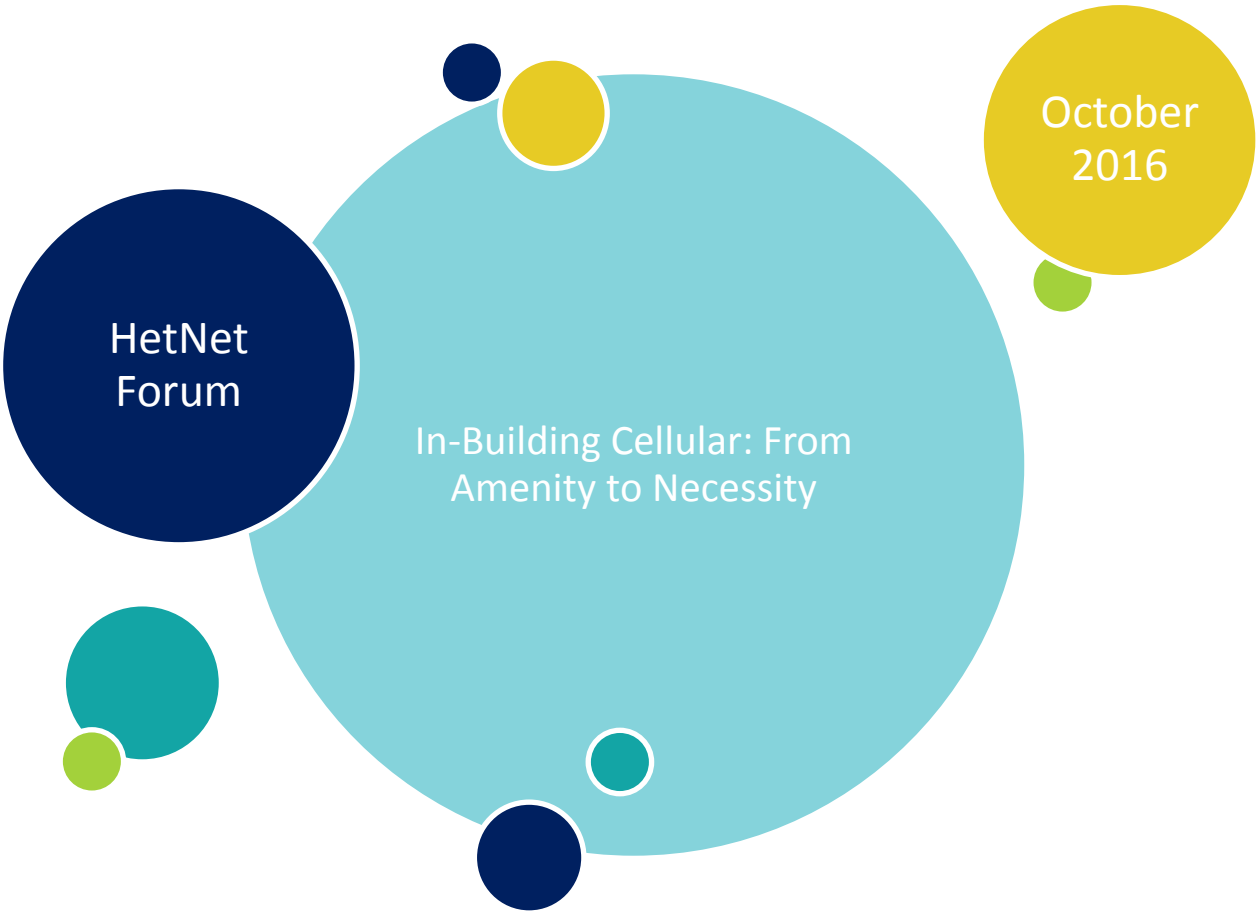
HetNetForum



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* The HetNet Forum is dedicated to the advancement of heterogeneous networks. HetNets provide increased network coverage, capacity and quality through the use of a variety of infrastructure and technology, enabling seamless voice and data communications. The HetNet Forum is a membership section of The Wireless Infrastructure Association. For more information, please visit www:hetnetforum.com

Executive Summary

Consumers know when problems with their cellular service occur. Experiences can include an inability to make a voice call or access a Web site, or maybe the problem is an application that takes slightly too long to load. Usually the first inclination is to assume the service provider is at fault, but if the problems keep occurring, consumers may start to wonder if it is their device or their location that is the root of the problem. Often, consumers will ask others if they are experiencing the same issues to validate their findings.

