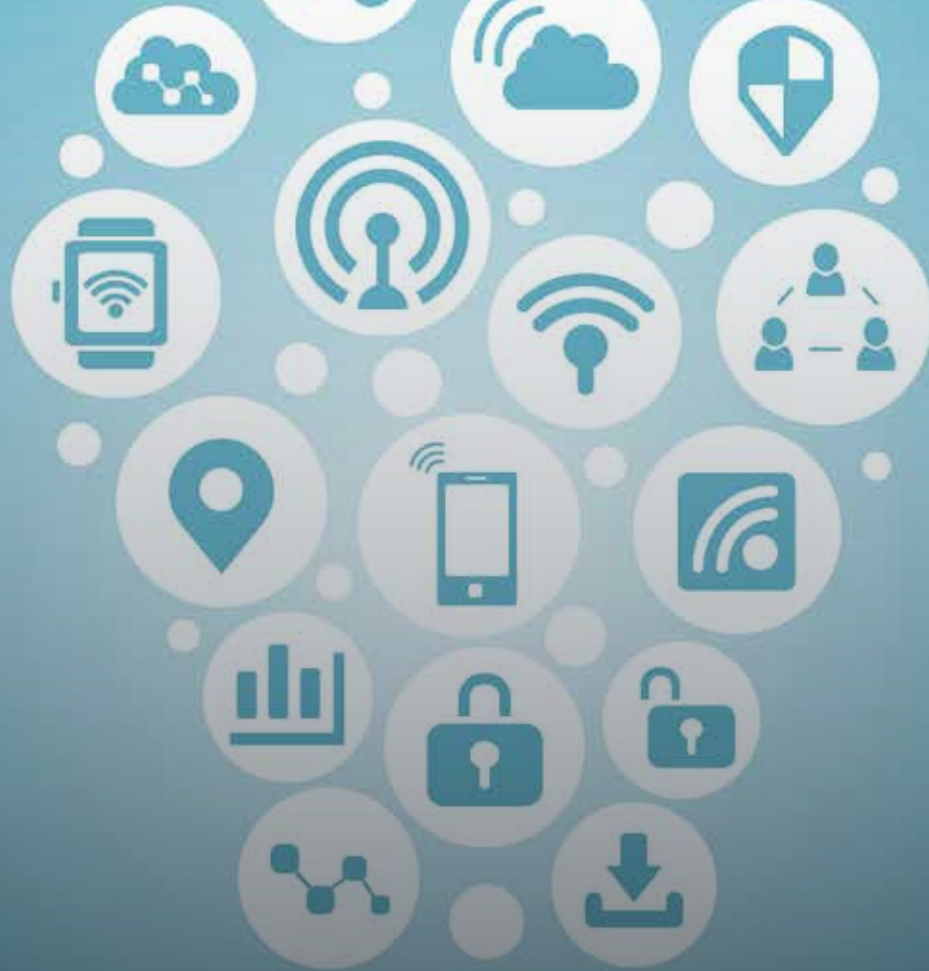


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Testing the internet of things: making the IoT work

By Kelly Hill

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As the “internet of things” takes off, companies have a wide range of wireless technologies to choose from and a plethora of use cases that make up the IoT. Companies with plenty of experience in their own verticals, but little exposure to integrating wireless, are running up against technical challenges in radio communications’ impacts on industrial design, in integration and in ensuring functionality - and the cost of getting their devices certified. Power consumption and battery life can be particularly crucial elements that are tightly meshed with overall technology choice.

Regulatory requirements in both the vertical to be served and the wireless industry “must be met, with attention to everything from water- and dust-proofing to electromagnetic radio emissions. New form factors pose challenges for physical test setups as connected devices become both much larger and much smaller than traditional smartphones and tablets that test approaches were designed for, forcing adaptation in test cases and certification processes that often move much slower than the overall industry.

Meanwhile, standards are in some cases just emerging or still being

developed, even as new IoT networks and devices are being built. The competitive landscape for cellular versus other wireless technologies is also shifting, with one of the major areas of impact being the overall cost and complexity of testing and certification. There are dozens of wireless technologies and formats to choose from for IoT devices and deployments, and those seem to be proliferating rather than consolidating.

“It seems a little chaotic right now, but it’s very practical,” said Adam Smith, director of marketing for test company LitePoint. “People are making practical decisions now, and coming up with solutions for their verticals rather than standardizing them to the broader technologies.”

This report explores some of the major issues related to testing for the “internet of things,” with some emphasis on radio frequency issues. It includes a market status update on expected IoT growth; a look at major testing trends being driven by IoT; and some of the technical challenges and pain points being encountered in IoT testing and development.

Market status: IoT growth and testing

Make no mistake, the “internet of

things” is already here. From fitness wearables to medical applications to smart farming and smart cities, millions of devices already are connected to cellular, Wi-Fi, Bluetooth and other wireless technologies. Millions more are being developed and planned in both the consumer IoT space and in industrial IoT. A few notable predictions for the market:

According to Machina Research’s annual IoT guidance report that published in August, there were 6 billion IoT connections in 2015. That number is expected to grow to 27 billion by 2025, a compound annual growth rate of 16%.

