ultra low power wirelessQ

QUARTER 2 | **SUMMER 2018**

COVER STORY

Enterprise next for Bluetooth technology

The many faces of Industrial IoT

The Internet of Finns

What next for silicon vendors?

NORDIC SEMICONDUCTOR

OPINION

Pär Håkansson

Smart home encourages wireless evolution

The smart home is driving wireless technology down an interesting (and somewhat challenging) path. Industry clusters such as the Bluetooth Special Interest Group (SIG), Thread Group, and Zigbee Alliance are jostling to position their respective technologies as the best smart-home solution. The prize is enticing; according to consultant McKinsey&Company, over the past several years the smart-home sector in the U.S. has expanded at a compound annual growth rate of 31 percent.

Each organization's RF protocol is mature with good vendor support and a proactive development program. And all hold the potential to power the low-cost, battery-friendly wireless sensor networks that will form the foundation of a smart home's lighting, heating, and security systems. But each has specific strengths (and weaknesses). Among Bluetooth Low Energy's (Bluetooth LE) advantages are smartphone interoperability; Thread boasts native IPv6 capability; and Zigbee is a proven, broadly-adopted mesh networking technology.

It is perhaps little surprise that no single technology dominates. The capabilities of each betray the protocol designers' compromises between throughput, range, power consumption, and cost. For example, Bluetooth LE technology's smartphone interoperability derives from its consumer roots, while Zigbee wireless' mesh compatibility is a result of its design for industrial automation applications. That's not to say the protocols haven't adapted to meet applications beyond the original specification; Bluetooth 5, for example, extended Bluetooth LE technology's throughput and range while Zigbee 3.0 enhanced the protocol's interoperability. But reshaping can only take a wireless technology so far. Ultimately a protocol's capabilities are limited by the laws of physics, and even the cleverest engineers can't bend those.

So it seems that no clear wireless winner is emerging in the connected home. More likely several technologies will be needed, working together with each playing to its strengths. If that's to be the case, collaboration between industry bodies will be important to ensure that devices using different protocols can interoperate. Such collaboration has started in some areas; the Thread Group and Zigbee Alliance, for example, have already cooperated on the development of a "common language" to aid communication between products supporting their respective technologies. (*See this issue pg16.*)

Nordic Semiconductor, despite perhaps being best known as the leading Bluetooth LE chip supplier, has always catered for multiple protocols, supported on a single hardware platform. Historically, the company offered Bluetooth LE/ANT+/2.4 GHz Systems-on-Chip (SoCs) and now with its nRF52840 SoC, support for those protocols is complemented by that for Thread and Zigbee. (*See this issue pg8.*) Better yet, the nRF52840 SoC offers concurrent Bluetooth LE and Thread or Zigbee operation. That allows a developer to use identical hardware across a range of multiprotocol smart-home products, safe in the knowledge that information can wirelessly pass between them all.

Yours Sincerely,

Pär Håkansson
Product Marketing Manager
for Smart Home Products and Strategies

Contributors

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Svein-Egil Nielsen is CTO at Nordic Semiconductor. On page 9 he looks at the wireless technology options for Industrial IoT implementations in enterprise applications

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Graham Prophet is a freelance electronics journalist. Here he examines the creation of Dotdot, a single language that handles connectivity attributes of the IoT

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Sebastien Mackaie-Blanchi is an Engineering Manager with Nordic. On page 21 he explains the critical role of firmware in Bluetooth Low Energy SoC operation

Enterprise wearables are driving a divergence in Bluetooth applications

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NEWS

The latest developments from Nordic Semiconductor

Korean technology giant Samsung SDS releases Bluetooth LE lock

Samsung SDS, a subsidiary of multinational corporation Samsung, has launched a Bluetooth Low Energy (Bluetooth LE) smart door lock employing Nordic's nRF52832 System-on-Chip (SoC).

Smart door locks are emerging as a popular product category in the burgeoning Asian smart-home sector. China in particular is driving market growth with the country investing more than $150 billion in the technology.

The Samsung smart door lock can be retrofitted to any existing door

The 'SHP-DP930 Smart Doorlock' is a full-body mortice unit that can be retrofitted to any existing door, enabling the user to access their home or office without the need to carry door keys. The 'push-pull' smart door lock can be activated from the user's Bluetooth 4.0 (and later) smartphone using Bluetooth LE wireless connectivity powered by the Nordic SoC, or alternatively by fingerprint, PIN, or RFID proximity card access options.

When a registered user approaches the door, they can unlock it by touching the door button on Samsung SDS' iOS or Android partner app. In addition, this 'sHome Doorlock' app enables the owner to view 'in and out' activity records for their home or office, and receive push notifications in the event of low batteries.

The SHP-DP930 Smart Doorlock is powered by eight AA batteries that provide over 12 months standard operation between replacement. "Battery life was one of the most important factors we considered in our selection of the wireless chip," says Joonho Moon, Group Leader with Samsung SDS' Home IoT team.

"Samsung is a universally known and trusted brand. It's therefore appropriate that the company is taking a leadership position in the smart home security sector," says Geir Langeland, Nordic's Director of Sales & Marketing.

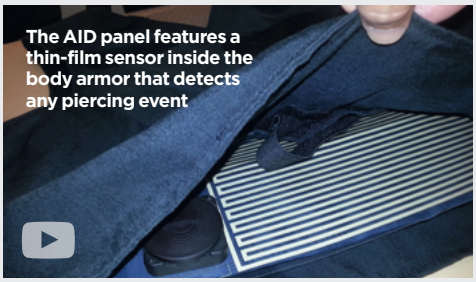
Gunshot detection wearable notifies first responders when vest is pierced

A U.S.-based low power wireless solutions company, DataSoft Corporation, has released a 'man-down' vest for law enforcement and the military, integrating its 'Automatic Injury Detection' (AID) sensor that wirelessly notifies first responders in the event the vest is pierced.

The AID panel features a thin-film sensor with a conductive ink trace inside the body armor that detects any piercing event to the wearer's front or back, such as the impact of a bullet, knife, or shrapnel. In the event the wearer suffers an impact, the vest automatically connects to a paired device—typically the user's smartphone or radio—using Bluetooth Low Energy wireless connectivity provided by a Nordic nRF52832 System-on-Chip (SoC).

The nRF52832 SoC's high link budget 2.4GHz radio enables the device to work over a range of almost 70 meters. The smartphone then sends an emergency alert to nominated first responders and/or backup units via SMS, or directly to a remote location such as the dispatcher's console.

Emergency notifications include the wearer's name and accurate personal medical information, the linked device's GPS location,



The AID panel features a thin-film sensor inside the body armor that detects any piercing event

and where on the vest the impact occurred, allowing medical responders to assess the urgency and seriousness of the potential injury. AID can also automatically and instantly initiate one call to a selected phone number, as well as activate a wireless body camera to record the incident.

The sensor employs a 300 mAh Li-Poly battery, allowing the device to operate for up to two years on a single charge. Because the AID sensors are installed inside the vest and are therefore difficult to remove and charge, the nRF52832 SoC's minimal power draw was said to be critical to the application's success.

In brief

Nordic posts strong Q1 results

Nordic Semiconductor has reported record high revenue of $60.1 million during the first quarter of 2018. The result represents growth of 27 percent over the same period in 2017. Sales of Bluetooth Low Energy solutions contributed $38.4 million towards the result, or 63.8 percent of total revenue during Q1 2018. The revenue growth came as a result of the strong design win momentum especially in the building and retail, and modules markets.

Report claims cellular key to IoT strategies

A new report from Ericsson claims 70 percent of surveyed telecom service providers said they were focusing on cellular IoT for their Internet of Things (IoT) strategy. For the report, *Exploring IoT Strategies*, Ericsson interviewed 20 fast-growing mobile broadband providers selected either for their IoT leadership or for their market maturity. Ericsson claims the push for cellular IoT amongst these providers is being fueled by 5G, and in particular the need for IoT connectivity.

Connected vending machines on the rise

The global installed base of connected vending machines reached an estimated 2.6 million units in 2017, with North America leading the way, a report has revealed. *The Berg Insight* report forecast that the number of connected machines worldwide will grow at a compound annual growth rate of 16.2 percent to reach 5.4 million units by 2022. Global penetration will reach 32.2 percent by that time. North America currently has as many connected vending machines as the rest of the world, the report said.

In brief

Over 1.8m visits for Nordic DevZone

The Nordic Developer Zone (devzone.nordicsemi.com), the online technical support community for those working with Nordic technology, was visited more than 1.8 million times during 2017, by over 574,000 users. Launched in 2013, Devzone received close to 6 million pageviews last year, with new users accounting for around 75 percent of visitors. Devzone allows engineers and developers to post questions and answer queries, as well as share code and documents. It is also moderated by a dedicated team of Nordic application engineers.

NB-IoT chipset sales set to surge

The need for low power consumption and large coverage networks are driving the demand for narrowband IoT (NB-IoT) chipsets, analyst Market Research Future has claimed. The analyst said a high level of security, compatibility with existing cellular infrastructure, and low cost of devices are fuelling the market growth, in addition to increasing smart-city initiatives. Asia Pacific is projected to show high growth rate, on the back of demand for advanced machine-to-machine communication technologies.

Global IoT health market booming

The global IoT healthcare market was valued at around $5.8 billion in 2014, and is expected to reach approximately $14.6 billion by 2022, at a CAGR of more than 11 percent between 2017 and 2022, a new report has revealed. Analyst, Zion Market Research, said the increasing implementation of diagnostic as well as therapeutic equipment is one of the major factors driving growth. It said in major developed countries, IoT had been successfully implemented in remote monitoring of diabetes and asthma patients in particular.

Air quality sensor system checks environmental pollution

Smart Sensor Devices, a Stockholm, Sweden-based Internet of Things (IoT) solutions start-up, has launched an air quality sensor system designed to provide users with rapid feedback on air quality and the presence of pollution in commercial, government, or consumer settings.

Employing Nordic's nRF52832 Bluetooth Low Energy (Bluetooth LE) System-on-Chip (SoC) to run the sensors' complex algorithms and deliver wireless connectivity to a user's smartphone or tablet, the Hibou unit includes a range of sensors measuring particulate matter (PM), gas (VOC), humidity, temperature, atmospheric pressure, as well as ambient and ultraviolet (UV) light.

The wall-mounted device monitors indoor and partly-outdoor air quality as well as environmental conditions, and syncs the data to the user's smartphone or tablet, where it can be reviewed via the company's Android-compatible 'Air Quality System' app. Alternatively the data can be transferred to an administrator's Cloud-based management system via Wi-Fi.

From the management system dashboard the user can review the data, set alerts, automate reports, and connect the system to third party AI and machine-learning platforms.

The device is powered via a micro USB connector or external power bank, but is also available in a low power version without a PM sensor, that provides up to one-month battery life between recharge, thanks in part to the ultra low power consumption of the Nordic SoC.

