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4G LTE Spurs Mobile Connectivity Growth with Multimedia-Rich Apps and Services

Users fell in love with using their smartphones for Internet access. Now new revenue is springing from reliable, high-quality mobile broadband, for human-to-human, human-to-machine or machine-to-machine applications.

By Charles Sturman, u-blox

The mobile communication industry originated in the late 1980s as an offshoot of the century-old telephone industry. The Global System for Mobile Communications (GSM) standard was first defined with voice as the only service and, later on, a low priority Short Message Service (SMS) was "added on," becoming the first global wireless data service. It will perhaps come as a surprise that this first mobile data service generated around 100 billion dollars in global revenues last year.

However, since then, much has changed. Voice telephony has become a commodity and is, in fact, being supplanted in society by various Internet data services, such as instant messaging and social networking. Today, the big growth is in multimedia-rich applications and services. Although, initially, operators struggled to monetize data during the days of 3G, today the value of reliable, high quality mobile broadband is seen to drive new revenue and it is why operators are rapidly rolling out 4G LTE, the fastest growing telecommunications standard ever, as shown in Figure 1.

LTE delivers a quantum leap in bandwidth and quality of service for both mobile devices, whether they're designed for human-to-human, human-to-machine or machine-to-machine applications. And affordable, high-bandwidth, high-quality and low-latency wireless connectivity is creating many new business opportunities that were unimaginable only a few years ago.

REVENUE OPPORTUNITIES FOR OPERATORS

Traditionally, operators fought for time-based voice revenues and dabbled with pay-per-use models for data traffic. However, the success of the mobile phone revolution drove average customer revenues lower in a frenzy of competition for market share.

Data services were an opportunity to reverse falling voice revenues, but operators started charging for data on a "per use" basis and produced their own branded content and services, most of which spectacularly failed to impress consumers. Then, as high-speed DSL and cable networks started to proliferate, there was an astonishing increase in Internet traffic and applications. This multimedia-rich broadband experience quickly came to play a central role in the everyday life of hundreds of millions of people in the developed world.

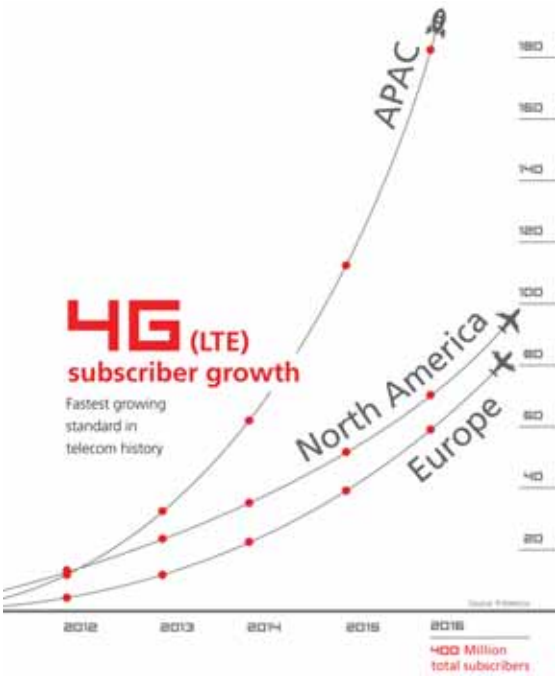

Figure 1: Data is now the primary driver of mobile connectivity, and why LTE demand has grown so fast.

When Apple launched the iPhone in 2007, it was the first phone to allow full access to the Web and it kick-started the mobile Internet revolution. The first generation iPhone only supported EDGE (at 236 kb/s), but even though the bandwidth was relatively low, because it offered a full web experience—and bypassed mobile operators' walled-garden services—it was a huge success.

Suddenly the operators' sales pitch changed to "all you can eat" data subscriptions and this, together with a bewildering array of new apps becoming available, launched the smartphone revolution.

Several iPhone generations later, mobile Internet users expect an experience comparable to that of

being connected to wired networks, either directly or over high-speed Wi-Fi.

Video from YouTube, IPTV, Netflix, and Hulu etc., is now the largest consumer of Internet bandwidth, followed by file sharing from the likes of Google Drive, MediaFire, FilesTube and RapidShare. Other traffic, including web surfing, VoIP, and gaming, together made up only 20 percent of total bandwidth in 2014, as demonstrated in Figure 2.