Analyst firm Berg Insight reported that 2.7 million cellular machine-to-machine routers, gateways and modems for connecting IoT devices were shipped in 2015. Berg predicts the market will reach 5.7 million units by 2020, a compound annual growth rate of more than 16%. North American and Asian vendors dominate the market, with Sierra Wireless, Cradlepoint and Digi International the largest North American vendors. IoT end devices are growing even faster, Berg has said, particularly in the industrial automation space. The firm earlier this year said there was

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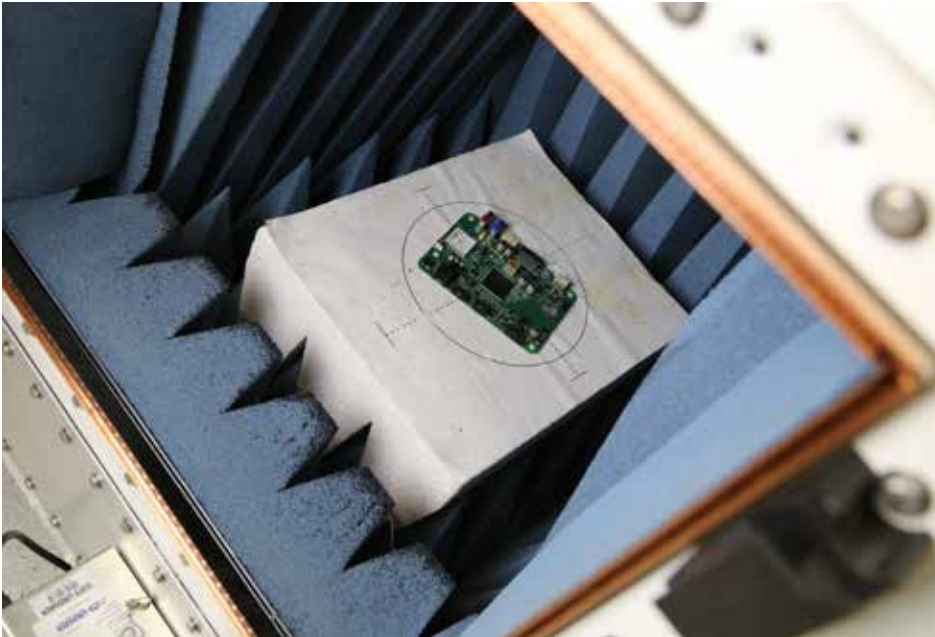
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an installed base of 14.3 million wireless IoT devices in industrial automation as of last year, expected to reach 62 million by 2020.

Cisco estimated in this year's Visual Networking Index forecast that there were 4.9 billion M2M connections in 2015, including almost 97 million wearables, and there will be 12.2 billion IoT connections by 2020. Cisco expects connected health to see the fastest growth, but that the connected home will see the largest number of connections overall. Smart home connections are predicted to grow from 2.4 billion in 2015, to 5.8 billion by 2020 and account for roughly half of all M2M

connections, Cisco reported.

Theresa Bui Revon, head of enterprise product marketing for IoT cloud at Cisco's recently acquired Jasper business unit, said that the company already has 5,000 enterprise customers and supports 34 million devices under management on its platform, and is adding more than 1.5 million devices per month.

"Some people talk about IoT hype; we talk about IoT reality," Revon said.

Gartner, meanwhile, has put out numbers estimating that around 5.5 million new "things" will be connected every day in 2016. The firm expects to see 30% growth in IoT devices from

2015 to this year, and for the market to reach 20.8 billion devices by 2020.

In terms of technology choices, Machina said 71% of all IoT connections rely on a short-range technology such as Wi-Fi or ZigBee, driven by IoT adoption in consumer electronics, building automation and building security. Cellular connections, meanwhile, it estimated at 334 million in 2015, and expected to reach 2.2 billion by 2025, with most of those being LTE connections and connected vehicles. The U.S. and China are expected to be the two dominating forces in the global IoT market, each accounting for about 20% of connections (although the U.S. is expected to generate more IoT revenue, 22% vs. 19% for China). Machina also said the IoT revenue opportunity will be \$3 trillion by 2025, compared to \$750 billion last year. Of that figure, about \$1.3 trillion will be generated from end users (devices, application revenues and connectivity) and the rest will come from IoT-related sources like app development, systems integration and data monetization.

Despite the growth, there are still a number of pain points in IoT development and adoption observers say are slowing the pace. One of

the biggest hurdles is the cost of making sure now-connected devices function the way they are supposed to, and testing devices from the research and development stage, to manufacturing test at scale and service assurance once a device is activated on a wireless network.

Mariano Kimbara, industry analyst with Frost & Sullivan's Measurement and Instrumentation division, said IoT testing is a hot topic, but still a tiny part of the overall testing market. He estimates it accounted for about \$168 million to \$170 million in 2015, but that "it's an area where we see strong, double-digit growth: 11% for the next five years." Testing for IoT is being driven by the need for security, interoperability, battery management and electromagnetic emissions management, Kimbara said.

In addition, testing for IoT is also being boosted by new and emerging standards as well as the wide variety of wireless technologies that can be used to connect devices, according to Kimbara, noting between new and legacy RF formats, there are more than 60 technologies that companies can use to connect IoT devices, ranging from the "personal network" level for wearables, local area networks such

as the home, neighborhood-range technologies and wide area networks that would include low power networks and cellular, among others.