This device monitors indoor and partly-outdoor air quality as well as environmental conditions

"We are using the nRF52832 SoC in Hibou specifically because of the powerful Arm M4F processor," says Axel Hammar, Smart Sensor Devices' Founder and CEO. "Nordic's Thingy:52 IoT Sensor Kit is also helping our organization to improve."

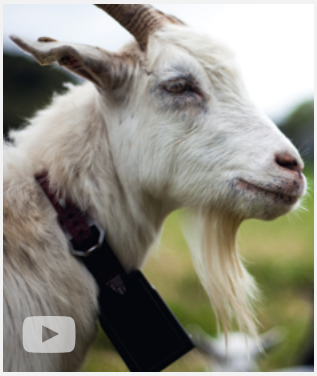
Wireless virtual fencing system keeps grazing animals from wandering

A virtual fencing system, designed to eliminate the need for farmers to maintain fences for grazing animals, has been unveiled by Norwegian technology company, Nofence.

The virtual fencing system consists of a collar, worn by the animal, incorporating a global navigation satellite system (GNSS) receiver and Nordic Semiconductor's nRF52832 System-on-Chip (SoC).

From a map on the Nofence iOS and Android app on a smartphone or tablet, the farmer draws a boundary for the pasture within which they want the animals to remain. This data is uploaded to Nofence's server and transmitted to the collar via a cellular network.

Once the collar is fitted to the grazing animal, straying outside the virtual boundary specified by the farmer will cause the collar to beep and vibrate, warning the animal to turn back.



Animal collar eliminates the need for farmers to maintain fences

The position of the animal is tracked using the GNSS receiver, and is relayed to the farmer's smartphone or tablet via a cellular network, allowing them to constantly monitor the location of each animal wearing a collar via the Nofence app.

At night or in bad weather, when the animals seek refuge in a barn or shelter, the GNSS receiver is turned off to extend the life of the collar's rechargeable Li-ion batteries. Instead, the Nordic nRF52832 SoC connects, using Bluetooth Low Energy (Bluetooth LE), to an iBeacon in the shelter to confirm the animals' location.

"Power consumption is critical as it is impractical to recharge the collar batteries frequently," says Oscar Hovde Berntsen, Nofence Founder and CTO.

"The GNSS receiver is the biggest contributor to power drain so we looked for opportunities to turn it off whenever possible. Bluetooth LE helped with that objective by communicating with beacons when the animal enters a fixed shelter to relay the animal's location to the farmer without using GNSS."

Gaming wearable monitors biometric responses to alter in-game experience

French start-up, Ironova, has released a gaming wearable that incorporates a range of biometric sensors allowing game developers to use the data to modify the gaming experience according to the player's emotional state.

For example, if the player's heart rate is elevated and they are perspiring, their in-game field of vision could be reduced or become clouded, representing anxiety or panic. Conversely, if the player is calm and has a normal resting heart rate, their in-game gestures could be made more precise.

The 'Ankkoro' wearable incorporates a range of biometric sensors including a Galvanic Skin Response (GSR) sensor to measure perspiration, a heart rate monitor, a skin temperature sensor, as well as an accelerometer and haptic vibration motor.

The captured biometric data is processed by the company's proprietary 'EmotionSense' algorithms and communicated to the user's iOS or Android Bluetooth 4.0 (and later) smartphone or tablet using a Nordic nRF52832 Bluetooth Low Energy System-on-Chip (SoC). The wearable is also compatible with Bluetooth 4.0 (and later)-enabled PCs and MacOS platforms.

The Ankkoro wearable incorporates a range of biometric sensors

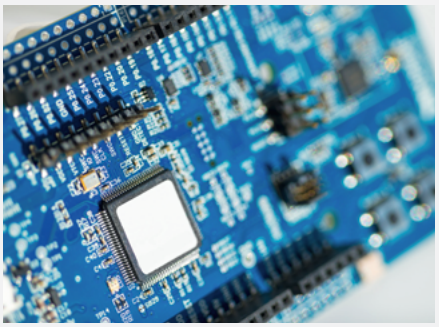
The Ankkoro wearable is powered by a rechargeable Li-Poly battery, providing up to one week's battery life between recharge, thanks in part to the ultra low power consumption of the Nordic SoC. The wearable's application programming interface (API) is available to developers on a subscription basis, while Ironova also offers a free, open source software development kit (SDK) which helps developers incorporate Ironova's technology into gameplay.

Nordic and Premier Farnell sign global distribution deal

Nordic Semiconductor has signed a new worldwide distribution agreement with Premier Farnell, the U.K.-based global distributor of electronics components and design services.

Premier Farnell has more than 3500 employees across 38 countries—with six global distribution centers—and will supply Nordic's complete range of ultra-low power wireless connectivity hardware, firmware, development tools, and reference designs, including the recently launched nRF52840 System-on-Chip (SoC).

"Premier Farnell seeks to provide its customers with an exceptional range of market-leading products coupled with a high level of support as they develop their products for market," says Simon Meadmore, Global Head of Semiconductor at Premier Farnell. "Nordic's solutions provide class-leading levels of wireless performance and sophistication at a price that enables their chips to be used in even the most cost-sensitive consumer products.



Premier Farnell will supply Nordic's complete range of wireless connectivity solutions

"With the Internet of Things driving democratization of design and the emergence of new start-ups with market-changing offerings, Nordic Semiconductor represents a key addition to our portfolio."

"Premier Farnell is a well-respected distributor with a focus on developer support," says Morten Staale, Nordic Semiconductor, Distribution Sales Manager for Europe. "This profile matches Nordic Semiconductor's requirement to make its Bluetooth 5 and other low power wireless connectivity solutions available to the widest audience."

Module enables IoT gateways

Taiwan-based InnoComm Mobile Technology Corporation has released its 'CM05 BLE-Wi-Fi Module' combining Nordic's nRF52832 System-on-Chip (SoC) with Wi-Fi to ease the development of Internet of Things (IoT) gateways for smart-home and industry applications. By combining the wireless technologies into one device, the developer claims to have eliminated the cost and complexity of working with separate Bluetooth Low Energy and Wi-Fi modules. The compact module is said to enable developers to reduce gateway size, decrease production costs, and speed time-to-market.

Smart security lifts home automation

In brief

Increasing smart security adoption—particularly smart entry solutions—will drive home automation and monitoring revenues from an estimated $12 billion in 2018 to over $45 billion by 2023, representing a growth of over 260 percent, according to a new report by analyst Juniper Research. Driving growth, the report said, is consumer desire for solutions that are easy to set-up and do not require monitoring. Home-contents insurers are also driving demand because the systems enable them to add value to existing client relationships, generate customer loyalty, and offer discounts on insurance premiums.

Bluetooth Low Energy smartwatch platform accelerates time-to-market

Geneva, Switzerland-based MMT SWISSCONNECT, has launched a development platform for smartwatch manufacturers to help them rapidly develop and build connected devices. The company's 'Smartwatch Platform (SP)' comprises a Nordic nRF51822 SoC-based watch module, watch firmware, iOS and Android apps, Cloud management, manufacturing, and service applications.

According to the company, SP brings the benefits of smartwatch technology to watch manufacturers that may have limited or no wireless connectivity experience. The product makes it easy for watch manufacturers to incorporate features and functions such as activity tracking, sleep monitoring, active coaching, smart alarms, support for outdoor

Smartwatch technology for manufacturers with no wireless connectivity experience

sensors (for example, compass, UV indicator, and temperature), activity/sleep display, Cloud backup, and restoring user data.

The platform also supports Bluetooth Low Energy connectivity between the watch and apps hosted on Bluetooth 4.0 (and later) smartphones or tablets. Through these SP companion apps, users are able to access their personal data and sensor information, as well as configure their watch features and Cloud account.

"The Nordic SoC offers the ideal wireless connectivity solution for our Smartwatch Platform by providing low power consumption, powerful microprocessor capabilities, an ultra compact package, and a software architecture that simplifies application code development," says Philippe Fraboulet, CEO of the company. "In turn, that enables us to offer the only complete turn-key solution for connected smartwatches to prestigious brands such as Frederique Constant, Alpina, and others."

MMT is now porting its platform to Nordic's nRF52832 SoC in order to improve power autonomy, processing power, and RF connectivity.

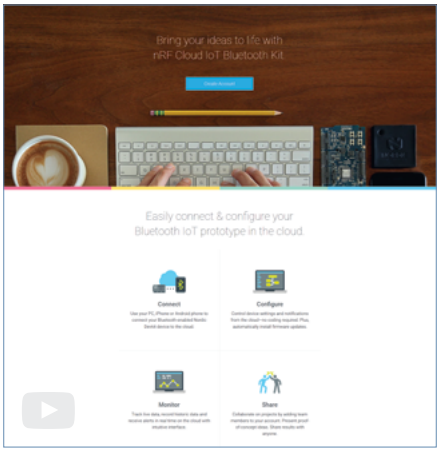
nRF Connect for Cloud accelerates development of Internet of Things designs

Nordic Semiconductor has announced the launch of 'nRF Connect for Cloud', a free service for Cloud-based evaluation, test, and verification of Bluetooth Low Energy (Bluetooth LE) designs employing Nordic's nRF51 and nRF52 Series Bluetooth LE Systems-on-Chip (SoCs).

nRF Connect for Cloud features an intuitive workflow and offers much of the functionality of Nordic's 'nRF Connect for Desktop' and 'nRF Connect for Mobile' which are popular applications used for building and developing Bluetooth LE products.

nRF Connect for Cloud also supports an extensive range of standard Bluetooth services together with proprietary services such as nRF UART.

Operating with all popular browsers, nRF Connect for Cloud uses Web Bluetooth application programming interfaces (APIs) to push and extract data to and from the Cloud, enabling the developer to test and modify the behavior and performance of prototypes. By using the front-end and visualization features of nRF Connect for Cloud, historical data can be extracted from databases and analyzed in a browser. The product also allows engineers to monitor and interact with remote wireless Internet of Things (IoT) designs enabling the collaboration of geographically separate development teams on a single project.



nRF Connect for Cloud enables developers to test and modify the performance of prototypes

nRF Connect for Cloud is supported by the 'nRF Gateway App' available for iOS and Android-powered mobile devices. The nRF Gateway App enables Nordic Bluetooth LE devices to use a smartphone-enabled Internet gateway to convert Bluetooth LE messages to ReST/MQTT/IP protocols for Cloud interoperability.

"nRF Connect for Cloud shortens the previously time-consuming migration from device-to-smartphone to device-to-Cloud connectivity and simplifies integration of Nordic wireless products into the larger systems that make up the IoT," says John Leonard, Product Marketing Manager, Nordic Semiconductor.

ULP WIRELESS TRENDS

The latest developments in technology

Samaritan is giving homeless people a hand through wireless technology

COURTESY: SAMARITAN

Beacon tech provides a financial helping hand to Seattle's homeless

A Seattle-based start-up has developed a mobile platform called 'Samaritan' that enables the city's residents to provide immediate financial assistance to people experiencing homelessness, without directly handing over cash.