Given that a great deal of cellular voice and data usage happens inside buildings, it is entirely likely that poor cellular service occurs while indoors because the building itself can impede the cellular signal.

In a recent survey of U.S. businesses, research firm *iG*R found that about 7.4 percent of respondents said that their in-building service was weak, poor or terrible – voice and data alike. And, in a May 2016 survey of U.S. consumers, *iG*R found that approximately 5 percent of the respondents stated their homes had "poor" or "very poor" cellular voice and data coverage. While figures for both the enterprise and consumer percentages are in the single-digit percentages, that translates into millions of U.S. consumers who consistently describe their cellular service as poor or worse.

Those in the market for a new commercial office building or a new home may not think to check their mobile phone for coverage when they are caught up in the headiness of a walkthrough, but when they use their mobile phone and find the signal is poor or unusable, then "poor cellular service" may add to the sensation of buyer's remorse. Increasingly cellular coverage, while not yet a qualifier for the choice of a building or home, is becoming a disqualifier.

As the world marches ever closer to ubiquitous wireless (Wi-Fi and cellular), coverage, people expect nearly perfect voice and data access wherever they are, regardless of whether that expectation is reasonable. In short, people expect connectivity in the basement of a commercial building as well as on the 15th floor of a high-rise apartment.

Adding "excellent cellular service" to the list of a building's attractions draws attention to the unconscious expectation of "service everywhere" and can mean the difference in a venue's vacancy rate.

It is time to add mobility to your checklist.

Wireless Deconstructed

With the world moving wireless, it is easy to lose track of the details in the sea of jargon, abbreviations, clever catch phrases and marketing spin. The word "wireless" refers to two large areas: cellular and Wi-Fi.

What is Cellular?

Cellular networks – also called mobile networks – are wireless wide area networks (WWANs). These are the networks created by cell sites, also called macrocellular towers. The equipment enclosed at those sites generates the cellular radio-frequency (RF) signals that propagate for miles.

Cellular carriers, (also called mobile operators or wireless service providers) lease RF spectrum from the federal government under agreements that let them use certain blocks of spectrum for a number of years. The Federal Communications Commission (FCC) manages the spectrum, arranges the auctions, and establishes the rules for how wireless and wired networks, carriers and equipment vendors operate, interact and provide service in the United States.

Cellular carriers each lease their own blocks of spectrum that no one else can use – so, the RF spectrum they use is both licensed spectrum and exclusive to that carrier.

Cellular technology is always improving; thus several generations exist today – 2G, 3G, 3.5G and 4G, which is also called LTE technology. LTE is the newest and predominantly is used today for mobile data, but older technologies are still used to make cellular voice calls.

AT&T, Verizon Wireless, Sprint and T-Mobile USA also have begun talking about tests and trials of the next generation of cellular voice and data, which is called 5G. Plans call for it to be better and faster than LTE service, but 5G will not be available for several years to come.

With respect to cellular voice and data, however, "better and faster" does not equate to the best signal strength everywhere. Even on today's wireless networks, five bars of signal strength – the highest – does not guarantee the best coverage or the fastest speeds. Any number of factors could conspire to promise one thing, but the consumer experiences a less-than-excellent experience. For example, two different phones using the same carrier could show different signal strengths in the same location; or the service might not work well because other network issues are occurring, even while signal strength is robust.

What is Wi-Fi?

The term Wi-Fi is actually a marketing term developed as a branding tool by the Wi-Fi Alliance. In contrast to cellular, Wi-Fi is a wireless local area network (WLAN) also called 802.11. For Wi-Fi, "local" means that the signal only carries about 300 feet. There are several versions of Wi-Fi, denoted by the letter suffix: 802.11a, .11b, .11g, .11n, .11ac. The newest and fastest is 802.11ac, but it is also the least deployed, particularly in residences. Some enterprises have begun upgrading to .11ac as part of their normal upgrade cycle.

Given that it is wireless, Wi-Fi also uses RF spectrum – the unlicensed 2.4 GHz and 5 GHz bands. Unlicensed means that anyone can use the spectrum, which also means that it is shared spectrum.

With shared, unlicensed spectrum, interference among multiple networks can be a problem since all of the networks in the same area are all using the same spectrum bands (2.4 GHz and/or 5 GHz) even if the Wi-Fi networks' names are all different, they are still using the same RF spectrum. While each individual Wi-Fi network probably operates in different radio channels, this only reduces interference; it does not eliminate it.