IoT testing is driving new approaches

New form factors, standards and communications demands unique to IoT are forcing adaptation in wireless device testing. Change tends to come slowly, filtered through standards and certification bodies, but it is happening.

Although the standard equipment - power meters, signal generators, spectrum analyzers - is often the same with IoT RF testing, there are some physical shifts in test set-ups. One of the main trends in IoT test evolution is that the physical forms of IoT devices demand new test approaches. Wireless testing was designed for smartphones, tablets, laptops, dongles and other "traditional" wireless devices, and that sometimes means a poor fit (literally) for devices that range in size from connected vehicles to small sensors.

To address large form-factor devices, which have one physical dimension greater than 42 centimeters, wireless trade association CTIA recently released a new test plan that

relies on a reverberation chamber (which enables a complex test environment of radio signal reflections) rather than the traditional anechoic or semi-anechoic chambers that absorb signal reflections and provide a very controlled and isolated view of radiated performance. Reverb chambers allow for more flexible testing because they don't require exact positioning within the chamber and can accommodate heavy or bulky items; they also typically tend to be less expensive than anechoic chambers and are currently the only measurement methodology for the large form-factor test.

IoT devices also may not have the physical connections necessary for cabled testing - they may even charge wirelessly, according to Smith of Lite-Point, which last month launched what it claims is the industry's first Bluetooth Low Energy OTA test equipment to help address that IoT test conundrum. Manufacturers may produce samples that have an exposed connection for control purposes in order to perform traditional tests on nontraditional devices. But generally, the reduced cabling capabilities in IoT mean over-the-air testing is growing in importance.

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“The biggest trend in test is moving to OTA first,” Smith said, particularly in light of the need to test antenna systems including multi-user multiple-input/multiple-output in a Wi-Fi context, and even more complex and advanced antenna systems for “5G” technology IoT use cases expected to utilize millimeter wave frequencies.

Even the phantom forms of human heads and hands that are used in wireless device testing are changing with IoT wearables meant to be placed on the wrist or elsewhere on the body. Mark Sargent, VP of certification programs at CTIA, said the organization’s OTA working group has a number of subgroups focused on various aspects of IoT testing. One of those is the development of a phantom wrist form for IoT devices such as smart watches. CTIA is also interested in developing standardized forms for testing devices worn on the ankle and chest, he added.

Standards proliferation and fragmentation is also impacting IoT test (see sidebar). While cellular standards have been produced by 3GPP and Wi-Fi standards under the auspices of IEEE, IoT encompasses a large and growing number of unlicensed, mostly short-range

technologies. Low-power wide-area networks including SigFox and LoRa are also being built out. Meanwhile, the cellular industry has responded with the development of Cat-M and narrowband-IoT designed to provide low-power licensed spectrum options for IoT. Verizon Communications has said it expects to have an IoT network available by the end of this year. However, test equipment for Cat-M and NB-IoT doesn’t yet exist, although network equipment and devices are already in field trials, according to Art Miller, senior director of business development for smart cities and industrial IoT at Qualcomm, which is participating in some of those current trials. Miller said this means tests have to be conducted with actual network equipment and user devices rather than test equipment that can emulate them.

“With IoT, I think the proliferation of standards is mostly proliferation of formats. It reflects the various vertical industries that IoT can be deployed into,” said Kailash Narayanan, VP and GM at Keysight Technologies. “There’s a little bit of, the market is finding the right technology for deploying.”

Narayanan does expect to see some

consolidation in standards within the next three to five years, so that within a vertical there may be one or two commonly deployed technologies.

Scale, cost and choices

Cost looms over every aspect of IoT, especially for use cases that require long-lived but inexpensive wireless devices. Cost is tightly tied to many choices IoT companies make along the way. Whether an IoT design starts with an idea for an entirely new product, or connecting existing hardware within a vertical such as vending machines, many choices along the design path ultimately impact the cost of radio frequency testing.

Technology choice is probably the single biggest factor: licensed versus unlicensed, short-range versus long-range, cellular versus LP-WAN, and the decisions of whether to support multiple technologies in a single device, or multiple bands across different global markets, all impact how expensive a device’s components and testing will be.

But those choices are crucial to functionality and use case.

“Unless your device is actually connected to you and the internet, it doesn’t matter how amazing the

Standards Proliferation

The standards for traditional wireless devices have typically been handled by one of two groups: 3GPP for cellular and IEEE for Wi-Fi. But in the IoT space, proliferating formats mean a diverse array of groups that are handling the standards, required testing and certification, and licensing – particularly for short-range technologies that may or may not have commonly been part of wireless devices like smartphones.

Here are some of the standards groups involved in IoT:

3GPP: Handles cellular standards from 2G to LTE and beyond, including development of LTE Cat-M and narrow-band-IoT standards.

IEEE: Home for Wi-Fi, the 802.15.4 standard for low-rate personal-area networks and dozens of other standards relating to the function and communication of wireless devices; many of these have been amended for specific machine-to-machine support.