The social enterprise launched its pilot in September 2016, and has to date assisted more than 500 homeless people via the contributions of nearly 7000 Seattle residents. Those in need can share their story and have their photo taken, the details of which are loaded onto a small Bluetooth Low Energy beacon keyfob—along with a $10 starting donation—which is retained by the individual.

If a city resident has the Samaritan app and passes within 25 meters of a beacon holder, a notification will pop up on their phone enabling them to read the beacon holder's story and make a donation. The beacon serves as a digital wallet and ID, giving the person the choice to spend the money with the help of a counselor, or directly at a partnered merchant for what they need to survive or leave the street. Samaritan does not collect location data, a privacy concern of many beacon holders, and makes its money from a scaled fee on top of the donation.

According to the start-up, city-going app users are currently investing more than $2,500 per month into Samaritan beacon holders, a number that's growing. With an estimated societal and state saving of $40,000 per year for every person that successfully leaves the street, Samaritan has received preorders for its platform from New York City and Austin.

The beacons track how long patients and staff interact

Hospital beacons track interactions

Japan's Nagoya University Hospital has launched a smart hospital pilot project at its Medical IT Center that uses Bluetooth Low Energy (Bluetooth LE) beacons to capture the vital signs and whereabouts of patients, and location of medical staff.

The pilot has two objectives, the first is to track the locations of staff members and understand where they go, as well as how they interact with patients. Second, the pilot aims to capture a patient's vital signs and his or her identity and location.

The project aims to understand how well the technology can measure nurses' responses to patient needs and the subsequent treatment patients receive.

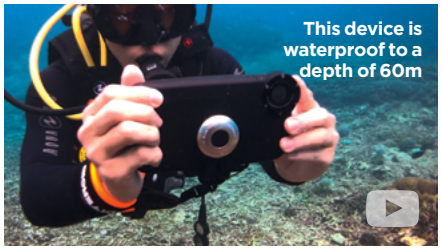
According to Shintaro Oyama, a researcher at the hospital, his team considered using Wi-Fi or magnetic detection-based systems, but felt the system required the location precision that Bluetooth LE technology offers.

The hospital is using sensor-based Bluetooth LE beacon wristbands, each device tracking vital signs in addition to location data, and transmitting that data to fixed beacon receivers installed in the ceilings of each hospital room. The software identifies the location of both patients and staff.

Bluetooth LE device turns smartphones into dive computers

A group of South Korean entrepreneurs has developed an inexpensive device that converts existing smartphones into dive computers. Known as the 'Diveroid mini', the device is waterproof down to 60 meters, and is designed to be mounted on popular underwater smartphone housings, offering a large full color screen dive computer without the expensive price tag.

Powered by a replaceable coin cell battery, the device measures both depth and water temperature, and using Bluetooth Low Energy wireless connectivity transmits that data to the partner iOS or Android app on the user's smartphone. The app tracks the dive statistics including duration, depth, and temperature, and calculates and displays important information such as decompression stops required when ascending. It also uses the phone's compass to show divers their current heading.



This device is waterproof to a depth of 60m

When users are taking photos or shooting video with the phone's camera, the app automatically adjusts the white balance in order to compensate for the loss of perceived color that occurs at depth. And when the dive is over, instead of manually transcribing all the data over to a log book, users can just instruct the app to transfer everything to its own built-in log. They can also use the app to share information about their dive direct to social media.

Zigbee support expands Nordic's offering for smart-home applications

The nRF52840 SoC now features the mature Zigbee mesh-networking RF protocol in addition to Bluetooth 5 and Thread

The home-automation sector is big business. The market is predicted to be worth a healthy $52.45 billion by 2022, according to analyst statista. Several low-power RF protocols are fighting for dominance with Bluetooth Low Energy (Bluetooth LE), Thread, and Zigbee among the leading contenders. Each claims an advantage. Bluetooth LE is interoperable with most of today's smartphones, providing consumers with a convenient and familiar interface to control their home-automation products. Thread is relatively new but has been purpose-designed for smart-home applications and is backed by a powerful grouping including Nest (part of Alphabet, the parent company of Google). For its part, Zigbee is a mature technology that's particularly suited to the mesh networking implementations favored for home-automation systems such as smart lights and security. (*See* ULP WQ *Winter 2017, pg9.*)

With no dominant wireless technology emerging, many OEMs have taken a hybrid approach for their home-automation end products. For example, some products employ Thread technology for communication between network nodes and Bluetooth LE for node-to-smartphone communication to ease configuration. The lack of a clear winner is also leading to collaboration between organizations. For example, encouraged by the use of an identical physical layer (PHY) for their RF protocol stacks, the Thread and Zigbee groupings are working on a common protocol to allow their technologies to interoperate. (*See this issue pg16.*)

Nordic Semiconductor's nRF52840, a Bluetooth 5-compliant and Thread 1.1-certified multiprotocol

Today's smart home plays host to multiple low-power wireless technologies

System-on-Chip (SoC), now forms the foundation for the company's first Zigbee solution.

Versatile offering

The introduction allows developers to take advantage of all three of the most popular low-power RF protocols and extends Nordic's portfolio of mesh-networking products for smart home, enterprise, and industry applications to Bluetooth mesh (*see* ULP WQ *Autumn 2017, pg8*), Thread (*see* ULP WQ *Winter 2017, pg8*), and Zigbee. The first engineering release of the Zigbee solution is available now with a production-grade Zigbee 3.0-certified release planned for the second half of 2018.

Nordic is part of the Bluetooth Special Interest Group (SIG), Thread Group, and Zigbee Alliance.

"Nordic's strategy is to support the leading standards-based low power wireless protocols on its silicon and through its development tools," says Geir Langeland, Nordic's Director of Sales & Marketing. "Zigbee is one of those leading standards, particularly in the home and industrial automation sector. The introduction of a certified, concurrent support solution for Zigbee and Bluetooth 5 on our high-end multiprotocol chip provides developers with complete flexibility in their wireless Internet of Things [IoT] designs."

"The Zigbee Alliance is privileged to gain Nordic's valuable industry insight and expertise"

The nRF52840 SoC uses a 'Dynamic Multiprotocol' technology which enables concurrent communication using Bluetooth 5 and Zigbee (or Thread). The Dynamic Multiprotocol enables, for example, interaction with a Zigbee smart lighting network from a smartphone via Bluetooth 5, or a Zigbee security network using Bluetooth beacons for location identification. The Software Development Kit (SDK) for use with the nRF52840 SoC Zigbee solution includes several examples including concurrent operation of Zigbee and Bluetooth 5 for a smart light bulb and switch.

Zigbee is a global, standards-based wireless solution that operates globally in 2.4GHz unlicensed bands (and other frequency bands in some geographical zones). Raw data throughput rates of 250kbps can be achieved at 2.4GHz (16 channels) and transmission distances range from 10 to 100 meters, depending on power output and environmental characteristics. The technology supports large mesh networks (which allow nodes to relay messages to other nodes) and low power operation for extending battery life.

Established in 2002, the Zigbee Alliance is a non-profit association of members that has created a thriving global ecosystem.

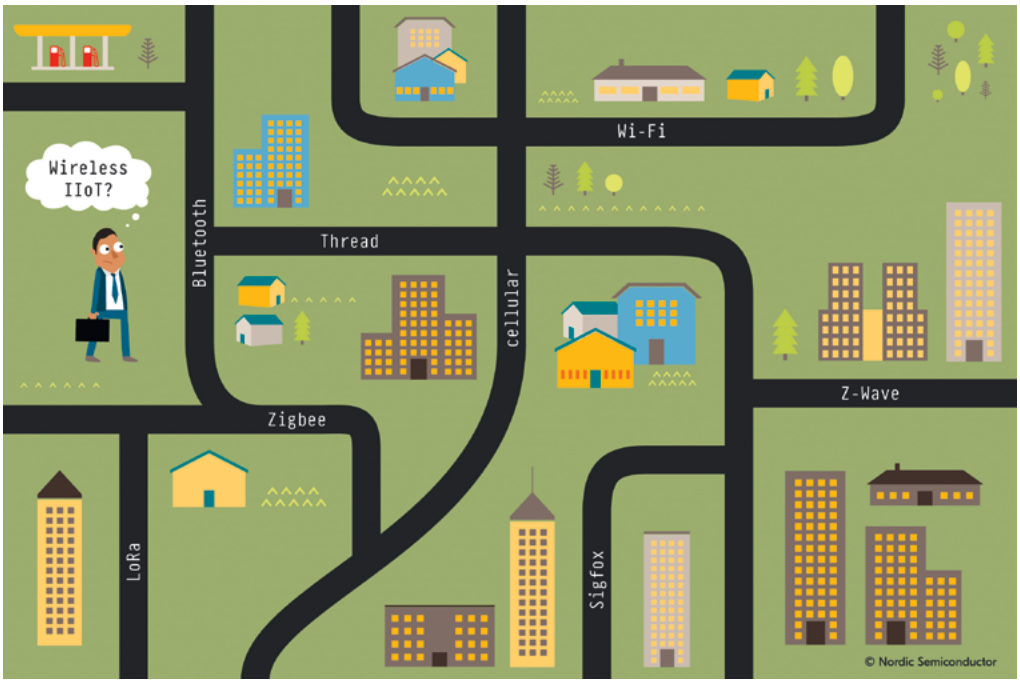
The Zigbee Alliance states that the technology is a global, standards-based wireless solution that can conveniently and affordably control the widest range of devices to improve comfort, security, and convenience for consumers. It is the technology of choice for world-leading service providers, installers, and retailers who bring the benefits of the IoT into the smart home.

"Our membership is privileged to gain Nordic's valuable industry insight and expertise," said Victor Berrios, VP Technology for the Zigbee Alliance, in a statement. "By adding Zigbee to its new software development kit, Nordic is expanding the reach of its product while providing additional design choice for IoT product manufacturers." ■

The many wireless faces of IIoT

Companies shouldn't wait for a winner in the wireless technology battle before embracing Industrial IoT, advises Svein-Egil Nielsen

Svein-Egil Nielsen is CTO of Nordic Semiconductor



Companies face a tough choice for their IIoT requirements as no single wireless technology fits every application

According to a recent Forbes article, Rolls-Royce used the Internet of Things (IoT) to improve jet-engine efficiency and save up to $250,000 per plane a year in fuel, Royal Dutch Shell realized a $1M return on an $87,000 investment in a remote IoT-based asset monitoring and maintenance solution across oil fields in West Africa, and Harley Davidson grew overall profitability by between 3 to 4 percent by shifting production to a fully IoT-enabled plant.

With cost and efficiency savings like these, industrial IoT (IIoT) will impact every organization's business model. But implementing IIoT is not easy; one of the most challenging parts of the process is deciding which wireless technologies are best suited to the network. It's likely to be a combination of several because no single technology meets all the communication demands.

Wireless standards relevant to the IIoT come in two broad categories: standards-based (for example LTE-M/NB-IoT, Bluetooth, Thread, and Zigbee) and proprietary (such as Z-Wave, Sigfox, and LoRa).