2G networks are now inadequate and many are being re-farmed in favor of 4G. 3G networks struggle because of inherent protocol limitations and so operators are rapidly rolling out 4G LTE infrastructure to bandwidth-hungry subscribers.

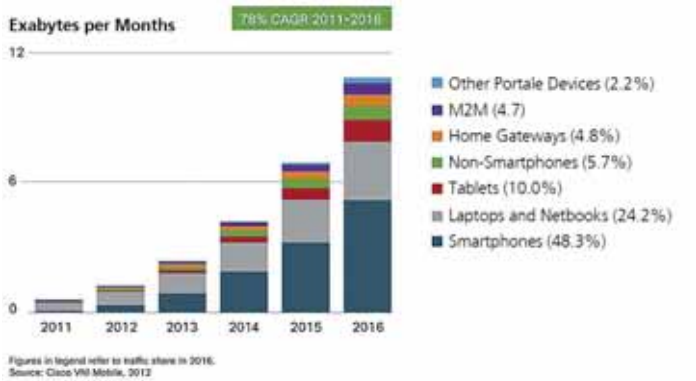

Figure 2: Internet traffic growth (2011 – 2016), Source: CISCO

HIGH BANDWIDTH—JUST THE START

LTE has four key advantages over earlier technologies:

1. Designed from scratch for high bandwidth, with up to 150 Mb/s download and 50 Mb/s upload in single carrier, or 300Mb/s + 100Mb/s in 2x20 MHz Carrier Aggregation mode. It is sufficient to stream 8 simultaneous HDTV channels—a level of demand that is rarely required in practice.

2. Bandwidth can be shared efficiently between large numbers of subscribers. This allows cost-effective data allocation to different devices and simultaneous handling of high-bandwidth human-to-human and low-bandwidth machine-to-machine traffic.

3. Operating Expenditure (OPEX) is reduced thanks to a simpler network architecture and improved spectral efficiency (double that of HSPA and 30X that of UMTS).

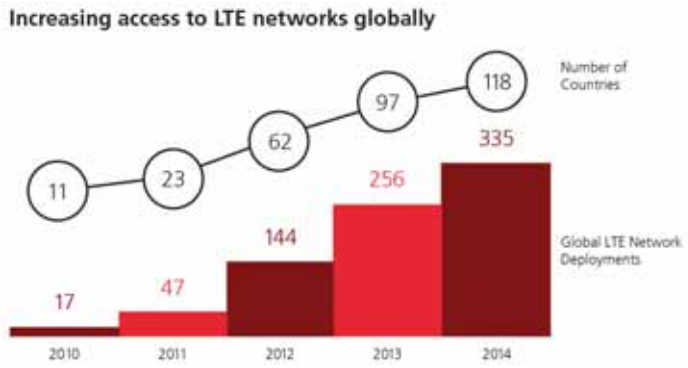

Figure 3: Global LTE network rollout, Source: GSMA

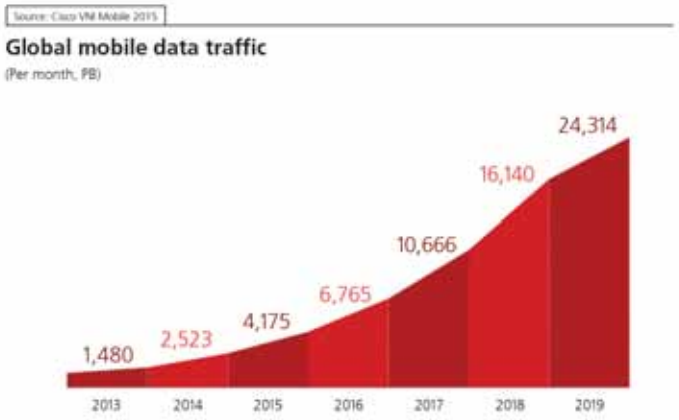

Figure 4: Global mobile data traffic, Source: CISCO VNI Mobile 2015

4. Real-time latency enables teleconferencing, video streaming and gaming applications. The maximum latency guaranteed over LTE is around 10 ms—a level below the threshold of human perception.