Bluetooth Special Interest Group: Responsible for standards development and certification for Bluetooth technology, used by an estimated 8.2 billion devices today. Bluetooth SIG announced earlier this year its newest release, Bluetooth 5, will have increased range and speed as well as broadcast messaging capabilities. Bluetooth 5 is expected to be released late this year or in early 2017.

Thread: A format built on open standards including IEEE's 802.15.4 standard and Ipv6/6LoWPAN protocols for mesh networking of up to 300

wireless devices in the home, focused on security and low power. Google, a backer of Thread, open-sourced Thread earlier this year so the protocol could be used by developers for free, though certification from Thread is still required for products.

NFC Forum: Certification body for near field communications, commonly used for contactless payments and increasingly used for smart access to connected vehicles.

ZigBee Alliance: Another IEEE 802.15.4-based wireless solution, this certification group includes more than 400 companies and says more than 200 ZigBee products have achieved its certification so far this year. ZigBee Alliance recently added a fifth accredited test lab group (UL), and its president and CEO, Tobin Richardson, said “we’re on pace in 2016 to have our biggest year yet as an industry alliance” due to surging demand in IoT.

Z-Wave Alliance: Responsible for interoperability/certification testing for this ISM-band mesh technology. Often used in home automation products, Z-Wave’s application layer specification was also made public earlier this year to encourage its use.

Open Connectivity Foundation: Sponsor of the IoTivity open source framework for IoT software, with the goal of interoperability specifications for connected devices across different verticals and reference designs for IoT. Worked out a liaison agreement with Thread earlier this year.

AllSeen Alliance: Charter members include Qualcomm and Cisco. Focused on interoperability certification among IoT devices through its AllJoyn framework.

Open Mobile Alliance: Focused on developing mobile service enablement architecture specifications independent of and able to work across specific networks and IoT platforms.

Industrial Internet Consortium: Cisco, IBM, AT&T and Intel are major players involved in IIC, which published an official common framework for industrial IoT security in late September. The group also focuses on support of and opportunities for IoT testbeds as one of its major activities.

OneM2M: A global consortium for IoT standards that includes collaboration among the AllSeen Alliance, Open Connectivity Foundation and Open Mobile Alliance for basic connectivity and interworking among their IoT systems. The group released its latest set of specs, Release 2, in late September.

LoRa Alliance: Certification and specification group for the low-power wide-area network technology LoRaWAN that relies on spread-spectrum technology in unlicensed bands for bidirectional communications for IoT.

SigFox: A LP-WAN network provider that relies on ultra-narrowband, sub-1 GHz bands similar to LoRa’s approach, but licenses its technology for radio module development and is the primary core technology operator for networks across 22 countries.

hardware is,” said Ravon of Cisco. “It doesn’t matter how amazing the app is that’s sitting on the device. Nothing is happening unless the connectivity is there.”

Module versus chipset is another crucial decision in IoT cost, in large part because modules have already passed Federal Communications Commission and/or carrier certification. Although the final device will still need to be tested as a system, having a pre-certified module generally means more rapid time to market and less overall cost of test to be shouldered by the device company.

For small-scale projects - meaning, less than one million units - modules are almost always the preferred route. Kyle Sporre, manager of RF and hardware engineering in Digi International’s wireless design services unit, said his company typically does very small, industrial devices including sensors, and small gateways and tracking devices, as well as wearables. The company works with more modules than chipset designs, he added; chipset-down designs tend to be more common for Wi-Fi, Bluetooth and other types of radio modules because of the cost difference.

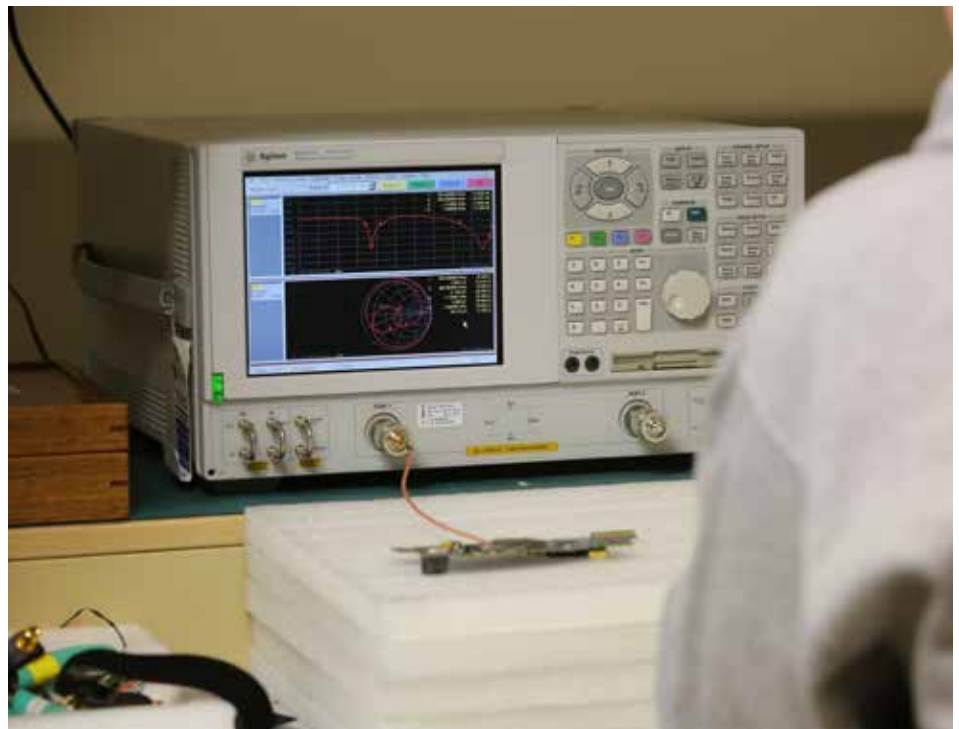
Sporre said that for cellular modules

there are a lot of advantages to a module approach: FCC certification is already done and there is often less software-related work to be done as well.

