, then the purpose and timeliness of the M2M data may be lost.

M2M distribution/operation should be broad. An M2M network operator must ensure that data can be transmitted across a country or continent and even in remote areas. Most traditional, consumer handset operators cannot guarantee such coverage. For example, consider a deployment within a major city, such as a towing company dispatch system. They can use 4G cellular technology if it is available (and needed for their application). A long-haul trucking company, however, simply cannot use 4G service today because it is not available in many of the markets or highways in which their trucks operate.

Longevity

Handsets are "turned over" frequently. The traditional consumer cellular industry has created an expectation that customers will replace their cellular handsets every couple years. This rapid turn-over fuels the rapid development of new technologies and new handsets. Operators and customers sign service contracts (for example, when subsidizing the cost of the handset) for two years typically. Thus, if a carrier wants to discontinue a technology and service, it is possible for them to transition their handset users in a relatively short time. Customers can buy new devices easily and begin using them immediately. Generally within one or two "cycles" of contracted service, most customers can transition to the new technology and any remaining customers can be offered further incentives to switch.

For a number of technical and business reasons, M2M devices have much longer lives than consumer handsets:

- The devices are often not "user-replaceable" and cannot be carried in to a store and changed out.
- The device may be embedded inside other machinery, thereby requiring a "service call" where a trained technician replaces the unit.
- The device cost is not subsidized by cellular operators, so they must remain in service for costs (device, installation, operation, etc.) to be recovered and the application benefits to continue.
- Many devices are owned by a single customer and it is often cost-prohibitive for them to replace all their units at once.

In this section, I described the many important differences between traditional and M2M cellular deployments. I did so in an effort to demonstrate why companies should put away their pre-conceived notions about network speeds and consider the optimal network characteristics for their M2M deployment for today and a decade from today. Let us now turn our attention to the "G's."

Picking the Right G

2G

With all the rapid advancements in network speed and throughput, you may be asking yourself why anyone would consider a 2G deployment for M2M today. We have all heard about AT&T's announced 2G GSM/GPRS sunset (including 2G GSM/EDGE) at the end of December 2016. And, in North America, the spectrum of other 2G GSM carrier networks are being re-farmed over the next few years in order to add 3G UMTS/HSPA and 4G LTE bandwidth.

The 2G GSM technologies (using Time Domain Multiple Access – "TDMA" protocols) are not as spectrum efficient as the newer 3G (using Wide-Band CDMA – "W-CDMA") and 4G LTE (using Orthogonal Frequency Domain Multiple Access – "OFDMA") technologies. In other words, for the same amount of bandwidth in a wireless spectrum, these 2G transports cannot send as much data, or support as many simultaneous phone calls, or allow as much device management communication, etc. as the newer technologies. In particular, the 2G GSM data technologies – GPRS and EDGE – use "TDMA" coding protocols that are not as spectrum-efficient as CDMA.

Furthermore, since the new 3G/4G technologies for operators who provide 2G GSM/GPRS are entirely different coding protocols – specifically W-CDMA and OFDMA – that spectrum cannot be shared. By design, W-CDMA and LTE devices (including UMTS handsets and HSPA data devices) can operate in GPRS mode in markets where only 2G GSM is

available, but the converse is not true – 2G GSM/GPRS devices cannot operate in 3G or 4G mode in the spectrum used for those new technologies.

However, 2G CDMA networks (and 1xRTT data transport) will be available for many years. Indeed, the cost of 2G CDMA is less than migrating from 2G GSM/GPRS applications to 3G UMTS/HSPA – thus, converting to 2G CDMA for many M2M applications is the best approach. There is less pressure to convert 2G CDMA devices because, from the start, they were more spectrum efficient than GPRS and EDGE from the start. The operators that deployed CDMA like Aeris, also deployed upgrades that have made the service viable for years to come, and on which CDMA devices can co-exist more readily.

Regardless, the traditional 2G operators in North America are pushing their M2M customers hard to upgrade. Most M2M devices, however, can still use 2G technologies very effectively because M2M transmissions generally require very few bytes. Therefore, if you have a 2G CDMA deployment that is low-usage, it can run on the Aeris network and there is no reason to spend the money on upgrades for equipment and higher network costs.