The key difference between the two is that standards-based technologies are developed, licensed, and controlled by alliances or special interest groups comprising many commercial companies, whereas proprietary technologies are owned (and promoted) by a single company.

Because they are collaborative ventures, standards-based wireless technologies tend to have a large pool of skilled engineers and resources to draw upon, encourage a sustainable multivendor supply chain, and give end-users confidence that the technology is likely to be there tomorrow. On the downside, standards governing bodies can be bureaucratic, which can slow the standard's development, place a drag on innovation, and introduce obstacles that make it harder for new or smaller entrants to gain traction.

In contrast, proprietary wireless technologies have a much smaller pool of available talent and resources to draw upon, carry the risks associated with any monopoly, and tend to remain niche. On the plus side, however, their lack of governing-body inertia can make the firms driving the technology quicker to respond to changes in market demand.

Playing nicely together

All wireless technologies were conceived to solve a specific engineering challenge in a specific sector. Bluetooth, for example, was initially designed to eliminate the tangle of wires created when PC peripherals such as mice and keyboards were connected to computers. And Wi-Fi got started to overcome the installation expense and complexity of hard-wired Ethernet networks used to link desktop computers. Such specialization is why some wireless technologies are better suited to certain use-cases than others in terms of cost, ubiquity, reliability, throughput, range, power consumption, and practicality.

"It's not a good policy for a company to wait around for a 'golden' wireless technology to appear and solve all its IIoT problems"

But it also means what might work very well in, for example, a relatively low-volume medical environment won't necessarily work well in a high-speed manufacturing application, which in turn won't necessarily be ideal for a large-scale smart city installation. Nonetheless, wireless technologies evolve because the demands of the applications they were created to serve change. This is why no single wireless technology will solve all of the IIoT's challenges: every application will almost certainly require a combination of wireless technologies and those that do not learn to play nicely together are going to struggle to succeed.

That means it's not a good policy for a company to wait around for a 'golden' wireless technology to appear and solve all its IIoT problems. Rather a firm should focus on solving today's IIoT challenge by choosing the best of contemporary wireless technologies rather than trying to predict which one will be dominant in a decade. Companies should pick what's winning today but accept its leadership might not always be assured and be ready to adapt if a better solution comes along. ■

Childproofing the IoT for the next generation of engineers

Computer scientists are using the Nordic-powered micro:bit in a project to better understand privacy and security challenges for children engaging with connected devices

If the Internet of Things (IoT) is to fulfil its potential, it won't be the current generation of working engineers that make it happen, at least not alone. Children, currently of school age, who have an interest in science and electronics will be our future engineers, and five or ten years from now will be key to the IoT's success.

To that end, child advocacy groups, educators, developers, and researchers in the U.K. are currently working together on a project which aims to discover how children would use IoT devices and what privacy and security challenges might arise from those future interactions.

It is hoped the 'Childproofing the Internet of Things' (IoT4Kids) project will help establish guidelines for young people to safely engage with IoT devices and develop the advanced computer literacy and core programming skills they will require in a rapidly evolving global technology landscape.

The one-year project began in November 2017 as a joint initiative involving the National Society for the Prevention of Cruelty to Children (NSPCC), the Family Online Safety Institute (FOSI), and the Micro:bit Educational Foundation, with funding provided by PETRAS IoT Hub and research conducted by computer scientists, including Joe Finney, Co-Investigator for the IoT4Kids project, at Lancaster University in the U.K.

"We are progressing to a world where the IoT is becoming commonplace; in fact it is widely believed that less than one percent of computer processors now reside in devices that look like traditional computers," explains Finney. "We must therefore prepare the next generation of citizens to understand, create, and innovate within this world."

The BBC micro:bit was designed to help children prepare for a safe and secure IoT-based future

Cutting-edge technologies come with exciting opportunities, but also new risks, according to Finney. "There is a risk of IoT devices being used for the invasion of privacy, or for covertly tracking others, all of which can contribute to forms of abuse," he says.

"Moreover, children may now even program devices themselves that collect personal data, yet they are not aware of what data is collected and where the data is going."

Exploring risks

How then do we ensure tomorrow's digital innovators can explore the enormous potential of connected devices whilst remaining protected from associated cybersafety risks?

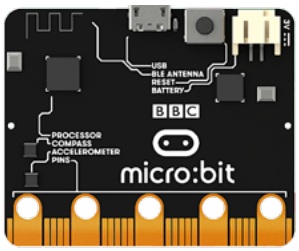
"Research programs such as the IoT4Kids project provide a platform to explore some of the potential risks and take a proactive approach to identifying the potential privacy and security concerns, such that we may then minimize their impact," says Finney.

"We have seen with current technologies that strategies for safeguarding children were only put in place after incidents had already occurred. By speculating a future where many children are programming IoT devices, we can start to uncover the risks and create strategies to educate children around those risks. In effect, we are defining a 'privacy by design' approach that allows manufacturers to avoid risks in their future products.

"We need to raise awareness of what privacy means, how data is collected and where that data goes. We need more education on how IoT devices could be hacked and the risks children might expose themselves to if the devices were to be hacked," says Finney.

The involvement of the Micro:bit Educational Foundation in the IoT4Kids project was a natural evolution for an organization founded around a 2016 British Broadcasting Corporation (BBC) project to provide every year-7 schoolchild in the U.K. with an IoT-ready, programmable handheld computer dubbed the "micro:bit".

A million Nordic-powered micro:bits were given away in 2016



At the heart of the micro:bit is a single Nordic Semiconductor nRF51822 Bluetooth Low Energy (Bluetooth LE) System-on-Chip (SoC), featuring an Arm Cortex M0 processor where the school child-created software code runs, and that also allows the device to both wirelessly communicate with other micro:bits, and sync to or be updated from smartphones, tablets, and computers via Bluetooth.

Privacy by design

For a device specifically designed to help prepare young people for an IoT-based future, the privacy by design approach was central to the micro:bit project from the start.

"The micro:bit was designed to make physical computing as enjoyable and accessible for children as possible, while also addressing the concerns around children's safety and security when using connected and programmable devices," says John Leonard, Product Marketing Manager at Nordic Semiconductor.

"Some connectivity features have a special focus on security aspects, which in some cases meant a limiting of certain functionality," adds Leonard. "For example, the device board is not equipped with Ethernet or Wi-Fi and therefore does not facilitate direct connectivity to the Internet, while minor restrictions were made around pairing the micro:bit to a smartphone via the Bluetooth Low Energy link."

Finney, who also worked on the development of the micro:bit, concurs: "The safety of children was the engineers' highest priority—above the traditional requirements of cost, efficiency, and functionality." ■

Enterprise next for Bluetooth tech

Bluetooth wireless' growth continues unabated and Low Energy technology leads the way by opening up alternative markets. By Caroline Hayes

Caroline Hayes is a U.K.-based technology journalist

This year, nearly four billion devices with Bluetooth technology will ship worldwide, finding uses in factories, homes, offices, transportation systems, and helping support our wireslessly-connected future.

Initially, Bluetooth technology was used primarily for audio streaming, and later in applications such as wireless speakers and in-car infotainment systems. The 2010 introduction of Bluetooth Low Energy (Bluetooth LE) extended the wireless technology to low-throughput data transfer applications in sports and healthcare devices, computing peripherals, and accessories.

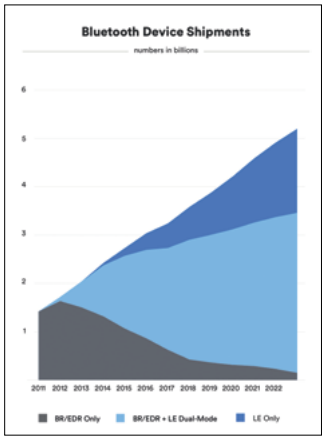
Today, the Internet of Things (IoT) is significantly multiplying demand for Bluetooth LE chips. In its forecasting report, *Bluetooth Market Update 2018*, the Bluetooth SIG predicts that in 2022, around 5.2 billion Bluetooth chips will be shipped, up from 3.6 billion in 2017. Today, 85 percent of Bluetooth chips include LE technology, 13 percent of which are Bluetooth LE-only chips of the kind found in smart devices such as wearables, lighting, and PC peripherals. In 2022, 97 percent of Bluetooth chips will include LE technology of which some 33 percent will be Bluetooth LE-only devices. It seems the battery-friendly variant is proving quite a hit.

Key market expansion

Bluetooth LE chip shipments are being boosted across a range of product sectors. For example, shipments of Bluetooth LE-powered products in the key markets of sports & fitness, health & wellness, and peripherals & accessories are forecast to increase from 850 million shipments in 2018 to 850 million in 2022.

Bluetooth LE chip shipments are being lifted by new enterprise wearable applications, including the healthcare sector

Bluetooth LE is also enabling new markets. For example, by using a broadcast topology, the technology can be used for location and asset-tracking in hospitals and factories, and beacon-based indoor navigation to guide visitors around an area or send retail information to their smartphones. These so-called location services are expected to increase more than four-fold, from a relatively low base, boosting chip shipments from 90 million in 2018 to 400 million by 2022.



COURTESY: BLUETOOTH SIG

By 2022, 97 percent of Bluetooth chips will support Low Energy and LE-only devices will exhibit the fastest growth of all

Bluetooth mesh, a new development for Bluetooth LE introduced in mid-2017 (*see* ULP WQ *Autumn 2017, pg10*) and targeting smart-building networks, is also predicted to drive chip sales. The technology will make it easier to configure, monitor, and automate building systems—such as lighting, heating, ventilation & air conditioning (HVAC), occupancy, and security—to optimize a building's energy use, and reduce operating and maintenance costs. The report notes that building these networks is expected to boost chip shipments in the sector from 170 million in 2018 to 520 million by 2022.

Accelerating connectivity

Market sectors where Bluetooth LE is already established are set to exhibit good growth through diversification. Wearables, for example, will extend into the enterprise sector in the form of smart glasses and wearable scanners for workers. Over 100 million enterprise wearable devices are expected to ship in 2022. Elsewhere, specialized healthcare wearables—providing continuous updates on patients' conditions—will increase by 28 percent compound annual growth rate (CAGR) over the next five years. And in the home, Bluetooth-based consumer robots, to vacuum homes and mow lawns, are forecast to reach nearly 80 million in the same year.

Another significant area for Bluetooth-connected devices is smart industry, where sensor networks can lower equipment downtime by enabling predictive maintenance, as well as track assets and output in manufacturing environments. Bluetooth smart-industry devices are expected to increase by a factor of seven between 2017 and 2022 to push LE chip shipments to 253 million per annum.

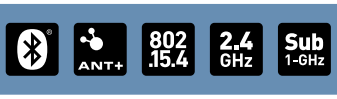
In the home, there are two streams promoting growth. One is the increase in wirelessly-connected appliances, toys, and entertainment devices, the other is the use of mesh technology for home-automation systems to control lighting and heating as well as security cameras and door locks. Lighting is expected to be a leading use case with 54 percent CAGR predicted over the next five years. Overall, home-automation products will use 505 million Bluetooth LE chips a year by 2022, up from 152 million this year.