These attributes combine to bring users affordable mobile data services with high quality of service and satisfy responsiveness supporting content-rich, interactive applications such as on-demand video, social media, voice, web, gaming and cloud-based applications.

LTE CREATES THE WIRELESS "LAST MILE"

LTE delivers the cable/DSL broadband experience to mobile users. As costs fall, LTE "last mile" connections will replace cable and DSL connections over ageing copper telephone wires. This will create an almost exclusively wireless environment on the periphery of the Internet.

Already, LTE is found in mobile routers that create Wi-Fi hotspots in public transport, at events, in city centers and apartment buildings. What's more, LTE is in remote locations where no other communications network infrastructure may exist.

CAPITALIZING ON GPS AND MORE

Although users typically access similar content when mobile or stationary, the combination of location data enables new usage models, such as location aware search and augmented reality. By exploiting an accurate GPS/GNSS (or other) positioning system,

LTE is able to bring a variety of new, video-rich, location-aware services to mobile consumers. These will include information services for shopping and tourism, and multimedia navigation that allow users to see and interact with destinations before they arrive. New social media applications will appear too, and those that are based on text and images today will increasingly use video as the medium becomes more easily accessible.

CLOUD COMPUTING MEETS THE MOBILE TERMINAL

Professional and consumer data storage and applications are migrating to the cloud, as demonstrated by everything from Google Drive to SalesForce and GoToMeeting.

Many consumer applications allow users to interact with each other and offload storage and data processing to the cloud. Servers can be thousands of miles (or kilometers) away, so fast access and minimal delay (latency) during both upload and download is critical to creating a response that is perceived as instantaneous. LTE is the first cellular network to achieve the required performance in this respect. As a result, cloud computing and LTE are complementary technologies, the availability of each driving the adoption of the other.

LTE SPECIFICATIONS FOR MACHINE-TO-MACHINE EVOLVE

In contrast to 'human to human' interactions, machine communication typically involves relatively low data rates, with a strong emphasis on low power and low cost of deployment. For this reason, new LTE specifications are being created to address LTE for Machine Type Communications aka LTE-MTC. In this configuration, the new LTE Category 0 specification provides a stripped down system with data rates closer to the traditional 2G GSM technology that has been used for M2M to date. However, LTE Cat0 and the next generation Cat 00 specification will provide better performance, power consumption and cost over time whilst fitting into operators' existing LTE network infrastructure and spectrum.

Through a combination of broadband LTE and narrowband LTE-MTC, some new M2M use-cases are already emerging:

- Vending machine monitoring and delivery of video commercial displays
- Retail terminals displaying product demonstrations or live helpdesks
- Remote wireless surveillance cameras
- Telehealth terminals providing remote diagnosis and healthcare
- Multimedia signage and advertisement displays
- Facial recognition systems for homeland security
- Wireless routers for in-car infotainment systems
- Unmanned video drones used for security, traffic, accident, crowd control and fire monitoring

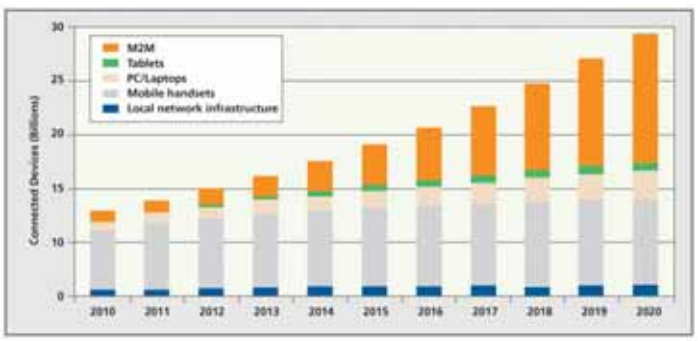

Figure 5: The number of wirelessly connected M2M devices is forecast to exceed all other types of connected devices by 2020 (Source: GSM Association)

The guaranteed low-latency of LTE is essential for time-critical applications in industrial control, vehicle safety, traffic control and financial systems. Here, split-second reaction times are as crucial for industrial robots as for automated financial transactions. Soon, devices connected over cellular radio networks will exceed human users.