“There are just a lot of schedule advantages as well,” Sporre added - module-based designs can typically go to market faster. Sporre said the cost break point is “very, very high for cellular” - on the order of a million units. For Wi-Fi and Bluetooth and other radio technologies, that break point is in the hundreds of thousands of units, perhaps even the low hundreds

of thousands of units.

Todd Zielinski, director of electrical engineering at industrial design company Bressler Group, said the company’s clients usually opt not to choose cellular for their IoT designs. “A lot of people stay away from the cost and the complexity of it,” Zielinski said, adding that about 80% of the devices the company works with are connected devices such as Zigbee, Bluetooth and Wi-Fi. “Cellular involves more acute testing with the network, even if we’re using a pre-certified module. ... It’s more expensive than a



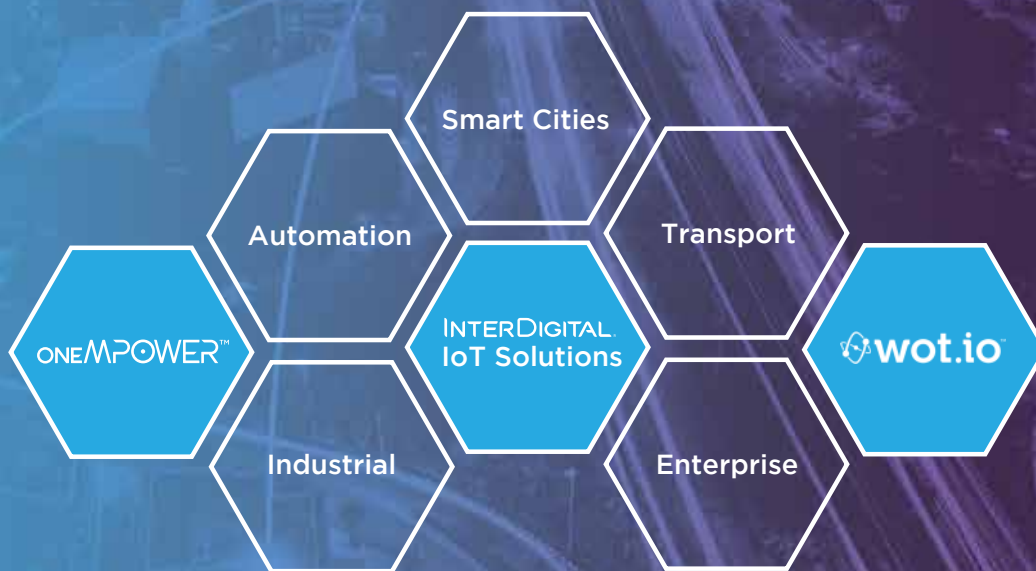
IoT testing conducted by Digi International

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3GPP is aiming to combat that competitive disadvantage with the introduction of IoT-specific LTE standards Cat-M and NB-IoT. Stripping out some of the complexity, the protocol overhead and other features of LTE should lower cost and complexity of testing and give LTE-based IoT a boost.

“Cat-M and NB-IoT LTE technologies are coming, and those technologies are simpler, lower cost, lower data-rate, lower power consumption and smaller. Along with that should come less certification testing or simpler certification testing,” Sporre said. “Certification bodies are working to reduce the required testing.”

Battery life is increasingly crucial for IoT, but challenging due to small form factors and use cases where devices are expected to last for years with little to no intervention, such as in-street sensors, smart lighting on bridges and other devices with long lifecycles.

Chris Lamb, CTO of engineering firm Device Solutions, said that the company often spends a lot of time characterizing power consumption, running hundreds of cycles to test in particular that devices correctly handle transitions in and out of

sleep mode. Even rare errors impact reliability. Tony Sammarco, director of product technology strategy for Device Solutions, added that use case also impacts overall battery life depending on how often a device needs to connect with the network.

Component choices can impact manufacturing test as well. Sometimes manufacturers will ask to swap components for cheaper options, which can affect overall reliability as well as change test results if the components impact RF performance.

Device packaging can include meeting standards for ruggedization and the ability to operate reliably in harsh outdoor environments, such as waterproofing and dust-proofing. There may be specific requirements across different verticals - such as being explosion-resistant - that will impact the choice of internal versus external antennas and RF propagation and performance.

Communication of data to the cloud for analysis and monetization. How often does a device need to communicate with the network, how much data speed and bandwidth does it require? Michael Starsinic, technical track senior manager at InterDigital, noted that the ability to send

small amounts of data via the control plane in the context of emerging IoT standards offers the potential for new, lighter-weight network architectures along with much lower protocol overhead (and battery demands) on end devices. All of these factors impact battery life and the cost of network access. If there are malfunctions in how a device communicates with the network, it can fail carrier acceptance testing.