Different applications demand different capabilities from the Bluetooth LE chip. A PC mouse is a simple application requiring a low-cost wireless chip. A more complex application such as smart lighting demands a mid-level chip while a complex product such as a premium wearable demands a high-end Bluetooth LE chip to support its sophisticated operation.

Nordic Semiconductor offers proven solutions for Bluetooth LE application. Its nRF52 Series, supports the Bluetooth 5, and ranges from the entry-level nRF52810 SoC, through the mid-range nRF52832, up to the high-end nRF52840. Each device is price/performance optimized for a particular set of applications. ■

Ultra low power wireless connectivity solutions

ICs	Operating Band	Wireless Protocol							IC Type			On-Chip										
		Bluetooth 5	Bluetooth Low Energy	ANT	Thread	Zigbee	802.15.4	2.4GHz Proprietary	System-on-Chip	Connectivity	Transceiver	CPU	FPU	DSP	Memory	MPU	PA	On-chip Balun	Clocks	NFC-A tag	2-Wire	ADC
nRF52 Series																						
nRF52840	2.4GHz	●	●	●	●	●	●	●	●			ARM Cortex-M4	●	●	1MB Flash 256kB RAM	●	●	●	64MHz / 32kHz	●	●	●
nRF52832	2.4GHz	●	●	●				●	●			ARM Cortex-M4	●	●	512kB or 256kB Flash 64kB or 32kB RAM	●		●	64MHz / 32kHz	●	●	●
nRF52810	2.4GHz	●	●	●				●	●			ARM Cortex-M4		●	192kB Flash 24kB RAM	●		●	64MHz / 32kHz		●	●
nRF51 Series																						
nRF51822	2.4GHz		●					●	●			Cortex M0			128kB or 256kB Flash 32kB or 16kB RAM	●			16MHz / 32kHz		●	●
nRF51422	2.4GHz		●	●				●	●			Cortex M0			128kB or 256kB Flash 32kB or 16kB RAM	●			16MHz / 32kHz		●	●
nRF51824	2.4GHz		●					●	●			Cortex M0			256kB Flash and 16kB RAM	●			16MHz / 32kHz		●	●
nRF8000 Series																						
nRF8001	2.4GHz		●							●		-			-				16MHz / 32kHz			
nRF24AP Series																						
nRF24AP2-1CH	2.4GHz			●						●		-			-				16MHz / 32kHz			
nRF24AP2-8CH	2.4GHz			●						●		-			-				16MHz / 32kHz			
nRF24AP2-USB	2.4GHz			●						●		-			-				16MHz			
nRF24L Series																						
nRF24LE1	2.4GHz							●	●			8051			16kB + 1.5kB Flash 1kB + 256B RAM				16MHz / 32kHz		●	●
nRF24LE1 OTP	2.4GHz							●	●			8051			16kB + 1kB OTP 1kB + 256B RAM				16MHz / 32kHz		●	●
nRF24LU1+	2.4GHz							●	●			8051			16/32kB Flash 2kB + 256B RAM				16MHz			
nRF24LU1+ OTP	2.4GHz							●	●			8051			16kB + 1kB OTP 2kB + 256B RAM				16MHz			
nRF24L01+	2.4GHz							●			●	-			-				16MHz			
nRF24 Series																						
nRF2460 (mono)	2.4GHz							●		●		-			-				16MHz		●	
nRF900 Series																						
nRF9E5	433 / 868 915MHz							●	●			8051			4kB + 256B RAM				4 / 8 / 12 / 16 / 20MHz			●
nRF905	433 / 868 915MHz							●			●	-			-				4 / 8 / 12 / 16 / 20MHz			



Find the chip you need using this latest listing of every Nordic product

Peripherals													Applications												Ref. Designs	Dev Tools	WLCSP Wafer-level chip-scale package option
AES	Analog Comparator	I2S	PDM	PWM	Real Time Clock	ARM CryptoCell	TRNG	SPI	QSPI	Temperature Sensor	UART	USB	PC Peripherals	Sports & Fitness	Gaming / VR + AR	Mesh Networks	Consumer Electronics	Automation	Healthcare	Toys	Wearables	Smart Home	Beacon	Wireless Charging	Automotive Graded			
●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		-	Single Board Dev Kit, Power Profiler Kit	●
●	●	●	●	●	●		●	●		●	●		●	●	●	●	●	●	●	●	●	●	●	●		PC Desktop, Smart Remote, Smartphone Demo Apps	Single Board Dev Kit, Power Profiler Kit, Nordic Thingy:52	●
●	●		●	●	●		●	●		●	●		●	●	●		●	●	●	●	●	●	●	●		-	Single Board Dev Kit, Power Profiler Kit	●
●	●			●	●		●	●		●	●		●	●	●	●	●	●	●	●	●	●	●	●		PC Desktop, Smart Remote, Smartphone Demo Apps, Beacon	Single Board Dev Kit, Dongle	●
●	●			●	●		●	●		●	●		●	●	●		●	●	●	●	●	●				Smartphone Demo Apps	Single Board Dev Kit, Dongle	●
●	●			●	●		●	●		●	●							●					●	●	●	Smartphone Demo Apps	Single Board Dev Kit, Dongle	
								●		●			●	●	●		●	●	●	●						PC Desktop, Smart Remote, Smartphone Demo Apps	nRFgo Dev Kit, Prog. Kit	
								●			●			●				●	●							Smartphone Demo App	ANT Dev Kit	
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												●		●				●	●							ANT USB Dongle	ANT Dev Kit	
●	●			●	●		●	●			●		●		●		●	●		●						PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit, Prog. Kit	
●	●			●	●		●	●			●		●		●		●	●		●						PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit, Prog. Kit	
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								●					●		●		●			●						-	Eval Kit	
		●						●							●		●			●						Microphone	nRFgo Dev Kit	
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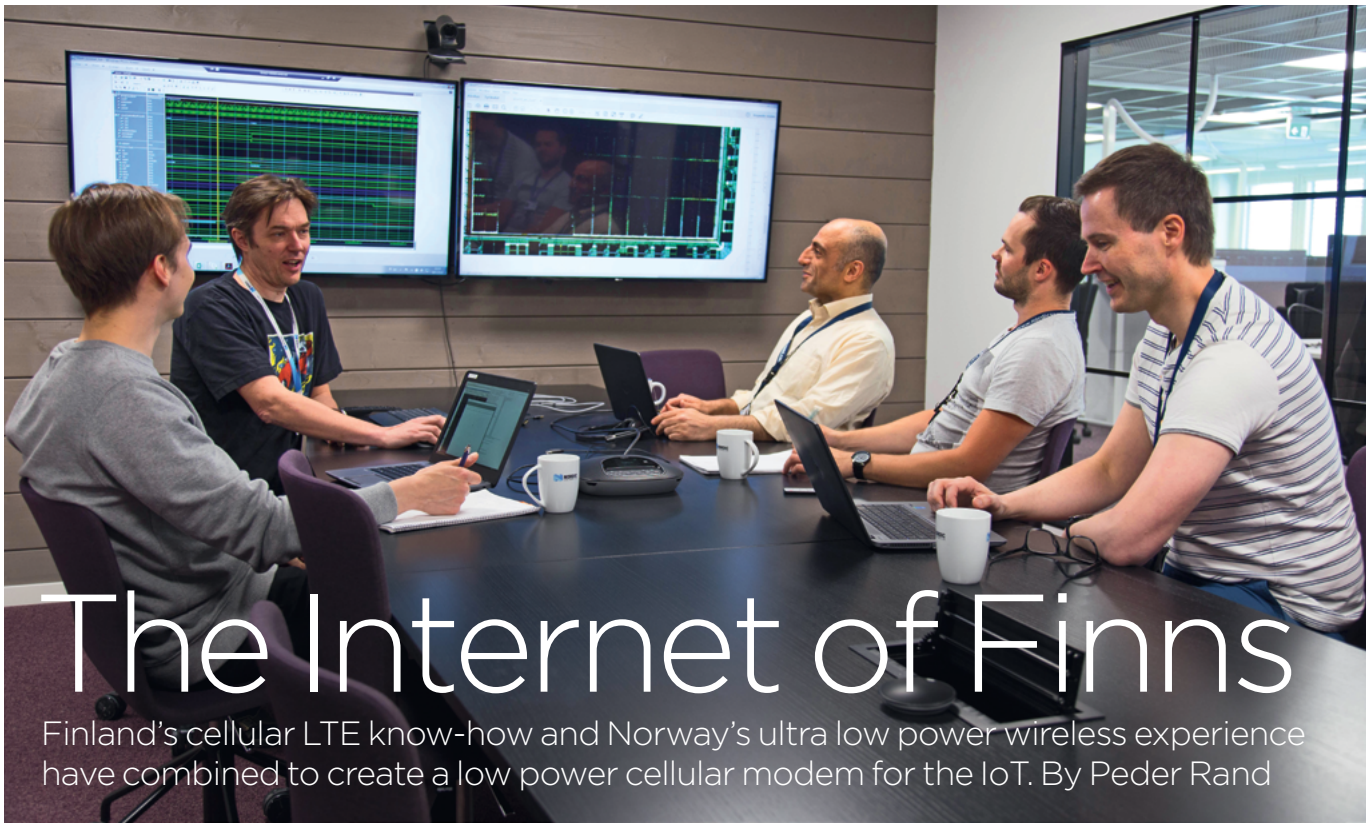

The Internet of Finns

Finland's cellular LTE know-how and Norway's ultra low power wireless experience have combined to create a low power cellular modem for the IoT. By Peder Rand

Nordic's cellular IoT R&D team comprises in part engineers who developed one of the best high-end LTE modems on the market

Peder Rand is Product Manager for Cellular IoT with Nordic Semiconductor

Success in the chip sector isn't just about executing a carefully considered and resourced strategy, sometimes chance comes into play.

In 2014, Nordic Semiconductor was working out the next step in its Internet of Things (IoT) strategy. Meanwhile, the high-tech workforce of Oulu, in Finland's north, was dusting itself down after a round of rationalization by silicon vendors.

In parallel, the 3rd Generation Partnership Project (3GPP), a collaboration of telecoms standard associations, was finalizing a specification that extended modem categories to include LTE products for low power IoT applications.

By early 2015 these three independent events had come together to kickstart a design project that culminated in the launch of Nordic Semiconductor's nRF91 Series, a low power, ultra-compact cellular module suited to the unique demands of the IoT.

Nordic built its reputation on proprietary ultra low power wireless connectivity and in 2010, Nordic's expertise in this technology became part of the core specification for Bluetooth 4.0, a new version of the popular short-range RF open standard which included a Low Energy element. Later, Nordic's nRF51 Series Bluetooth LE solutions found favour with thousands of manufacturers of IoT solutions, such as smart lights and smart locks, across the globe.