With no cabling needed, high-bandwidth enterprise-grade LTE networks can be set up quickly and easily. They can then be managed remotely with minimal hardware configuration or associated IT costs.

Despite all this new capacity and the exciting opportunities it presents, as with every previous mobile standard, traffic will grow to occupy all available LTE bandwidth, but with many new techniques under study, such as carrier aggregation, multi-antenna MIMO and beamforming this is happily some way off; as far as we can tell.

FUTURE-PROOF CONNECTIVITY

LTE is destined to be the long-term future of all cellular networks as 2G and 3G networks are gradually phased out. Many M2M operators already consider LTE as the only choice for long-term service applications and Fierce Wireless reports that there were already 497 million LTE subscribers in December 2014.

Where cellular wireless-enabled devices are used in remote locations, retrofitting modems to hundreds or thousands of units is expensive so, at least as far as possible, it's wise to design with future technologies in mind. This means either designing with LTE modem technology now, whether you need it or not, or at least future-proofing hardware design so that modem upgrades are as economical as possible.

As a major manufacturer of cellular modems, u-blox addresses the future-proofing challenge by providing its customers with PCB mounted modems based on a nested design (Figure 6). This means that 2G, 3G and 4G cellular modem modules all drop onto the same printed circuit board footprint. Customers do not need to keep changing their PCB

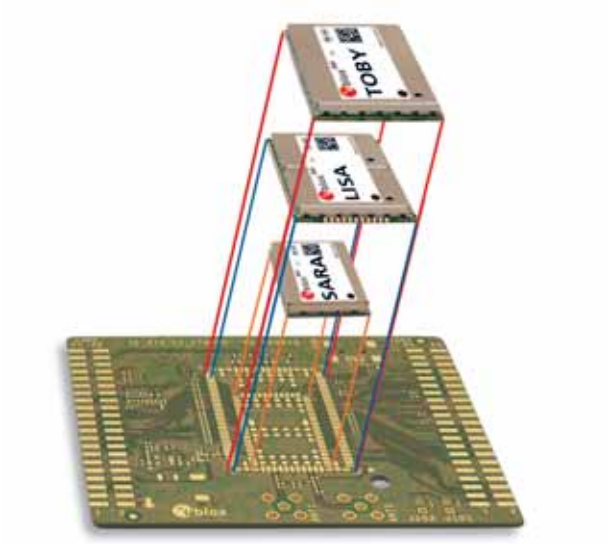

Figure 6: u-blox nested design philosophy: SARA 2G, LISA 3G and TOBY 4G module series are footprint compatible

Figure 7: TOBY-L2 series modules enable product manufacturers to quickly add reliable LTE connectivity.

designs whenever u-blox introduces an improved version of its modules. In addition, u-blox offers a range of pluggable modules in both mini PCIe and the newer PCIe M.2 form factors. Furthermore, portfolio-wide standard software APIs ensure upgrades and evolution with minimal effort.

WHAT TO EXPECT FROM THE LATEST 4G LTE MODEM MODULES

Now available are LTE modem modules designed for Cat.4 operation. (Figure 7) The LGA-format surface mount modules, of which there are several variants, measure 24.8 x 35.6 x 2.8 mm, making them very easy to install, even where space is limited. Depending on the version selected, they can be used on most major North American, European and Asian LTE networks and on some in South America.

WHAT'S NEXT

The rapid deployment of LTE infrastructure has laid the foundation for the next revolution in mobile connectivity. The ready availability of small, economical, network-certified modem modules has made it easier than ever for multiple devices to be connected to the Internet and take full advantage of the low latency and wide bandwidth now available, even when moving around the globe. New products and services are emerging that deliver tangible benefits to consumers, enterprises and public bodies as 4G becomes the norm and 5G dangles the promise of an even more exciting connected future.

Charles Sturman is senior principal product strategy, u-blox. He is leading u-blox' product marketing activities in the consumer space, responsible for product strategy and market development. Prior to this he was a founder and executive VP Sales & Marketing at Cognovo, responsible for business, product and market strategy together with sales planning and leadership.

5G and the Push for Pervasive Connectivity: Q&A with VDC Research's Daniel Mandell

5G could be the next wave, but it will take more than new waveforms for it to create a splash.