However, if you have already deployed 2G GSM/GPRS applications, the problem is very significant. It is likely that 2G GSM/GPRS service will be impacted soon as spectrum is re-farmed, and converted to 3G and 4G, particularly in the dense urban areas where the business need for 3G/4G service is greatest.

Traditional operators have stopped certifying and allowing any new M2M applications that use GPRS-only radio modules in an effort to avoid more devices on the network that will require replacement when the 2G GSM/GPRS technologies are removed. And, for most customers, they have also stopped provisioning new devices – even for certified 2G GSM/GPRS applications.

Summary: 2G CDMA

Regardless of the lowest-cost module availability, 2G GSM/GPRS service availability has no real longevity and this is a killer issue – it makes no sense to develop and deploy a new 2G GPRS M2M application in North America. Thus, the rest of this section only covers 2G CDMA.

- Low-cost CDMA (1xRTT) radio modules are available today and prices continue to drop.
- There are multiple suppliers of 2G CDMA radio modules. Thus, 2G CDMA is a cost effective solution for most M2M applications.
- Excellent 2G CDMA data services are available just about everywhere that cellular services are available, although service may degrade in Canadian markets sooner than US markets.
- And perhaps most importantly, the typical 50 to 100 Kbits/sec data rate is more than sufficient for most M2M applications. Why spend so much for technology that your application will never need?

3G

3G networks increase both the download and upload performance for IP data. When 3G became available but it had little impact on most M2M applications because they rarely needed – or could make effective use of – the higher performance that these technologies provided. However, if you are now planning an M2M deployment that will be deployed for 5 to 8 years, you should consider 3G. Both the equipment and network connectivity are more expensive than 2G, but if you can anticipate that your M2M application will evolve significantly, you can prepare yourself for the growing demands for M2M data collecting and management.

It is important to note that the 3G HSPA coverage has not grown significantly in the past few years – the capital and effort for the operators deploying this technology has been diverted to their 4G LTE expansion. Thus, it is important to ascertain whether the coverage – particularly for a non-mobile, fixed-location, M2M application – is available.

On the other hand, 3G CDMA EV-DO coverage is excellent – essentially equal to the 2G CDMA coverage footprint today. Of course, this may change in the future after 4G LTE becomes more common.

Since the 3G Module prices are higher than 2G CDMA Module costs, selecting either 3G EV-DO or 3G HSPA will be more expensive than a 2G CDMA application today.

Summary: 3G

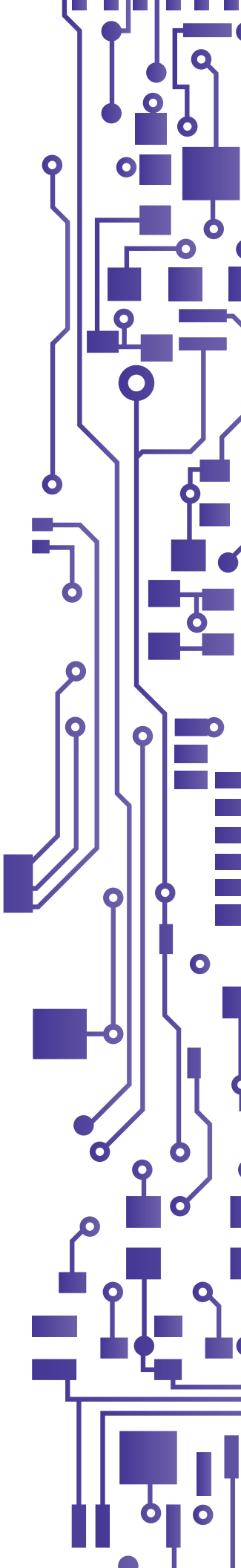
- Faster speeds than 2G (although, in many cases, faster than most M2M applications require).
- More expensive devices, equipment and connectivity than 2G.
- Speeds are typically 1 to 3 Mbits/sec; this is more than sufficient for almost every M2M Application. 3G HSPA and HSPA+ data rates are higher than 3G EV-DO Rev. A data rates.
- Excellent coverage for 3G CDMA EV-DO Rev. A. Services are available from a number of operators just about everywhere that cellular services are available.
- Coverage for 3G HSPA and HSPA+ is much less than 2G GSM/GPRS, 2G CDMA and 3G CDMA and further expansion is not expected.