Wi-Fi also has no built-in Quality of Service (QoS) capability, but that can be added by a router – and usually is in an enterprise setting. Wi-Fi networks at companies tend to be highly engineered and are managed by IT managers. Wi-Fi used in homes rarely enjoy the same level of care.

What Devices Are Used?

Smartphones are commonplace, both at home and at work. *iG*R's May 2016 survey of U.S. consumers found that 98 percent of respondents used a smartphone. Note, too, that the split between Android and iOS operating systems is nearly equal.

With respect to cellular and Wi-Fi, consider the following:

- All smartphones have Wi-Fi and cellular data connectivity. Wi-Fi is backwards compatible from the most common versions (802.11g and 11n) to the first, and oldest, version (11b). Virtually all smartphones sold today in the United States support LTE technology as virtually all of the U.S. cellular operators have deployed LTE service.
- In a recent survey of medium and large businesses, *iG*R found that 37 percent of respondents said that their smartphone was indispensable to their work; another 25 percent said it would be hard to work without it.
- Laptops are more common than desktop computers.
- Tablets are prevalent as well, but their market-share growth has slowed particularly because of large-screen smartphones.

Wi-Fi is not only the predominant way consumers connect their various devices, but it is the primary way many employees connect their devices.

In the enterprise, the IT department handles Wi-Fi and wired Ethernet network design, installation and maintenance. The IT department also issues the security and usage guidelines and policies associated with those networks. Often, employees are required to use a virtual private network (VPN) when connecting to corporate databases.

Smartphones automatically switch to Wi-Fi once the network has been learned and the security credentials are verified. However, savvy users sometimes turn off the Wi-Fi and use LTE service if the Wi-Fi network cannot scale to handle the number of users on the Wi-Fi network or the amount of content they are accessing.

Laptops typically do not have cellular data capability; the buyer has to pay more for both the required module/modem and the monthly service. For consumers, this service is usually a $10 per month add-on (though prices vary). Enterprises typically get different rates because they buy in bulk and are perceived as less prone to churn (switching to another operator). As a result, Wi-Fi is often the most-used network for laptops.

Tablet computers only use Wi-Fi, though a small percentage of tablets sold support embedded LTE data capability. Again, this means the tablet costs more and the user must pay a per-month add-on charge. Some tablets do support wired Ethernet connectivity through a third-party adapter/dongle.

People also can connect to the cellular network from laptops and tablets by way of a personal hotspot on a smartphone.

When Coverage and Capacity Limit In-Building Use

Clearly, cellular is used everywhere for business and personal communications. Wi-Fi is used for the same reasons as cellular, and in many of the same places as cellular, but the main restriction on its use is that Wi-Fi is a "local area" network. This means that the antennas have to be much closer to the devices – up on the ceiling rather than on a tall tower a mile away (as is the case with cellular).

In an enterprise setting, many companies block and/or filter the Internet connection used by their employees. Wi-Fi is subject to that control regardless of what device is being used – desktop, laptop, tablet or smartphone.

The trend toward eco-friendly buildings may impair cellular coverage because the low-emission glass used to reduce penetration of the sun's rays into the structure also deters cellular signals. Other building materials like concrete and steel also deflect the RF signal. In other cases, poor reception may happen because the cell tower is too far away.

Even if cellular coverage is robust, too many subscribers on the network simultaneously can lead to capacity issues, which may result in slow connectivity speeds or lack of connectivity. Cellular carriers continually invest in their networks to have them perform optimally, but as more people access more content via smartphones, carriers are under constant pressure to improve their networks.

Cellular carriers offer products called femtocells to address in-home voice coverage issues. A femtocell is basically a mini base station that connects to the cellular network using the Internet. When sold to or deployed in an enterprise, a femtocell is called a picocell. It is basically the same thing, except the picocell is built to handle more simultaneous voice calls. The generic term for picocell is enterprise small cell, just as a femtocell could also be called a residential small cell.

Other solutions exist to improve in-building voice and data services, such as:

- Distributed Antenna Systems: Think of a DAS as a macrocell lying on its side. Because they can be pricier to install and operate, they traditionally have been deployed in stadiums and other large buildings but are making their way into smaller buildings as prices decline and new solutions come to market.

