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IoT Product Roadmap Considerations in the 5G Era

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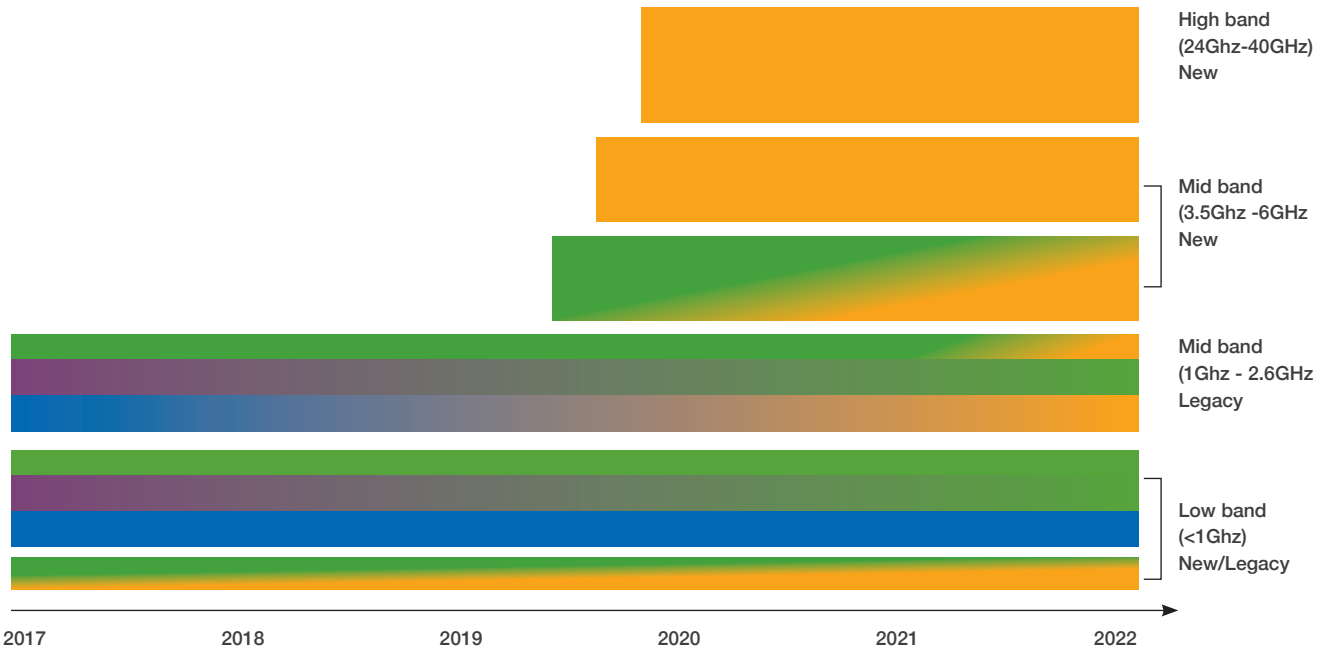
The Internet of Things (IoT) is a phrase that entered the technical lexicon in the early 2000s. One definition offered by Cisco Systems states that the Internet of Things came into existence when the number of connected devices on the internet exceeded the number of people using the internet.[1] The term IoT is used to represent a range of products and solutions that rely on internet connectivity across a vast spectrum of mediums and networks. To narrow the conversation, we will specifically address how IoT is implemented in North America on wireless cellular networks, like 4G LTE Cat M1, and how it will evolve into 5G implementations. 5G network service is becoming available in limited areas of major markets across the United States.[2]

The 5G networks being deployed today are primarily of the 5G NSA (Non-StandAlone) variant, as opposed to the 5G SA (StandAlone). 5G NSA deployments are using 5G software and protocols on legacy 4G LTE hardware and some of the new spectrum in the 3-6 GHz range. These implementations are sometimes described as 5G LTE. The 5G SA on NR (New Radio) hardware in bands above 6 GHz requires substantial investment and deployment of densely placed cell sites to achieve mobile access. For the immediate future, this type of deployment will most likely be limited to densely populated metropolitan areas or fixed-base, point-to-point applications. The large customer base of 4G handsets, and the expectation that a phone should work anywhere, dictates that 5G NSA deployments will remain the norm into at least 2021 and beyond (FIGURE 1), especially in areas with extensive suburban populations.