Search for talent

By 2014, the company was looking for experienced RF engineers to bolster its R&D team tasked with introducing a new generation of Bluetooth LE Systems-on-Chip (SoCs). News of the availability of a rare pool of talented cellular engineers just across the country's border led to Nordic organizing a recruitment event in Oulu. (*See* ULP WQ *Spring 2016, pg16.*)

Over 200 engineers turned up, including Juha Heikkilä, a veteran 3G and 4G LTE engineer who had started his career with Nokia. When Nokia dropped out of cellular modem design in 2010, selling its assets to Renesas, Heikkilä went too. The pattern was repeated when Broadcom bought Renesas' modem business for $164 million in 2013. In mid-2014, Broadcom decided to focus its investment elsewhere and closed the Oulu plant leaving Heikkilä looking for a new challenge.

He was joined at the Nordic recruitment event by dozens of engineers with similar backgrounds including some who had worked for Ericsson (which moved out of the business in late 2014). In short, the talent available represented the cream of the world's cellular engineering expertise at that time.

"I'd been responsible for running 3G and 4G-modem design teams for years," explains Heikkilä. "I was joined by four similarly-qualified colleagues at the recruitment event. We quickly realized that if Nordic was truly ambitious about its IoT strategy it needed to consider a long-range but low power wireless area network [LPWAN] solution to complement its Bluetooth LE products by enabling Cloud connectivity. Cellular technology was a perfect option."

Bluetooth LE is ideal for local area networks (LAN) but its short-range and lack of TCP/IP Internet interoperability demands a 'gateway'—such as a smartphone or Wi-Fi router—to send data to the Cloud. For IoT applications, gateways introduce complexity, cost, and (depending on the technology) can compromise reliability. In contrast, cellular technology is secure, reliable, and enables Cloud connectivity without a gateway. (*See* ULP WQ *Spring 2018, pg10.*)

According to companies such as telecoms equipment maker, Ericsson, cellular IoT will rapidly expand to power 75 percent of the 1.8 billion LPWAN-connected devices in service by 2023.

It turned out that Nordic and Heikkilä's group had been thinking along similar lines about cellular IoT. Nordic's senior management backed development of an LTE-based product line for IoT applications. By January 2015, Heikkilä, newly

installed as Nordic's Finland General Manager and reporting to Nordic's CTO, Svein-Egil Nielsen, had assembled a team of 60 Finnish LTE experts and opened a dedicated Nordic office in Oulu. (The headcount today has risen to 165 of which all are engineers bar two administration staff.)

At around the same time the 3GPP formally released its specification for lower power category LTE. Later, as part of the subsequent Release 13, this became LTE category M1 (LTE-M) and narrow band (NB)-IoT. The intention was to remove complexity from the modem hardware and encourage development of low cost, low power devices for the LPWANs needed to service the IoT. The specification focused Nordic's Finnish team's efforts on specifically developing LTE-M and NB-IoT cellular products.

Vision into reality

LTE modems present big engineering challenges to design, put into production, and certify. The magnitude of the challenges makes cellular a business only a few companies can afford. In January 2015, the number of global teams that were capable of designing a high-end LTE modem could be counted on the fingers of one hand. One of those teams now worked for Nordic.

"Our team comprises in part the engineers who developed one of the best high-end LTE modems on the market when they worked for Broadcom," explains Heikkilä. "They have been working with LTE from the very beginning."

While LTE-M and NB-IoT modems are simpler than high-end, high data-throughput cellular units, there's no getting away from the requirement for extensive LTE expertise when designing such products. According to Heikkilä, the expertise is even more vital for the lower category products because everything has to be highly-optimized to meet the constraints dictated by the specification.

The nRF91 Series is not a stripped down high-end modem. Some competitors have adopted the stripped-down approach, but Heikkilä explains that his preferred methodology is to design "from the ground up".

Juha Heikkilä worked for Nokia, Renesas, and Broadcom running 3G and 4G modem design teams. He now heads up Nordic's LTE-M/NB-IoT group

"It's a completely new product area. While you definitely need the high-end expertise, if the low power modem is based on a previous design you can be led down a road that leads to compromises to meet the constraints of the specification," says Heikkilä. "We wanted to embark on the project with no pre-conceived ideas to marry innovation with experience and end up with a product that exceeds the specification's requirements and offers customers flexibility to power any IoT application they can think of."

One of the specification's constraints is power consumption; the modems must be designed to run from small batteries for long periods. This is where Nordic's Trondheim R&D team's decade of experience in minimizing the power consumption of Nordic's Bluetooth LE SoCs came into play. This experience, explains Heikkilä, compressed the project timescales. "We would have got there in the end," he says, "but without that in-house expertise it would have taken much, much longer and diverted resources away from the critical and intensive RF design."

Extending cellular heritage

Designing a low power LTE modem is just the start. The cellular spectrum is licensed and regulated; this is an operational advantage because it ensures quality-of-service, coexistence rules, and security, but it also means products connecting with the networks must be certified by the cellular network carriers. Certification is a daunting prospect for companies entering the sector. Nordic eased some of the certification challenges with a single variant capable of running on all the cellular frequencies used across the globe.

However, as a company new to the carriers and integrators some questions were raised about Nordic's ability to make the grade. But once the heritage of the Finnish cellular engineering team working for Nordic became clear, those doubts evaporated.

"The key to success isn't just in making a good job of the engineering side of things," says Heikkilä. "Yes, LTE engineering is very difficult, optimizing power consumption is very difficult, and component integration is very difficult, but what's also very difficult is making sure the product can be manufactured in high volume using as little silicon as possible with very high yields.

"The nRF91 Series integrates radio, application processor, Flash and RAM memory, and power management on the same die. This level of integration pushes the envelope of high-volume, high-yield silicon production."

While high-volume production is still some months away, the product's development is very advanced and at a January 2018 event in Oslo, Nordic unveiled its nRF91 Series to the world. (*See* ULP WQ *Spring 2018, pg8.*)

The success of the nRF91 Series will see Finland's cellular heritage—an essential foundation of the five billion smartphones now in circulation—live on as a key enabler of tomorrow's IoT. ■

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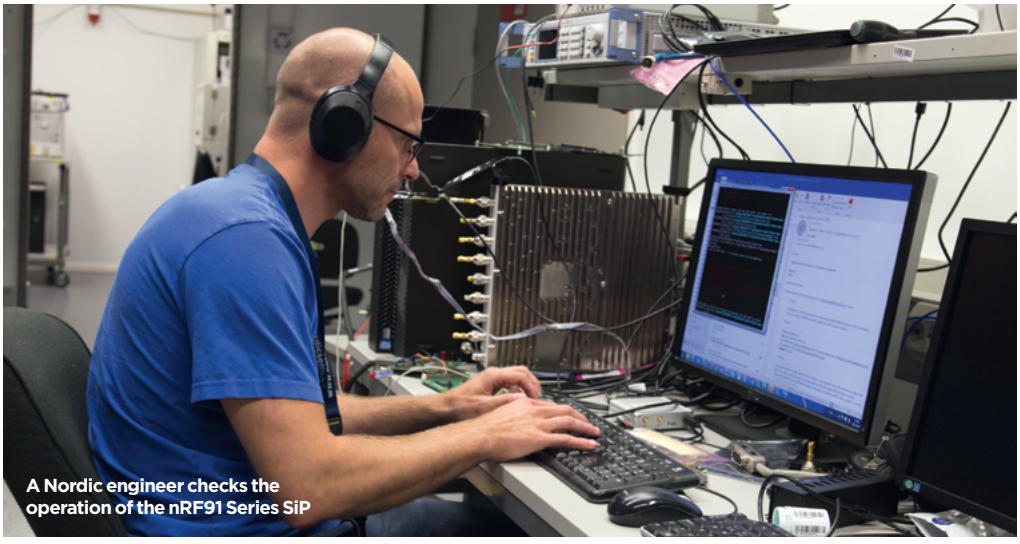
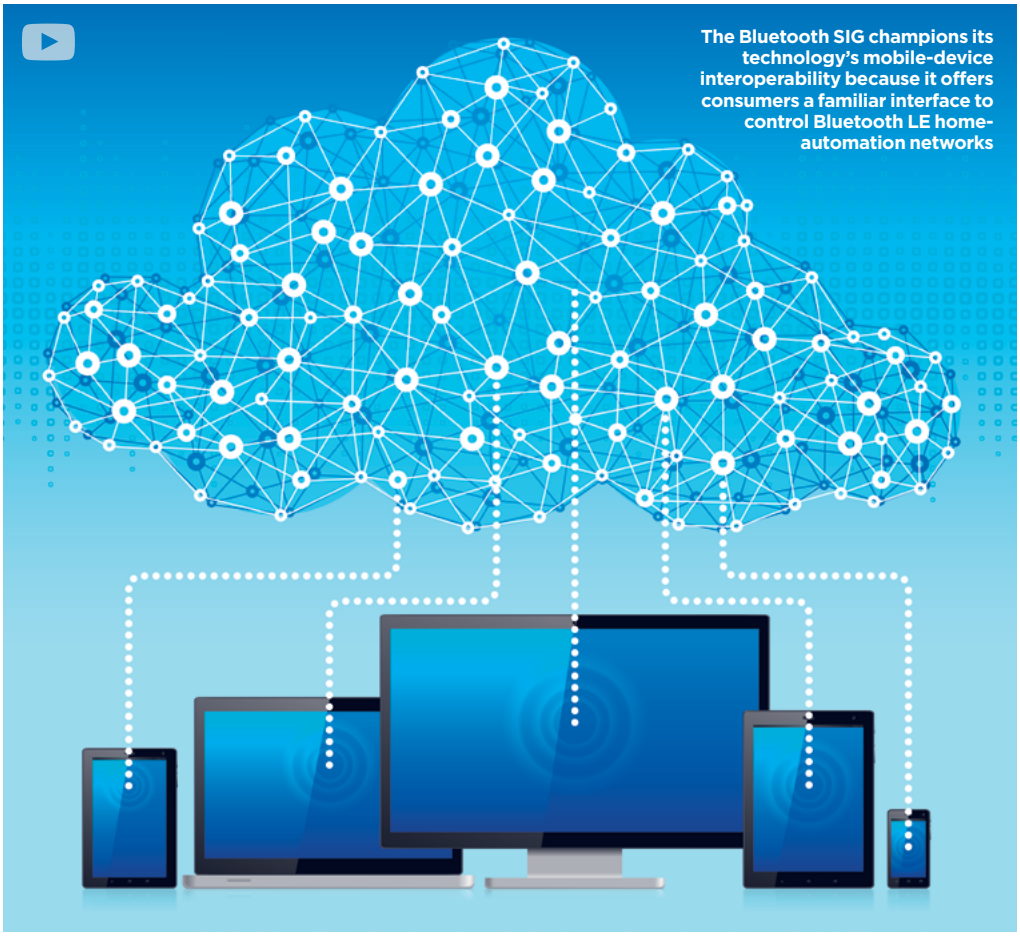


A Nordic engineer checks the operation of the nRF91 Series SiP

Joining the Dot(dot)s with Thread and Zigbee

RF protocols Thread and Zigbee join forces to create a single language that handles the connectivity attributes of everyday objects. Graham Prophet reports

Graham Prophet is a former Editor of EDN Europe and a freelance electronics journalist



The Bluetooth SIG champions its technology's mobile-device interoperability because it offers consumers a familiar interface to control Bluetooth LE home-automation networks

Smart home. Connected home. IoT in the home. The concepts have been around for some time, and have developed into healthy—if, thus far, sometimes niche—markets for a list of end-equipment makers. The pace of adoption looks set to accelerate with the increasing use of voice command devices, such as Amazon's Echo and the Apple HomePod. "Alexa, make the lights in here brighter," may be the spur to boost installation of the systems that give "Alexa" the sensor data to know which spaces are occupied, and what the ambient conditions are, together with the control channels to switch 'things' on and off. At the same time, new developments in the technology for wireless networking continue to offer improved performance, increased flexibility and greater interoperability.