By Chris A. Ciufo, Editor-in-Chief, Embedded, Extension Media

VDC's Daniel Mandell leads research services for IoT gateways, embedded processors and other computing hardware. Recently he shared insights on 5G.

Chris "C2" Ciufo: Perhaps we need a baseline first. What is VDC's view of 5G?

Daniel Mandell, VDC: We view 5G as the maturing integration of next-generation wireless communications technologies—both for hardware and software. The concept is still fresh with no particular specifications yet published by any telecommunications standards bodies. 5G will deliver exponential increases in data speed and bandwidth in addition to pervasive coverage/connectivity across environments. Basically, there is no market opportunity yet present for 5G hardware and it is very much still in the "science & testing" phase.

"U.S. carriers absolutely need to start planning for the next wave of mobile connectivity now to support the deluge of connected devices currently pouring into the market."

C2: The U.S. went from being behind in broadband mobile technology (when we were 3G, at best) to broad 4G/LTE penetration. Is there much of a need for U.S. carriers (and their consumers) to ratchet up the bandwidth—and CapEx—yet again?

Mandell: U.S. carriers absolutely need to start planning for the next wave of mobile connectivity now to support the deluge of connected devices currently pouring into the market [see Figure 1]. While not all of these devices will feature their own SIM cards or connect to carrier networks directly (unless supporting high-value/mission-critical applications or remote locations) they will be likely connecting to an intermediary gateway, which themselves will still require progressively more bandwidth to sufficiently send the appropriate data to the cloud (as most IoT solutions are adapting) and harness the full power of analytics. The exponential growth of data traffic over the next several years is further complicated by spectrum limitations that carriers are already dealing with today.

In fact, 53.9% of respondents from one of our recent embedded engineer surveys to large communications organizations (1,000+ employees) already agree that 5G technology is critical to their organization's ability to adapt to IoT/M2M market demands.

C2: What are the core technologies needed to implement 5G?

Mandell: Software-defined radios (SDRs) are critical to rapid prototyping of base stations supporting the development of 5G technologies over the next 3-5 years. Many of these devices feature a programmable fabric/FPGAs. FPGAs, too, have grown in importance across the embedded landscape because of their configurability and ability to adapt to supporting different applications or workloads (plus the growing support from semiconductor vendors for facilitating their programmability). The merger of Intel-Altera is indicative of the growing importance of programmable logic for prototyping and developing future high-performance embedded systems.

Other technologies that will be critical to defining 5G technology will be massive multiple-input multiple-output (MIMO) systems, millimeter wave (mmWave) wireless and the development of new waveforms optimizing packet size, latency and the like. Software-defined networking (SDN) and network function virtualization (NFV) will be just as critical to optimizing new and deployed embedded systems supporting communications applications. The evolution of communications infrastructures to support 5G will extend through several seemingly different and distinct technologies, but will be ultimately defined by the culmination of their integration.