FIGURE 1[3]



It is estimated there are already more than 25 billion devices connected to some IoT network and that number will grow to over 75 billion by 2025[4]. Many of these new IoT devices will be 5G capable. All major network operators have published intentions to support narrowband IoT devices on their 5G networks and provide a path forward from their 4G narrowband offerings. The intention to support 5G IoT is understandable, given the substantial number of 4G LTE Cat M1 devices, as well as NB-IoT and others. However, where 4G IoT is widely supported in hardware and software, 5G offerings are far more limited. 5G IoT hardware is divided into 5G LTE M, 5G NB-IoT and 5G NR standards. The standards are being developed by the 3GPP Technical Specifications Group[5]. The next step in the GPPP standards release will be 5G NR R15, commonly known as "Release 15." This iteration of the standard contains specifications to address narrowband IoT hardware implementations. It is expected the standard will be released in late 2019, though there is no objective date being offered.

When the penetration of 5G networks reaches large enough markets where the advanced use cases reach economically feasible scales, then the applications that require super high bandwidth may begin to appear.

For a hardware team designing a new IoT device, it is safe to assume that a narrowband 4G device will not become obsolete or fall prey to 4G networks being turned off and replaced by 5G SA NR networks anytime soon. People keep their smartphones for increasing lengths of time, so it should be at least three years before the 1.5 billion 4G smartphones sold in the last 12 months get upgraded in appreciable numbers.[6,7] This is in addition to the billions of narrowband 4G IoT devices that are currently deployed.

Other considerations that might drive a decision to go with a 4G or 5G solution are the cost sensitivity of the application and the data bandwidth required. While a 4G implementation is low risk from an obsolescence standpoint, there may be use cases that would drive a design to a 5G solution. For several years to come, signal availability indoors will remain a limiting factor for 5G implementations. The denser antenna coverage required with 5G, including potentially installing antennas indoors, will delay the availability of seamless coverage similar to what we see with 4G. Despite potential delays, 5G is coming; we will look at some specific 5G IoT standards and use cases in the next segment.

5G IoT Solutions and Use Cases

The promise and possibilities of a fully connected digital world are quite compelling. The revolution of the internet has brought many changes that were inconceivable until the technology matured. No one predicted the rise of social media and the profound changes ushered in as a result. As has always been the case, technology advances far faster than society as a whole can absorb and adapt. While it may be tempting to rub the crystal ball and predict the possibilities, we will focus instead on some of the low hanging fruit and incremental improvements.

5G LTE M and NB IoT on Low Power Wide Area (LPWA) are already baked into the roadmap of standards being developed by the GPP and ITU 2020. GSMA has divided 24 use cases into four major application areas that cover the vast majority of what is already in use, being developed, or coming soon.[8] While these groups are by no means exhaustive of all possibilities, they provide some helpful categories and insights into which resources might be necessary to accomplish the task.

Application Group 1 includes intermittent or periodic type data transmission commonly used in location tracking or other telemetry scenarios. This might be high-value

asset tracking, biometric data for a healthcare setting, or episodic events, such as geo-fencing or industrial process endpoint controls. This data transmission is bi-directional and requires relatively high bandwidth and some level of location tracking. There may be a robust security requirement, as personal data or valuable infrastructure, could be at risk.

Application Group 2 includes cases that might require near real-time monitoring. These could include process controls, agricultural livestock monitoring, and near real-time environmental monitoring. These cases could also require relatively high bidirectional bandwidth as may be needed for firmware updates or single-frame images.

Some assets in this category might be mobile over some fixed range.

Application Group 3 covers extended ranges for stationary cases and also deep indoor coverage. This could be smart home or building controls and environmental sensor data collection. These would be bidirectional to allow for actuator activation or firmware updates.

Application Group 4 would be for stationary main-powered devices like smart city infrastructure, home appliances, vending machines, or other kiosk-type services.

It may not be obvious how Groups may be similar or differentiated, so let's take a look at the Groups in terms of a requirements matrix:

REQUIREMENT		GROUP 1	GROUP 2	GROUP 3	GROUP 4
Mobile	Small Area		X		
	Wide Area	X		X	
Location Tracking		X			
Stationary				X	X
Battery	Days		X		
	Weeks	X			
	Years			X	
Mains power					X
Data Load	High BW				X
	Med BW		X		
	Low BW	X		X	
Bi-directional		X	X	X	X
Latency	<50 ms		X	X	X
	>50 ms	X			
High Power				X	

The requirements matrix quickly reveals the number of permutations over many use cases quickly becomes exponentially larger with even a basic set of features.