The appeal of reliable, robust, and low power wireless networks using mesh principles has long been obvious, in both the industrial and domestic environments. To succeed in the latter, it is imperative that operation is simple, out-of-the-box, and faultless. For the homeowner, anything other than simple set-up and consistent operation means a product returned to the store. Similarly, while early adopters might settle for proprietary families of devices, the full potential of a market sector can only be realized when products from multiple sources can be used together. Standards are required.

The sequence of events triggering standards is familiar. The bright idea of the moment takes hold in the industry; there is more than one concept of how the idea might be set on course to become a successful product line; groupings and collaborations take root; and in a very short time, competing candidates vie to become, 'the standard'.

When compared to some of the epic standards 'wars' that have marked the development of other categories of technology-based products, low-power, short-range radio has spawned relatively few such efforts, to the sector's benefit. Bluetooth, ANT, Zigbee, and Thread—accompanied by a host of proprietary and non-interoperable offerings using many of the same basic elements—basically covers the technology space.

Standards mature

The basic ideas of low-power, modest-data-rate RF protocols for wireless monitoring and control applications date back more than 20 years. The Zigbee Alliance was constituted in 2002 and has developed a broad-ranging standard. It currently has specifications that span a range of application spaces including home automation lighting control, and smart energy. Member companies now have many millions of products deployed in markets worldwide.

The Thread protocol was a later arrival on the low-power mesh networking scene, with the Thread Group being constituted in 2014; membership at its debut included names such as Arm, Samsung, and Qualcomm. The Thread protocol is structured around use of Internet Protocol (IPv6 addressing) and uses the 6LoWPAN standard; it therefore employs IEEE 802.15.4 RF hardware, as does Zigbee, with silicon available from multiple suppliers. The Thread Group presents the protocol as being specifically designed for the home automation space, with built-in security using established

IP-based techniques. It also claims "battery-friendly" operation and brings the technology to, "...use Internet standards with constrained [limited-resource] embedded devices."

Also present in the home-automation networking space is Bluetooth, coming from a different starting point, as it was conceived to enable wireless point-to-point, device-to-device data links. Through its evolution through Bluetooth Low Energy (Bluetooth LE), Bluetooth recently gained range and throughput enhancements (albeit not concurrently) in the latest iteration (Bluetooth 5) and mesh networking support with the Bluetooth mesh 1.0 release. (*See* ULP WQ *Autumn 2017, pg10.*) The Bluetooth Special Interest Group (SIG) reports market success for its mesh network option in, in particular, the smart-lighting sector. Bluetooth LE is supported natively in all currently available smartphones and tablets, which the Bluetooth SIG sees as an advantage because it offers consumers a familiar interface for controlling wireless home-automation devices.

Creating a single language

Thread and Zigbee have not stood idle while the Bluetooth SIG has enhanced its product for home-automation applications. Rather the groupings have joined forces to champion a new standardization effort; Dotdot. Dotdot represents a move to extend standardization in the higher, application layers of the stacks of existing standards. Dotdot is an effort to create a single language that handles the connectivity attributes of the everyday objects that the IoT aims to animate. It is an "open, common protocol" developed by Zigbee and using the IEEE 802.15.4-compliant physical layer (PHY). At the same time, it runs on Thread's IP-based platform. (*See Figure 1.*)

Dotdot is not, therefore, a new standard in its own right – the Zigbee positioning is that it is a "common layer for IoT [devices] with Thread as a common platform". Dotdot also isn't a ground-up exercise but is based on application-level features already present in the Zigbee specification – the Zigbee Cluster Library (ZCL). ZCL, now "re-branded" as Dotdot, is a set of commands and attributes, spanning multiple Zigbee profiles, that a developer uses to construct products that will interoperate with products from other makers, or that will use Zigbee public profiles (for example, Zigbee Smart Energy). In an analogy with the App Store model of smartphone usage, Dotdot will enable applications to run on any suitable, and compliant, device.

The person who most needs visibility of Dotdot is the developer, so that he or she can readily write the interoperable, device-level code. While consumers will start to see the Dotdot brand name and logo they will be less interested in hearing about the technical detail. For them, the essential attribute is that operation of their networked devices will be simple, intuitive and that everything "just works".

Standards wars are resolved in a number of ways; there may be a process of attrition, with some contenders disappearing; or one of collaboration and convergence. Help may also come from the hardware part of the equation. Successive generations of integrated circuits in a particular technology space build on experience gained; and integration levels increase. In early generations of a product line, there may be different silicon for different firmware/software standards. When later iterations are taped out, the optimum choice for configuring the feature set may be to produce a multiprotocol part that will accommodate all of the relevant protocols and standards freeing the developer from the risk of narrowing his or her options too soon.

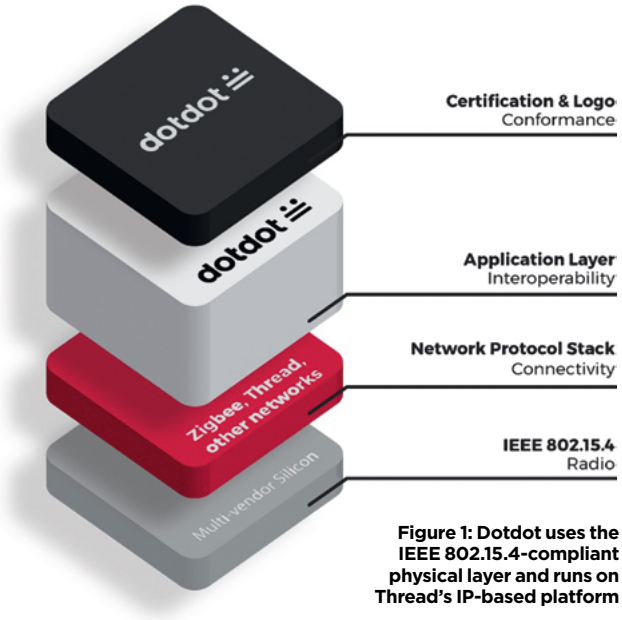


Figure 1: Dotdot uses the IEEE 802.15.4-compliant physical layer and runs on Thread's IP-based platform

"The optimum choice for configuring the feature set may be to produce a multiprotocol part accommodating all the relevant protocols and standards"

Smart lighting is a key sector for mesh-enabled RF protocol standards

An example is Nordic's nRF52840 multiprotocol System-on-Chip (SoC) built around an ARM 32-bit Cortex-M4F microprocessor with 1MB Flash and 256kB RAM. The chip supports Bluetooth 5 and ANT, in addition to configurable, proprietary 2.4GHz operation. Additionally, the nRF52840 includes an IEEE 802.15.4 PHY to support any protocol based on the standard. (*See* ULP WQ *Winter 2017, pg8.*)

The chip is Thread 1.1-certified (running the OpenThread stack) and is accompanied by the nRF5 Software Development Kit (SDK) for Thread and Zigbee. Concurrent operation between the Zigbee/Thread and Bluetooth LE environments enables development of most flexible products to populate the next generation of home, commercial, and industrial networks. ■

Beyond silicon, but where next?

The semiconductor industry is reinventing itself as chip makers try to keep pace with technology demands, particularly in the hotbed that is the IoT. ULP Wireless Q reports

In 2016 the Global Semiconductor Alliance (GSA) released a report, *Charting a New Course for Semiconductors*, at the heart of which lay the question of whether chipmakers would be able to respond to the four-pronged threat of slowing sales, tighter margins, product commoditization, and industry consolidation.

To do so, the report said, would require the industry to identify and adopt a variety of new business models, including embracing open source hardware, and exploiting the arrival of the industry's potential next blockbuster technology platform – the Internet of Things (IoT). Two years on, and the concept of open-source hardware is gaining serious traction, while, according to the analysts, the IoT has moved beyond the nascent opportunity it presented in 2016. The industry has not stood still, but neither have the challenges.

Earlier this year the GSA in concert with Rambus, a U.S.-based vendor of semiconductor technology, released a follow-up report titled *Monetizing Semiconductors – From Silicon to Services*. In it, the paper's authors concede that the challenges facing the industry have intensified in the intervening years. Among continued merger and acquisition (M&A) activity and eroding profit margins, there are still as many questions as answers.

According to the report, while new models for both R&D and revenue are needed, companies are beginning to acknowledge the potential of new markets and downstream revenue opportunities realized from a comprehensive "silicon-to-services model", particularly servicing the IoT.

The IoT installed base is expected to increase by between 15 and 20 percent through 2020, forecasts analyst McKinsey Global Institute (MGI), with an annual economic impact of as much as $11 trillion by 2025 across multiple verticals, chiefly smart cities, smart homes, medical and healthcare, and automotive.