- Cellular signal boosters: Consumers and businesses can buy cellular signal boosters for their homes and vehicles. These boosters are relatively simple – they take an existing signal from the outside, bring it into the building up to 30,000 square feet via cables, amplify the signal and then distribute that strong signal via an indoor antenna. Installation requires some effort, but they work across multiple spectrum bands, which means they work for all carriers. Many low-voltage contractors offer this solution.

Voice Over Wi-Fi

Another option to improve voice service is via Voice over Wi-Fi (VoWi-Fi). This solution has gained traction recently as a viable alternative to cellular coverage in some camps and as such, needs an in-depth analysis of the technology.

All major U.S. carriers offer it. With VoWi-Fi, all voice calls to and from the smartphones inside the home or building go over Wi-Fi instead of the carrier's licensed spectrum.

VoWi-Fi is a service provided by the carrier and, once turned on, the user really has no idea what network their voice calls go over. This sounds ideal – Wi-Fi and wired broadband are already in many U.S. homes and offices, as are smartphones.

In reality, VoWi-Fi does not fix problems with LTE coverage in a building, it just covers them up. The issue is that most enterprises are already involved in an "arms race" to keep up with the needed Wi-Fi capacity. Adding VoWiFi calling to the network and the problem can get worse.

Also consider that total Wi-Fi network capacity is limited by spectrum (2.4 GHz carries less total traffic than 5 GHz spectrum), by generation (802.11g carries less total traffic than 802.11n than 802.11ac) and by the size of the incoming/outgoing wired broadband pipe.

For example, if a home has a 15 Mbps downstream wired broadband connection, then that is the most any single Wi-Fi device attached to that network can get from the Internet. Divide that 15 Mbps by a couple of Netflix streams, a YouTube stream, some streaming music, light Web browsing across five Wi-Fi devices, and that 15 Mbps is gone faster than the "working" cursor spins – and this does not even include losses associated with overhead, interference, distance to cell edge, etc.

This example is illustrative of how even a seemingly "big enough" wired broadband connection can be consumed, especially in an office with heavy data users.

VoWi-Fi typically works well for residential applications because its own capacity demands are low – a Wi-Fi voice call does not require much more than 100 Kbps, good coverage and signal strength, as well as low latency. But, if all these are not within certain thresholds, then the VoWi-Fi call will not sound good.

Because Wi-Fi lacks a built-in Quality of Service (QoS) function, the traffic carried across it is best effort – meaning that there is no guarantee with respect to throughput or latency. An enterprise IT manager might know how to deal with QoS. With respect to VoWi-Fi, they could dedicate spectrum on the corporate Wi-Fi network (usually comprised of dozens of Wi-Fi access points) to achieve it. Dedicating spectrum means that a certain amount is removed from the pool and reserved for only a certain type of traffic. This limits both pure data capacity (Web, e-mail, etc.) and total VoWi-Fi traffic.

In addition, an enterprise's IT department (or the third-party to whom that IT function is outsourced) may need to add Wi-Fi access points (APs) to make sure coverage is even. They, or the third-party contractors doing their IT work, may need to further sub-divide the network to add new APs to bolster total capacity and coverage. It is also possible that the enterprise might need to increase the size of the wired data connection. Any of these options add both capital and/or operating costs.

Other problems with VoWi-Fi include:

- Not all smartphones are supported – mostly just the latest iPhones and Android devices. Given the extensive amount of carrier testing required for mobile OS updates, *iG*R believes it more likely that VoWi-Fi capability will grow organically as consumers upgrade their smartphones. It is less likely that the operators or device manufacturers will patch the capability into older devices.
- Users have to enable VoWi-Fi on the phone, it does not happen automatically. Users may not know how to enable VoWi-Fi – and they might not know it exists.
- Wired broadband and Wi-Fi are required. When the wired Internet goes down, or the power, the VoWi-Fi stops working.