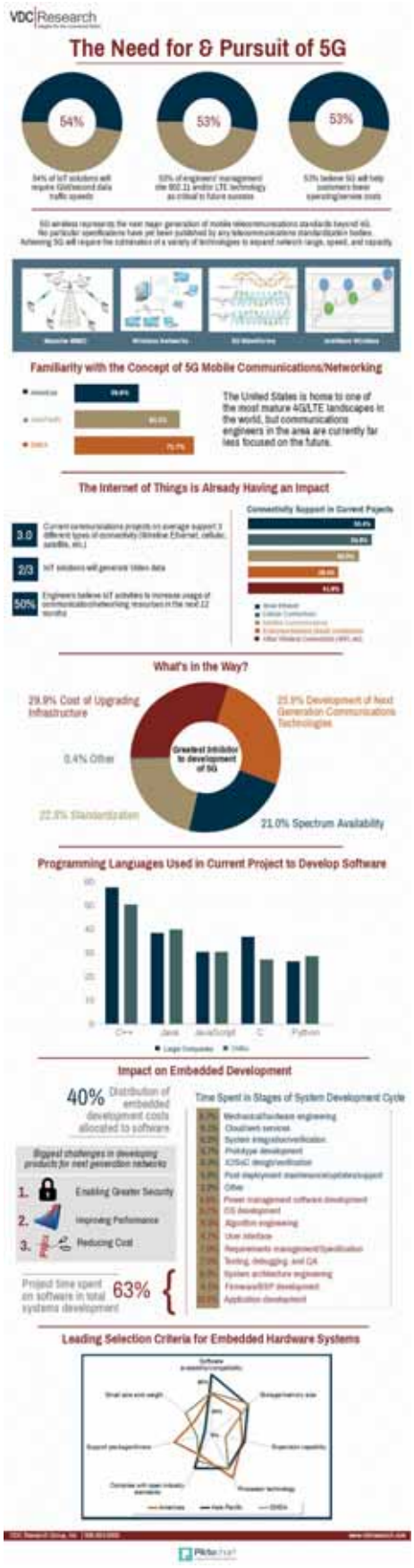

Figure 1: Factors fueling 5G and potential impediments to implementation. Courtesy VDC Research Corporation.

C2: Who are the key embedded vendors with technology to bring to 5G?

Mandell: National Instruments has been aggressive in this area and has several test beds currently underway for various 5G technologies like MIMO on its own campus as well as a few other installations at different universities. Other companies to really keep an eye on include Intel (NI partner for 5G), Xilinx and Ericsson.

C2: Will 5G use the same core technologies—such as RapidIO and ATCA—as are used in 4G/LTE, or is there something new?

Mandell: We do anticipate a dramatic slowing of the ATCA market over the next five years, but it remains to be seen which non-proprietary bus architectures or form factors will be favored or required for these types of systems.

C2: Will 5G be just a speed increase, or is there a fundamental network architecture change to Mobile Edge Computing (MEC)-—as companies like ARM have postulated?

Mandell: The move to 5G will be as much a move towards pervasive connectivity (indoor and outdoor) as higher data rates and throughput. In short, the vast requirements/expectations for 5G will necessitate a fundamental network architecture change by carriers.

Chris A. Ciufo is editor-in-chief for embedded content at Extension Media, which includes the EECatalog print and digital publications and website, Embedded Intel® Solutions, and other related blogs and embedded channels. He has 29 years of embedded technology experience, and has degrees in electrical engineering, and in materials science, emphasizing solid-state physics. He can be reached at cciufo@extension-media.com.

Extending Security To The Cloud And Beyond

The IoT's arrival puts the security issues that arise from connectedness front and center.

By David Friedman, CEO and Co-Founder, Ayla Networks

OVERVIEW

The concepts of product security and embedded security have always been complex, but at least they were familiar. But the Internet of Things (IoT) takes the idea of "product" and upends it by making connectivity an integral part of the product definition.

As a result, it's no longer enough to talk about security at the device level. Everyone from embedded system designers to manufacturers of home appliances must factor in the issues that arise from connectedness. Complicating this challenge is the fact that most IoT products were not originally conceived as connected products, and their manufacturers rarely have the in-depth expertise required to secure their products when they are connected to the IoT.

What's needed is a holistic, end-to-end platform approach to IoT-enabled devices that's available and accessible to manufacturers of any kind of product. With such a platform approach, interoperable security technologies and processes can be woven into each step, from a device and all its embedded components to the cloud to the mobile apps used to control the final product.

WHAT END-TO-END SECURITY MEANS

Connectedness increases security risks. Potentially sensitive data generated by IoT devices in our homes, workplaces and public spaces now traverses the public Internet. Securing this data is of primary concern to both the manufacturers and the users of these connected devices.

To achieve end-to-end security for an IoT-connected device, security processes and procedures must extend in a seamless, fully integrated way in the device, cloud and application—each of which has its own set of security protocols and standards. For example:

- Chip-level security focuses on encryption technologies, including encryption key transmission protocols such as Secure Sockets Layer (SSL).
- Cloud-level security combines computer and networking security protocols.
- Application-level security encompasses security measures taken during software development as well as after the app is deployed.

Computers and smartphones have evolved sophisticated operating systems with built-in security measures. But typical IoT devices—such as kitchen appliances, baby monitors, fitness trackers—were not designed with computer-level operating systems or the security features they include. The question becomes: Who is responsible for the end-to-end security that these connected products require?