“We’ve seen a lot of times when the devices can get aggressive on the network in certain situations,” said Cameron Coursey, VP of product development for IoT Solutions at AT&T. “They can start transmitting too much information, or retrying things too often.” Standards typically define how often a device should be retransmitting data, he noted, and those must be abided by both to avoid network impacts as well as to limit straining battery life.

Even with pre-deployment testing, troubleshooting still needs to happen in the live network as well. “We do catch a lot of configuration errors and protocol errors,” said Vikram Saksena, with the office of the CTO at NetScout, which monitors IoT deployments once they are rolled out.



IoT testing and development work at AT&T's IoT Foundry in Plano, Texas

Source: AT&T

Such errors often reflect errors in provisioning or a poor implementation on the part of an IoT manufacturer, he added -- and as device deployment models change in IoT, it's going to be even more important to have the ability to identify and troubleshoot device issues within the network. "People want to buy these devices from Best Buy or the manufacturer, plug it in and expect it to register and work," he said. "If you're going to hit billions of devices, you're not going to be able to certify all of those -- at some point, you have to catch them when they're trying to

attach to the network."

Mahbubul Alam, CTO and CMO of connected car firm Movimento and a veteran of Cisco's IoT business, noted that even beyond the standards, there are no agreed upon architectures for IoT implementations: no standard way of designing a IoT deployment in a plant, for example, or a fleet architecture, or one for oil and gas. Companies develop architectures based on their own best practices, but there aren't "plugfests" or widely established certifications for such work.

Security is one of the single biggest concerns for IoT, and while best

practices exist in the security space, there is no single recommended standard. George Japak, managing director of ICSA Labs, an independent division of Verizon, said securing data end-to-end for IoT as well as maintaining security even when multiple technologies are supported in a single device are some of the primary concerns. ICSA Labs launched a new certification program for IoT security that includes communications and authentication analysis earlier this year.

Another issue of concern to companies developing devices and services for IoT is the longevity of the companies involved, according to Zielinski. Chipset companies are being bought and sold, and companies wonder if their module provider will be stable, he added - and with LoRa and Sigfox entering the field, "I don't think anybody knows what it's going to look like two years from now."

Top 3 IoT testing pain points

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is often not as simple as just popping in a module.

“A lot of companies coming from the machine side or even with some networking background do not have the RF background. RF is black magic for them,” said Alam. “It’s not a network card, it’s not a USB, it’s not HDMI, it’s not a physical interface.”

There are three basic levels of certification testing to get an IoT device to market:

Regulatory certification, which in the U.S. means FCC acceptance testing. This is often described as “do no harm” testing to ensure that electromagnetic radiation is within acceptable limits.

Industry certification, such as Global Certification Forum or PTCRB (administered in the U.S. by CTIA) for cellular, Wi-Fi Alliance testing for Wi-Fi, and specific standards laid out for technologies such as Bluetooth, ZigBee, Z-Wave and others. This primarily focuses on ensuring interoperability across devices and the networks. CTIA’s Sargent noted the group has been certifying IoT devices since 2004, when they were primarily “machine-to-machine” fleet management devices or point-of-sale terminals.

More than 2,500 such devices have been certified by CTIA since 2004, he added.

Carrier acceptance testing, which mobile network operators use to ensure that devices operate within parameters that provide acceptable performance and protection to network operations and stability. These tests can be very involved and strict, particularly for major U.S. cellular carriers.

All too often, industry experts said, companies who develop IoT devices get to FCC or carrier acceptance testing and fail, resulting in costly redesign work and still more money and time sunk into repeating tests. They also lose precious ground on time-to-market, which in a rapidly developing space can mean that a competitor beats them to market with a similar product. And no one wants to be in a position to recall malfunctioning or dangerous devices - a position Samsung, for all its experience in design and wireless, found itself recently with its flagship Galaxy Note 7.

There are three particularly challenging RF pain points for IoT. These include:

Antenna design. Antennas are often underestimated due to the

perception they’re simply a passive component that will have little impact on overall design. But whether internal or external, antennas are central to performance and whether or not a device will pass certification testing.

Tony Opfermant, business development manager at Rohde& Schwarz, noted in addition that if a company wants to have its device work on different frequencies - either multiple bands supported by one carrier, or different bands around the world - that will necessitate different antenna sizes and probably impact design. Low-band cellular spectrum, for example, requires larger antennas than Wi-Fi at 2.4 or 5 GHz.

Noise from other components. Proximity and type of nearby components within an IoT device and how circuit boards are designed can result in interference for IoT RF systems. Device design that doesn’t take into consideration the impact of all components on RF performance can result in certification failure and the need to fix or redesign the product.

Cost of test. Despite the growth in IoT, many observers say the cost of testing and certification means the space is not growing as rapidly as it

could - in part because the high cost of test presents such a significant hurdle for small and start-up companies, or for small-scale IoT projects. Several experts said test can account for half the cost of a device, particularly for the very low-cost end points such as sensors.

Eric Heiser, who leads strategic partnerships for Ublox, said certification costs are becoming a bigger part of the total cost of test and the value chain of bringing IoT to market. Heiser also said self-certification seems to be an emerging trend.