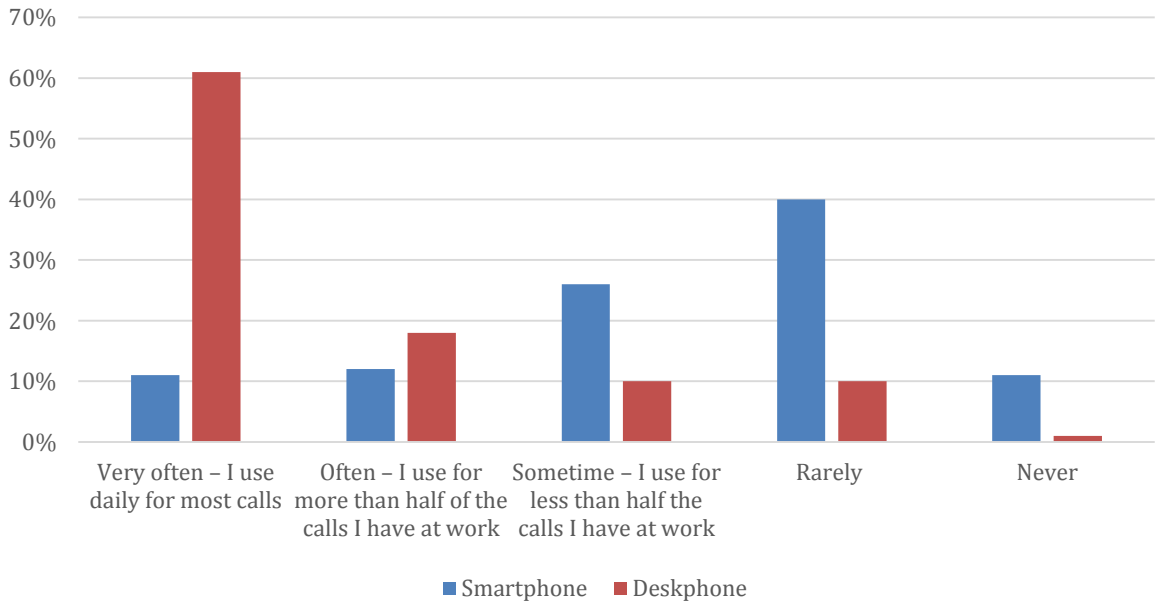
In short, VoWiFi is better than nothing, but not an enterprise-grade mobility strategy.

Cellular Coverage and Quality

As outlined earlier, a great deal of cellular voice/data usage happens inside buildings – not surprising since the average American spends nearly 9 hours per day on working and related activities (according to the Bureau of Labor Statistics, American Time Use Survey).

At home, U.S. consumers' use of data on smartphone typically occurs on Wi-Fi, not on cellular data (LTE). As with businesses, this is because smartphones (and tablets, laptops, etc.) automatically attach to remembered Wi-Fi networks.
In U.S. businesses, employees typically have a landline desk phone. That desk phone is still heavily used as the following chart shows.

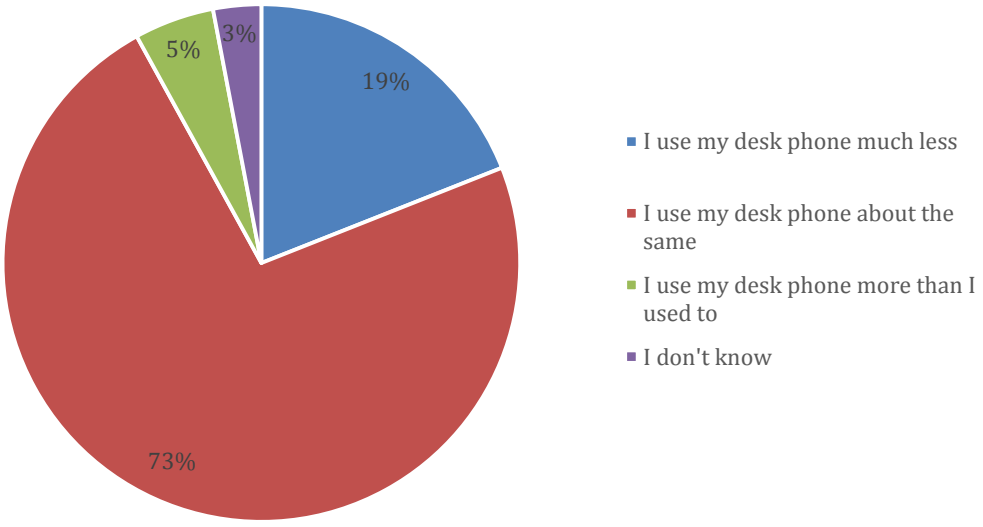
Figure 1: Current Frequency of Your Desk Phone & Smartphone Use



Source: *iG*R, 2016

There are various reasons why the desk phone is still used – convenience, easier to cradle the handset, does not have to be charged, reliability, quick dialing to colleagues, etc., as well as the fact there may not be robust cellular coverage inside the building. However, there are some indications that desk phone usage is changing – as the following chart shows:

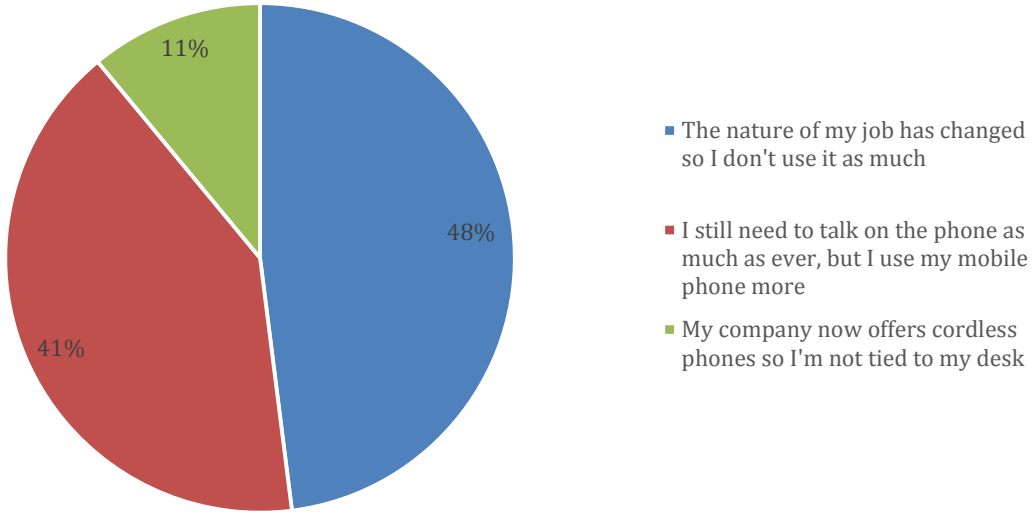
Figure 2: How Has Your Desk Phone Use Changed?



Source: *iGR*, 2016

The following chart provides a glimpse into why desk phone use is changing; 41 percent of respondents said it is because they use their mobile phones more.

Figure 3: Why is Your Desk Phone Use Changing?