Device security is an additional consideration when choosing a connectivity solution. No connectivity type is totally secure on its own, but some do offer more protection than others. 5G is not inherently more or less secure than current 4G LTE connections, but the sheer number of devices and types of applications may increase risk. For example, when 5G enables autonomous vehicles, the risk of a cyber attack is much higher than the risk to a connected home appliance. Regardless of connectivity type, product development teams need to use appropriate risk management planning and a combination of hardware- and software-based solutions in combination.

When developing a roadmap for a product that is not dependent on 5G connectivity but could offer enhanced performance with 5G in the future, flexible and adaptable product designs are key to long-term success. Designing an upgradeability path into your design, such as by using circuits compatible with higher 5G frequencies in a 4G device, reduces the amount of re-design required in future upgrades and increases agility. Layer on a hybrid product connectivity strategy in markets where falling behind the competition is likely to be permanent, or to avoid multiple versions of the same product for different geographic markets. 5G will evolve dynamically, and no one can predict exactly when or in what ways; these types of strategies serve as an insurance policy against tech failure.

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Example Use Cases

One of the most interesting and compelling areas may be the virtual reality and augmented reality applications. Virtual reality headsets and games are growing in popularity. Still, they require data sets and computational power that are not feasible to a mobile user. The bandwidth required between the base station and headset is far higher than could be supported in a multi-user mobile environment. Most people are familiar with using a YouTube video to quickly learn how to solve a problem or fix a gadget, but imagine watching a YouTube video with an augmented reality headset. This is already happening in critical aerospace applications, where there is zero-tolerance for mistakes and lives depend on the outcome.

Where does the virtual and augmented reality use case fit on the requirements matrix? To be truly mobile, it needs to be wide-area. Battery life can be one day or less, but the power requirements are significant. Most importantly, the data load will be massive, and to accommodate adjustment with a user's movement, bi-directional latency must be <50ms. This is a textbook example of a 5G application, and the next level 5G SA NR networks are on track to provide these types of services.

Health care availability and delivery could come full-circle to where doctors are making house calls again, albeit virtual house calls. The savings in productivity to both doctor and patient could bring substantial cost reductions and better outcomes due to less wait time and more timely access. These types of scenarios are already being played out in hospitals where mobile kiosks allow doctors to make their rounds as a virtual presence with bidirectional HD video.

Where would virtual medicine fall on the requirement matrix? Currently, telemedicine is delivered using remote kiosks that require large bandwidth over Wi-Fi or other networks, and are not practical outside of a fixed base setting. For a mobile solution, data load would be high to accommodate medical imaging, and power requirements would be high. Again, this is a quintessential 5G use case. As 5G NR becomes more widely available, doctors and specialists from anywhere in the world could be consulted in the home within minutes or hours instead of days or weeks.

How Benchmark Can Help

Benchmark delivers our customers future-proof products quickly and affordably by combining their ideas with Benchmark's technology platforms, engineering expertise, and advanced manufacturing capabilities. Whether a customer has an idea they need to be brought to realization or a prototype to be optimized for manufacturing, we design, engineer, and build their custom connected device. We also work with customers to take their existing product and refresh it to take advantage of the latest technologies, such as 5G.

Becoming 5G ready starts now. If you're reacting to the technological landscape in five years when the technology that has matured, you'll be too late. Benchmark engineers work with companies to evaluate their connected device product roadmaps, identify optimal connectivity solutions and create antenna and circuit designs that are flexible enough to work with ever-evolving connectivity types. We also help companies future-proof their designs using 5G-compatible circuitry to speed the transition to 5G connectivity later, making their newest products more competitive in the market.

Benchmark is pioneering 5G communication solutions with expertise in millimeter wave RF design and high speed circuits, as well as 5G connected device architecture. Benchmark's 5G design and test services are tailored to meet the needs of complex and highly regulated markets including, aerospace and defense, telco, compute medical, and industrial. Benchmark's expertise in technologies critical to 5G, including millimeter wave, photonics, free space optics, microwave arrays, heats sinks, and lightweight components for satellites, allow for a broad understanding of the ecosystem as a whole, leading to future-proof designs. Whether you're building applications for Industry 4.0, IoT, autonomous driving, or smart cities, Benchmark has the expertise and tools to enable your 5G innovations.

To learn more about how Benchmark's engineering and manufacturing capabilities can help you get prepared for the 5G future, please visit wwww.bench.com.

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