"If the cost doesn't come out of this system, you're never going to get the billions of units," Heiser said. "And the cost lives in a lot of places, with certification being one."

The cost range for cellular certification could range from as little as \$20,000 to approaching \$100,000, Sporre estimated.

Eran Eshed, co-founder and VP of marketing for Altair Semiconductor, said a cellular LTE module "can easily be between half a million and a million dollars" to certify, and each carrier requires the purchase of specific test suites and packages that replicate GCF or PTCRB test equipment set-ups. Meanwhile, Eshed pegged the

cost of LoRa certification as around \$10,000 or less.

Opfermant said one company he knew of chose a chip design (rather than a module) to work with because they needed support for multiple technologies including Bluetooth, W-Fi and cellular - and it took more than a year and around \$1.5 million to certify the device, including 1,500 test cases from the mobile network operator.

"The testing that is performed today on broadband devices is outrageously expensive and exhaustive," said Eshed. "I think that for the first time, in the IoT space, it is clear to the carriers that this test strategy has to change. And I think to a large extent it is a reaction to the competitive forces from the proprietary LPWAN technologies."

Unsurprisingly, new network IoT operators such as LoRa and Sigfox are trying to make simplicity and low-cost test a competitive advantage. Derek Hunt, technical director for ecosystem at Actility, is also chairman of the LoRa Alliance Certification Committee and has been deeply involved with protocol development for LoRa. Actility, which has been working on remote

certification processes, has a certification server in Europe, Hunt said, which supports remote connections to gateways around the world so IoT test protocols for LoRa can be run.

Steve Ball, LoRa network provider Senet's senior director of product management, said the technology is deliberately taking a very different approach to certification than cellular and that remote and self-certification are part of its strategy.

"It's important that testing costs don't dwarf the overall development cost," Ball said.

Faced with those competitive pressures, cellular network operators feel the need to respond. One possibility that could significantly lower the cost of test is self-certification, rather than the requirement to pay an external test lab thousands of dollars a day for certification testing.

If a simpler technology where much of the complexity of cellular (along with features) has been stripped out, a simpler testing process can be used - and there may be an opportunity for trusted relationships to be built between chipset and module providers and carriers for testing to be done in-house and reports provided to the carriers, Eshed said, and perhaps



Manufacturing Connected Things?

When referencing IoT in regards to manufacturing, the focus is generally targeted at the flexibility in production that the smart factory will provide. But, what about the manufacture of the connected things themselves and the test and measurement challenges that the manufacturing industry will need to tackle with the Internet of Things?

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“They are thinking about these things and discussing them. How fast this happens is yet to be seen,” Eshed said.

Reducing IoT test costs

So how can companies reduce the cost of IoT testing?

Many wireless industry experts said connectivity needs to be a consideration early on in IoT projects, not an afterthought. If companies and IoT developers prioritize the importance of good connectivity design and seek out RF and

networking expertise early in their development processes, then they can avoid costly mistakes that result in certification test failures and time-to-market delays.

Given the fact antennas can make or break a design, “the antenna has to go first,” said Ruben Cuadras, engineering manager for 2J Antennas. “You can have the best hardware, the best solution, the best software, the best servers, the best everything - but if the antenna is not working, nothing works.”

Cuadras recommends starting with a proof-of-concept as simple as a circuit board with a ground plane and

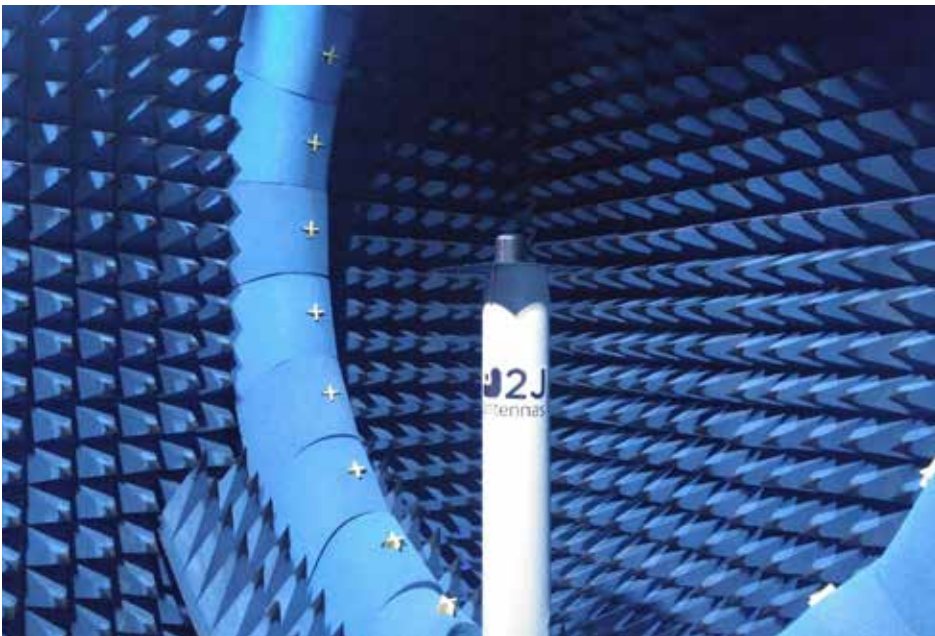
antennas of choice to establish the desired size and technology choices. Companies can then test the mock-up for efficiency, including radiated power and minimum sensitivity. It will cost a couple thousand dollars, he said, “but it can save you millions of dollars.”