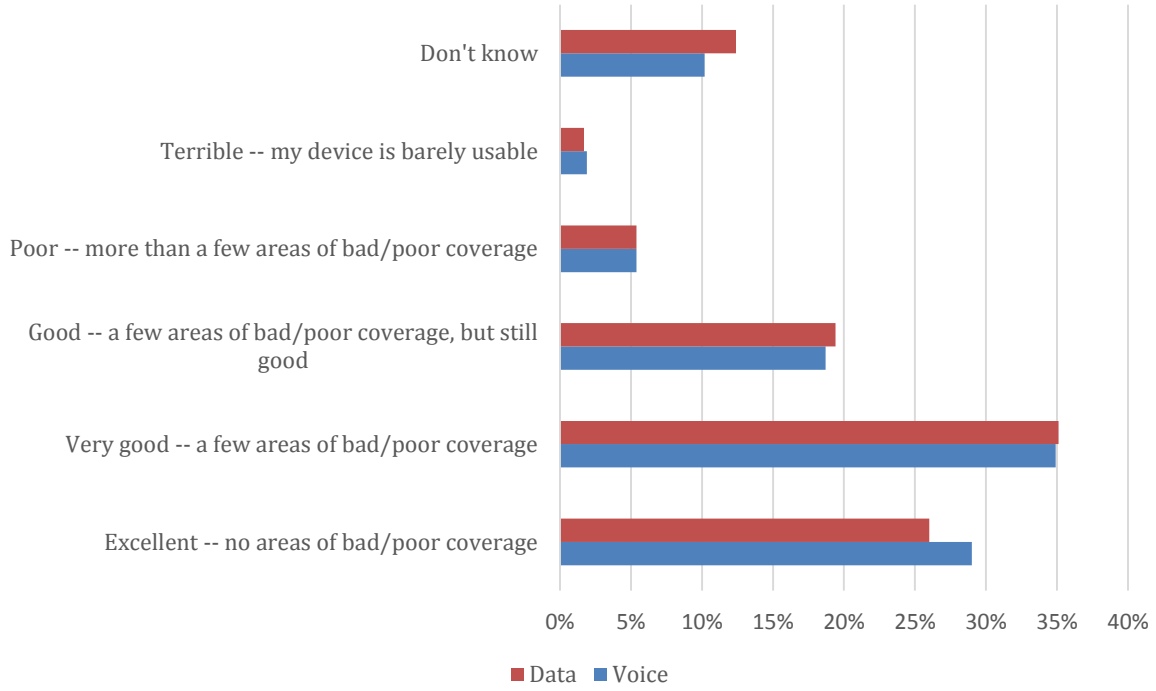
Source: *i*GR, 2016

Continued use of desk phones obviously does not preclude the simultaneous use of smartphones. Survey respondents said that they frequently use their devices for messaging (text, email, IM), voice calling and general data use (Web, etc.). So even if the smartphone is not being used for "most" calls, the device is still sitting there, probably charging, and being used off and on. With respect to communications, the respondents also indicated that they viewed texting and voice calls as equally important.

The following chart shows how the survey respondents rated their in-office cellular voice and data experience. The vast majority said their service was fine – no real issues. But, about 7.4 percent of respondents said that their in-building service was poor or terrible – voice and data alike.

This looks like a small number, but that is potentially as many as 11.2 million U.S. workers in perhaps as many buildings with poor or terrible cellular service. The only way to improve this service is via one (or more) of the solutions mentioned above: enterprise small cells, DAS or cellular signal boosters.

Figure 4: How Would You Describe Your Experience of Mobile Voice and Data In-Building?

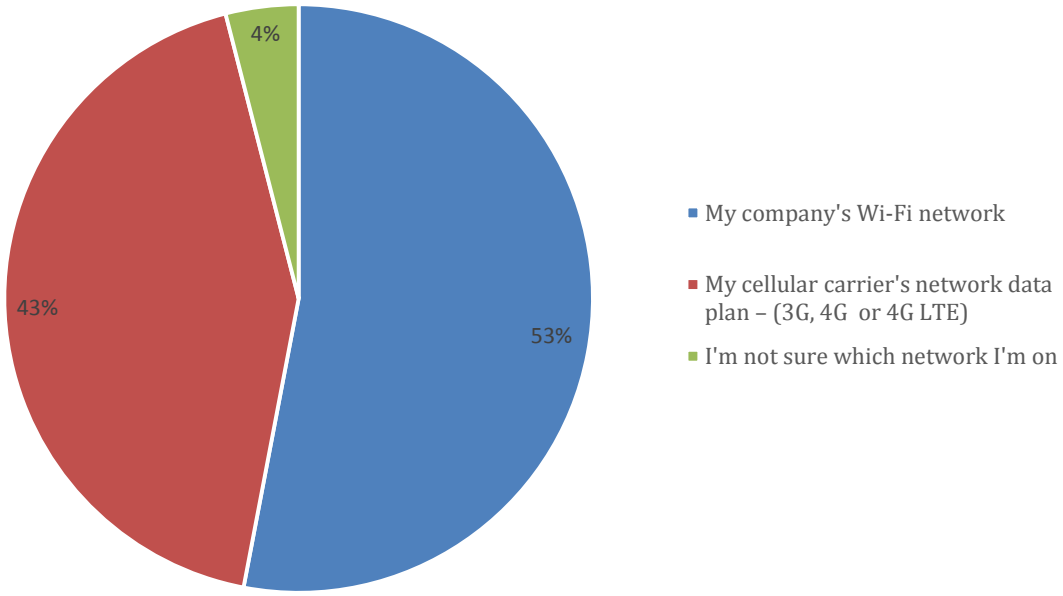


Source: *iG*R, 2016

It is important to note that the respondents were actually aware of which network(s) they use, as the following figure illustrates. The implication is that they'll also be able to tell which network is giving them problems.

Approximately 53 percent of the respondents said they typically use their company's Wi-Fi; 43 percent said they use cellular data. Only 4 percent said they did not know what network they typically use.