The best answer is for manufacturers of connected devices to take advantage of a well-conceived IoT platform.

A PLATFORM APPROACH TO IOT SECURITY

A holistic platform approach can enable IoT-based devices to be continuously available and secure, on the physical, cloud and software levels.

Here are some important security principles that an IoT platform should follow:

- Deliver AAA security. AAA security refers to the Authentication, Authorization and Accounting approach, which enables mobile and dynamic security. It means authentication of users, typically identifying an individual based on a username and password; authorization of access to network resources to authenticated users; and accounting for or auditing what the authenticated, authorized user does while accessing the network resources.
- Manage lost or stolen devices. This might include remotely wiping out the contents of a device or disabling its connectivity.
- Encrypt all user-identifiable information. Encryption helps protect data in transit, whether it's via networks, mobile phones, wireless microphones, wireless intercoms or Bluetooth devices.

- Use two-factor authentication. With two layers of protection, hackers must breach both layers to complete an attack.

- Provide security of data at rest, in transit and in the cloud. Data security in transit is dependent on the method of transport. Securing data at rest and in transit typically involves HTTPS and UDP-based services to ensure that each packet is encrypted using AES 128-bit encryption. Backups should be encrypted, too. Ensuring that data is secure as it passes through the cloud might mean using services deployed within an AWS Virtual Private Cloud (VPC) environment, which allocates a private subnet to the service provider and restricts all inbound access.

Manufacturers of connected devices need IoT platform providers that can help them:

- Consider potential scenarios for user data. How much privacy control should end users have over data such as when they leave the house and return? What data should maintenance or service personnel have access too? What different kinds of users might want to interact with the same device, and in what ways?

- Think about how customers will take ownership of the devices. If ownership transfers, what happens to the original owner's data? This concept applies to both infrequent transfers—such as someone buying and moving into a new house—and situations such as hotels, where guests are checking in and out daily.

- Deal with the default credentials provided when IoT platforms are first used. Many devices, such as wireless access points and printers, come with known administrator IDs and passwords. Devices might provide admins with a built-in web server so they can connect, log in and manage devices remotely. Such default credentials represent a huge potential vulnerability that can be exploited by attackers.

Role-based access control is essential to protecting user privacy and for handling the real-world usage of all kinds of IoT-based devices. With role-based access, security can be fine-tuned to handle nearly any kind of scenario or use case.

Figure 1. Typical IoT devices—such as kitchen appliances, baby monitors, fitness trackers—were not designed with computer-level operating systems or the security features they include.

COMBINING SECURITY STRENGTH WITH FLEXIBILITY

Manufacturers must realize that their security is only as strong as the weakest link. Minimizing those weak links is what an IoT platform is designed to do.

An IoT platform with built-in end-to-end security allows security to permeate all aspects of data collection and transmission. It will be able to provide security for device booting and authentication, access control, firewalling, data transmission, and updates and patches once a device has been deployed.

Security requirements vary by device. For instance, unlocking the doors of a vehicle requires strong user authentication. Protecting medical data being transferred from an outpatient's heart monitor to a physician's iPad requires rock-solid data encryption. An IoT platform's architecture must distinguish among these various scenarios and be able to incorporate the appropriate multilevel security with end-to-end protection.

It might be tempting for some manufacturers to try building their own end-to-end security solutions in-house. But unless they have deep expertise and extensive experience with all aspects of security, they'll find it too daunting.

A better approach is to take advantage of an IoT platform designed from the ground up to deliver the right kind of security from the device to the cloud to the mobile app.

The IoT continues to evolve rapidly, and new scenarios and use cases are emerging all the time. New security threats are inevitable. To gain and retain end users' trust, manufacturers of IoT-connected devices must choose an IoT platform that incorporates advanced security principles and processes and that is flexible enough to keep pace with novel security threats as they arise.

The reward for manufacturers who choose their IoT platform wisely is the knowledge that breaches in software, hardware, communication or physical security will not jeopardize the acceptance of IoT applications, nor threaten the privacy of those who use them.

David Friedman is co-founder and chief executive officer of Ayla Networks. He holds an MBA from the University of Michigan, a BA from Colgate University, and five U.S. Patents.

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