Nearly every company across the IoT ecosystem said partnerships are essential: partnerships for RF expertise, for product development, for testing and certification experience. Wireless companies can partner with companies interested in IoT who know their own verticals deeply in order to produce IoT solutions that address specific needs of the vertical.

“It would be very difficult to do this all in a vacuum by yourself,” said Brad Briggs, director of product development for IoT development company ATEK Technologies. “You need partners.”

However, partnerships are still being established in IoT and are likely to shake out over the next few years to provide more consolidation and streamlined opportunities for development.

“Everyone has ideas, but very few know how to implement them,” said Qualcomm’s Miller. “Which leads to



Source: 2J Antennas USA

2J Antenna's testing chamber for characterizing antenna performance

many C-level calls. There are a lot of calls between CEOs on ‘what are you doing? How can we work together?’ - dozens of calls per week. And established players trying to figure out how they can partner to be successful. Part of it is that everyone is fishing a little bit - they want to figure out where everyone else is going. But in some cases, I think there will be synergies between large companies that can really move the needle.” Saksena noted as well that for service providers, there can be potential in these emerging days of IoT. “This fragmentation and silos

create challenges and an opportunity,” he said. “I think one of the values that service providers can provide is by unifying the silos.”

Even if formal partnerships are still in the works, companies of various sizes can take advantage of ecosystem support being offered by players large and small. A few examples: AT&T has its AT&T IoT Foundry in Plano, Texas, where it offers space and assistance to companies developing products for its network. Senet has its IoT Foundry product development program, a four-step process that includes training,

product ideation and development consulting, and certification testing readiness. Actility allows developers to connect up to 10 devices for free as part of their LoRa development kit. Companies such as Qualcomm are increasingly offering reference designs for various verticals with integration and design tips for licensees using their chipsets so that design issues can be avoided.

“We’d like [companies] to come earlier rather than later [in their IoT development process],” said AT&T’s Coursey, who added that high-end module providers often offer a high level of service associated with their products - but that adds to the overall cost as well. “For someone who is only going to manufacture a thousand to two thousand devices, that can be tough. So there are other players in the ecosystem that can take up the slack on some of the smaller projects and be able to offer services.”

Companies entering IoT also need to keep in mind the problem they are solving rather than pushing technology for technology’s sake, according to Lori Kirkland, VP of experience transformation of Universal Mind, which is a digital solutions company serving customers including AT&T,



Source: AT&T

IoT testing and development work at AT&T’s IoT Foundry in Plano, Texas

Verizon and T-Mobile US. IoT involves both devices communicating on an individual basis as well as a macro view of how well many devices work together as a system and how it may change how businesses operate, she said.

“Companies have to work with other companies,” Kirkland added, while noting some companies are “still trying to get their own digital houses in order” they are also faced with a new world of integration. IoT offers the opportunity not just to connect people, but brands.

One thing smartphones have done, Kirkland added, is introduce end users to good design. Companies may have been able to build apps around how their businesses functioned rather than the most efficient and effective customer experience, she added, “but that’s not okay anymore. You need to change how you’re doing business and how you’re building your software.” And, Kirkland added, “now companies that have not valued that before are having to do a lot of legwork to get to the point where they can produce good solutions for their customers.”

“These things are coming in all shapes and functionalities, and it’s

almost dizzying what the applications are doing today. The applications in the future are basically endless,” said ICSA Labs’ Japak. “A lot of these devices don’t connect in the traditional fashion anymore,” he added. They may be standalone devices with their own battery or solar power sources and, “The more you embed in a single device, the trickier it gets.”

The sheer number of potential IoT verticals also makes it difficult for companies to play in more than one, Japak noted, and serve them well. Health care, he noted, has very specific data security requirements with legal ramifications.

“You end up coming to realize that you can’t play everywhere,” Japak said. “And in some cases I know, where the headache is worse than others, and the headache is, ‘how do you do business there’ and ‘how do you get vendors or developers engaged.’”

Companies at all points in the IoT ecosystem - from developers to device manufacturers to the operators of IoT networks - have to ensure that whether consumer or industrial, short-lived or long, IoT devices perform as expected.

“It just has to work,” said Brad

Robbins, president of LitePoint. “The brands that generate reliable products are the brands that are going to win.”

Key takeaways

New form factors and wireless technology choices are driving physical and logistical changes to testing for the “internet of things.” Emerging standards are making a concerted effort to allow testing to be more efficient and cost-effective for devices that do not fit the traditional smartphone or tablet cost models.

The cost and time involved with testing is a major barrier to IoT development and adoption, influencing everything from technology choice to time to market. It also may disadvantage cellular compared to other wireless technologies, due to cost and complexity.

Companies interested in the IoT space would do well to consult RF experts early on in their development and design processes, particularly to avoid common pain points such as antenna design issues and RF noise from neighboring components that can cause certification failures, increase time to market and result in costly retesting. ((☹))



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