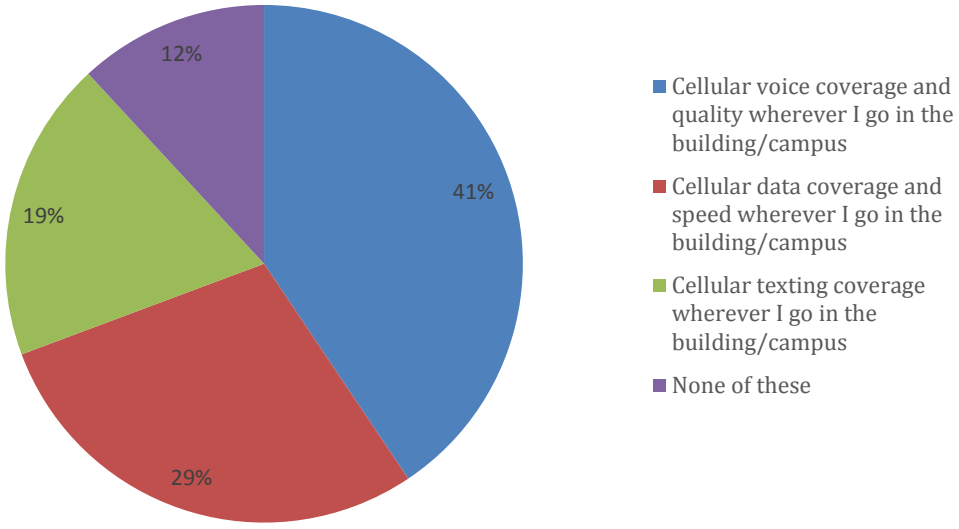
Figure 5: Data Network Used on Smartphone while at Work



Source: *iG*R, 2016

When given the choice of among three options (as shown in the following figure), 41 percent of respondents said that cellular voice coverage and quality was paramount wherever they are in their office building or campus.

Figure 6: What's Most Important?



Source: *iGR*, 2016

The Future Is Now

Most companies today have landline telephones, cellular and Wi-Fi. However, the trend is that people will be physically attaching devices to wires much less frequently. This means that cellular and Wi-Fi will be more prevalent, but neither work without two things:

- Sufficient coverage and capacity
- Adequate infrastructure to transport the data from the antenna to the Internet and back again.

Most buildings today have sufficient infrastructure – fiber connections – but can be lacking in cellular coverage. But where cellular voice coverage, at least, is most needed – inside buildings – is where operators are least likely to invest their capital dollars. Instead, operators are:

- Upgrading outdoor macrosites;
- Acquiring or leasing "small cell sites," which are multiple physical locations (lamp poles, building roofs and outside walls) where small cell transmitters are installed, and are required for the move to 5G;
- Buying new spectrum;

- Diversifying into new areas (content, other markets, etc.);
- Using third-parties to install in-building cellular systems.

The need for wireless connectivity is growing and robust cellular and Wi-Fi solutions are needed to handle network traffic. Consumers, workers and enterprise management know when their devices do not work as they should and, moreover, expect nearly perfect voice and data access wherever they are, regardless of whether that expectation is reasonable.

For example, getting robust cellular and Wi-Fi connections in basements, parking garages, elevators, top floors of buildings requires a lot of infrastructure and a great deal of effort. Ubiquitous cellular and Wi-Fi coverage also are needed to address public-safety concerns because 70% of 911 calls take place over the cellular network and 64% of calls made to 911 are indoors.

The end result is that enterprises today are more likely to prefer a building in which cellular/Wi-Fi access is as unconscious as the expectation behind it.

Making that happen can be complicated and expensive for the inexperienced. Finding trusted experts is a necessary step in that process, as is knowing where coverage and capacity is good, bad or indifferent. This requires measurements – site surveys – so that there is a baseline against which to measure improvement. That site survey needs to take every location into consideration from the offices and elevators, to the bathrooms and parking lots and garages.

But there is a return on the investment. Adding "excellent cellular service" to the list of a building's attractions draws attention to the unconscious expectation that this building is different and safer; that dollar for dollar, it provides a better value. Venue owners and managers should invest the time, money and effort to be able to make that statement.

It is time to add mobility to your checklist.

Methodology

*iG*R relied on the following sources when writing this white paper:

- *iG*R's primary surveys of U.S.-based businesses and consumers
- Discussions with mobile operators and vendors in the industry
- Secondary research.

Disclaimer

The opinions expressed in this white paper are those of *IGR* and do not reflect the opinions of the companies or organizations referenced in this paper. All research was conducted exclusively and independently by *i*GR.

About the HetNet Forum and the Wireless Infrastructure Association

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About *iG*R

*iG*R is a market strategy consultancy focused on the wireless and mobile communications industry. Founded by Iain Gillott, one of the wireless industry's leading analysts, we research and analyze the impact new wireless and mobile technologies will have on the industry, on vendors' competitive positioning, and on our clients' strategic business plans.

A more complete profile of the company can be found at http://www.iGR-inc.com/.