4G LTE

LTE is an "All IP" technology. The bits and bytes are transported using IP data packets and control messages are also modified to fully use IP. The deployment of the 4G LTE network infrastructure is simpler and less expensive than older cellular technologies, allowing for more rapid deployment of service. However, since 4G LTE technologies use new OFDMA protocols, today's handsets and radios must be multi-mode. CDMA operators (Verizon, Sprint, Aeris, etc.) therefore provide radios that work in 4G mode when in LTE coverage, and in CDMA mode when not in LTE coverage.

For GSM operators (AT&T, etc.), this means providing radios that work in LTE mode when in LTE coverage, and in UMTS mode (and HSPA and HSPA+ data) when not in LTE coverage. Since UMTS is not deployed everywhere, these radios also use 2G GSM/GPRS and EDGE if it is available. It is not surprising that these radios are expensive to produce today.

Dual-mode M2M Modules cannot operate in all technology modes simultaneously. Thus, companies must enhance network infrastructure to allow a radio to change modes easily. This is particularly important



for highly mobile M2M devices (used in a fleet management application for example) that need to handoff between technologies while in the middle of a critical IP data session.
The increased complexity of the protocols requires higher performance processors in the radios. Thus, 4G cellular chipsets are necessarily much larger. This means a higher cost for the radio – the relationship between increased chip size and increased cost is well-known. In most cases today, this makes large-scale M2M deployments using 4G technologies difficult.

LTE Spectrum

Cellular operators are deploying LTE at different frequency bands because of the allocations of spectrum they acquired. For example, Verizon and AT&T are deploying LTE at 700MHz (different bands though!) and Sprint is deploying LTE at 1.9GHz. Clearwire intends to deploy LTE at 2.5GHz. Other operators are deploying LTE at yet different frequencies; for example, MetroPCS used 1.7GHz / 2.1GHz for their LTE deployments.

This use of differing bands is important for companies currently considering LTE deployments. For example, AT&T is also deploying LTE at 1.7GHz/2.1GHz, and will eventually convert much of their current 850MHz and 1900MHz GSM bands to LTE. In the future, Verizon is likely to convert their 800MHz and 1.9GHz CDMA deployments to LTE. Sprint intends to deploy LTE at their 800MHz Nextel frequencies and some unused 1.9GHz blocks.

Thus, unless an LTE radio can be used at more than one of these LTE bands and blocks – particularly for the spectrum in the US – it is likely that LTE roaming will be difficult to impossible for many years. This means that the market is not yet ready for LTE M2M deployments and if your application requires roaming, then LTE is not an option for you yet.

Summary: 4G LTE

LTE is an excellent choice for longevity of service; however, due to current unavailability of low-cost modules, and the potential for roaming problems without many multi-band Modules, this is not a good choice for most M2M applications.

- 4G offers the highest data rates available for the foreseeable future (at least until LTE Advanced becomes available!).
- The need for dual-mode radios drives high LTE hardware prices.
- Due to frequency spectrum differences, roaming among operators is likely to be poor for a long while and modules cannot be “moved” to another provider.
- Coverage is in major cities only, and insufficient for many M2M applications today. This will change in time as all operators will deploy LTE.
- Speeds are typically between 3 to 10 Mbits/sec - this is more than sufficient for almost all M2M applications.

Overall Summary

To summarize, for planning a new M2M deployment today:

- Do not deploy a new 2G GSM/GPRS application unless you are prepared to deal with the removal of this service within a few years.
- Select 2G CDMA if the data rate is sufficient for your application requirement – this is the best choice today for most M2M applications.
- Select 3G if higher data rates are required and your application will be deployed for 5 to 8 years – this is the next-best choice after 2G CDMA.
- Select 4G if the above 2G and 3G technologies do not have sufficient data rates, and if the

limited coverage and high module costs are not a concern.

- Select LTE if the highest data rates are absolutely required, and the current limited coverage and very high module costs are not a concern. Be prepared to deal with the roaming limitations due to spectrum differences.

Contact Aeris at info@aeris.net or 1-888-GOAERIS for more information.

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