Security first

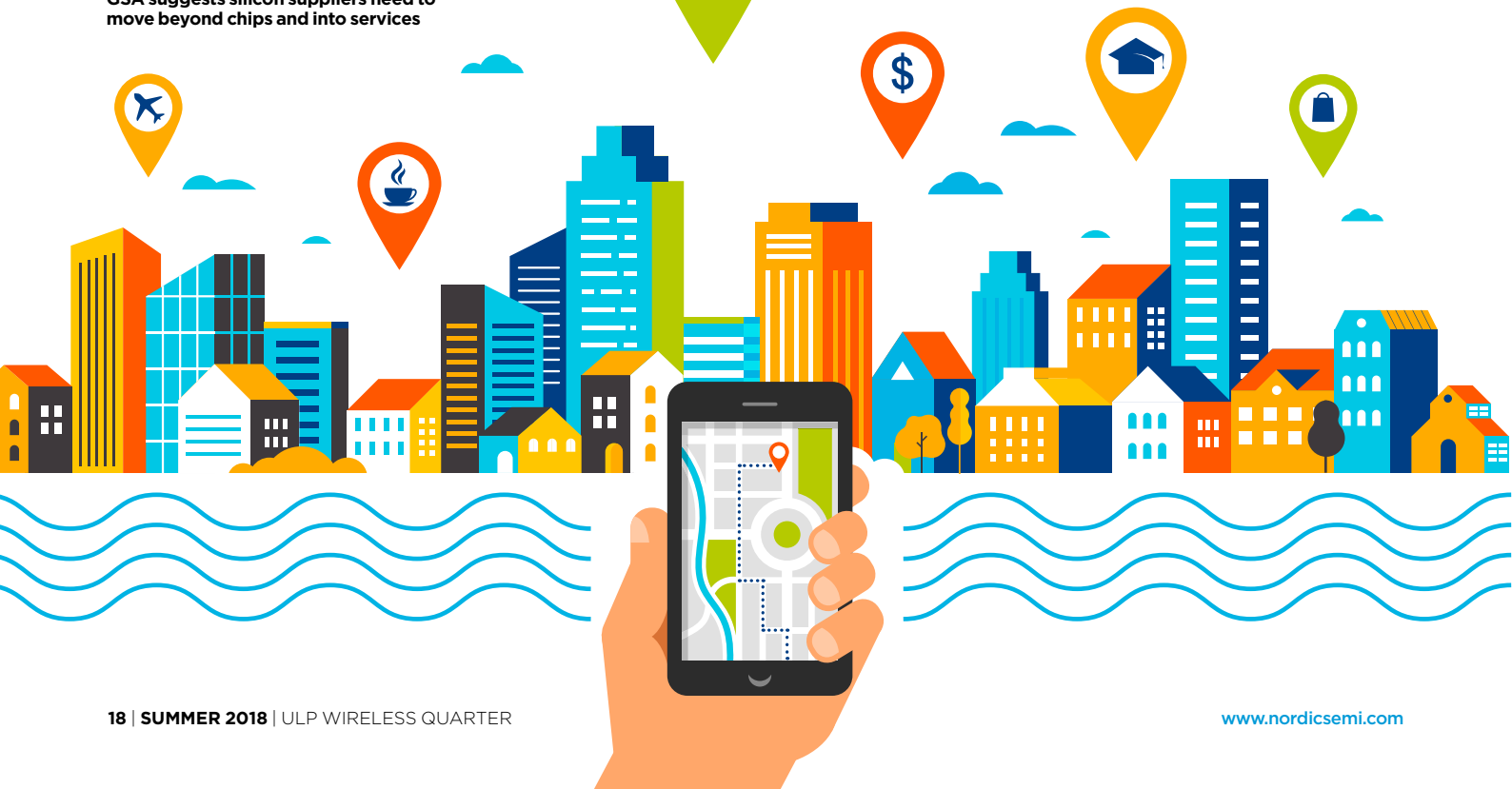
If the MGI estimates are correct, IoT security will present itself as both a major challenge and opportunity for semiconductor companies across the entire IoT spectrum.

According to the GSA report, one opportunity for chip vendors lies beyond the provision of core technology, and in particular in the creation of end-to-end security offerings. The development of 'tailored' security technology—for example, secure device management and low-cost security solutions—will allow semiconductor companies to secure a share of the value chain.

The report said building security in at the design stage could not only help reduce potential IoT service disruptions, but would also allow manufacturers to avoid the difficult and expensive endeavor of adding security measures to IoT devices after they have been deployed. It's a philosophy adopted by Nordic Semiconductor and implemented in its Bluetooth Low Energy (Bluetooth LE) solutions.

According to Pål Kastnes, Technical Marketing Manager with Nordic Semiconductor, connected

GSA suggests silicon suppliers need to move beyond chips and into services



product developers must: "Build devices based on security-hardened platforms and adopt standard security controls. Select the most secure platform as your base on which to develop. Any connected product's architecture should support the ability to patch, quickly, and at scale."

Becoming a service firm

The 2016 and 2018 GSA reports suggest the future for a pure silicon company is limited. Rather, suggest the organization, the chip should be just the start, because helping customers build an end-to-end solution is where the true value lies.

Nordic has moved far down this road and now sees itself as much a service provider as a wireless chip maker. The company has invested heavily in simplifying wireless product development for its customers with hardware reference designs to ease the complexities of RF design, and development kits which include software examples of the most common applications. Further, the recent launch of its Nordic Thingy:52 IoT Development Kit enables an app developer with no firmware coding expertise or high-level development tools to design, configure, test, and demonstrate IoT devices.

Smart homes and cities

If a shift from silicon to services has the potential to deliver greater growth across the semiconductor industry, then smart homes and smart cities loom large as key verticals, according to the GSA report.

These verticals offer recurring revenue streams. For example, a silicon-to-services based vendor, instead of just offering smart-meter technology, could instead sell a platform offering energy management services to utility companies, with companies paying for meaningful and actionable customer information on a subscription basis.

Similarly, the report said, chips embedded in IoT smart city infrastructure could offer semiconductor companies, and indeed their customers, the opportunity to implement a long-term Platform as a Service (PaaS) model.

Platform as a Service allows companies to introduce new business models

"Intelligent street lighting, responsive signage, and next-gen Bluetooth beacons also require future-proofing to avoid constant physical maintenance and upgrades," the GSA report says. "Therefore, silicon powering smart city infrastructure should be capable of supporting secure in-field feature configuration, along with various PaaS-based services such as advanced analytics, predictive maintenance alerts, self-learning algorithms, and intelligent, proactive interaction with customers."

It's an opportunity not lost on Nordic's diverse customer base. Alibaba Cloud IoT, a business unit of e-commerce giant Alibaba's subsidiary company Alibaba Cloud, late last year launched 'Alibaba Cloud Link', a partly Nordic-powered secure IoT platform for Cloud computing, artificial intelligence, big data, content delivery, and Cloud integration processes across home automation, smart city, and industrial applications.

"The platform enables developers, software vendors, and system integrators to not only develop complex IoT applications and scenarios, but also efficiently connect the devices, and manage the device data," says Mark Yang, a specialist with Ali Cloud.

So too Cassia Networks, who last year released the E1000, the first long-range, bidirectional Bluetooth IoT edge processing router for the IoT enterprise market. Cassia Networks CEO, Felix Zhao, said enterprise IoT deployments were by their very nature expensive and complex, and companies that could deliver solutions that reduced cost and complexity were well positioned to succeed in the IoT space. Not least semiconductor companies, and those employing Bluetooth LE in particular.

"According to a May 2017 Cisco report, three quarters of IoT projects are failing," says Zhao. "The new long range Bluetooth Low Energy edge routing capability solves many of the failure points around the IoT namely connectivity, scalability, complexity, and cost.

"Many of the other low power protocols lack a mature business ecosystem. Though they may be deployed in the millions in some cases, building a mature business ecosystem will take billions of dollars and several years. By contrast, the Bluetooth ecosystem is much more mature and is already in place in the many billions, and accelerating."

Ben Corrado, CEO of U.S-based wireless solution company Rigado concurs: "Many manufacturers and integrators are now choosing Bluetooth Low Energy for their Commercial IoT applications—such as asset tracking and smart lighting—and new Bluetooth 5 features make it an even more attractive option," says Corrado. "But using Bluetooth 5 for large-scale IoT deployments requires a solution that addresses flexibility, interoperability, and security."

Which is precisely what Rigado has done with its new 'Edge Connectivity Suite', a device-to-Cloud solution for reducing the cost and risk of commercial IoT deployments, employing Nordic's high-end nRF52840 System-on-Chip (SoC). "We are positioning our Edge Connectivity Suite as the solution to a growing market need at the center of two powerful trends - low power wireless adoption for commercial IoT and edge computing at scale."

As the GSA report says, in 2018 the semiconductor industry continues to seek a return to stability and organic growth, but to do so will need the opportunities that lie within a more comprehensive silicon to services business paradigm. Specific strategies will vary, but the industry is on the front foot.

Further information: The GSA's report is available from the its website at gsaglobal.org. ■

Nordic and Rigado have brought together the Edge Connectivity Suite and the Nordic Thingy:52 to make development of IoT products easier

Wireless tech helps farmers keep track of foraging animals

Using satellite navigation and Bluetooth LE connectivity, the 'Nofence' collar offers farmers an IoT solution to secure and track grazing animals. Kalon Huett explains

Kalon Huett is an Australia-based freelance journalist

The 'Nofence' collar recognizes virtual boundary lines and warns a goat if it strays beyond them

While the rapid advancement of the Internet of Things (IoT) is removing barriers to the development of digitally intelligent devices across various industries, one IoT innovation in the farming sector is removing the barriers entirely - in this case, the fences previously required to secure grazing animals.

Designed by Norwegian agricultural technology company, Nofence, the eponymous virtual fencing system consists of a solar-powered global navigation satellite system (GNSS) collar, and a digital map on the Nofence iOS and Android app for Bluetooth 4.0 (or later) smartphones or tablets. The app allows the farmer to draw a virtual boundary line indicating the area of pasture land where the herd of grazing animals should remain. The system was initially designed for goats, but will eventually be developed for other animals, including cows.

When properly facilitated by an experienced farmer, if the GNSS-enabled collar discovers a goat straying beyond the virtual boundary, the collar will immediately vibrate and make a beeping sound, thereby warning the goat it needs to turn back to familiar pastures.

The success of the Nofence system relies on its ability to communicate bidirectionally between the app and the collar. Initially, the map and virtual boundary data is uploaded to Nofence's server and wirelessly transmitted to the goat's pre-fitted collar. At the same time, all the location, movement, and acceleration data gathered by each collar's GNSS receiver is relayed back to the farmer's smartphone via a cellular network.

The farmer even receives a direct smartphone notification if anything unexpected occurs or there is reason to check on a specific goat; for example, when the goat might have become stuck, escaped, or been taken by a wild animal. This means the farmer is simultaneously able to update virtual boundary lines, monitor individual animals in the herd, and respond to incidents.

Bluetooth LE to the fore

In addition to the GNSS receiver, each collar is also equipped with Nordic's nRF52832 Bluetooth Low Energy (Bluetooth LE) System-on-Chip (SoC), to address key weaknesses of the GNSS receiver – notably battery life and loss of signal.

Since farm animals, particularly goats, often seek refuge in a barn or shelter at night or in bad weather, the Nofence team overcame the lack of GNSS connection caused by a steel-roofed shelter by turning to Bluetooth LE beacons. The use of beacon technology also extended battery life because Bluetooth LE uses much less power than GNSS.

Beacons are installed in the shelters and when a collar moves in range, the GNSS receiver is disabled, and the collar continues to relay the animal's location to the farmer's smartphone, via the beacon, using Bluetooth LE connectivity provided by the Nordic SoC.

"The ultra low power consumption of the Nordic chip was the most important feature of Bluetooth LE functionality for the collar, but we are constantly looking at other ways to use the Nordic SoC in the system," says Oscar Hovde Berntsen, Nofence Founder and CTO.

"For instance if a collar is lost it is possible to press a button in the app that makes the collar play a song, allowing it to be located. We are also looking into mesh networking between collars so that they can cooperate on data transfer. This would enable most of the collars to do without a SIM card because they would transfer data over Bluetooth Low Energy with just a few collars then accessing the cellular network."

According to Berntsen, Nofence has the potential to provide greater flexibility to farmers and, in general, encourage more sustainable farming methods. For example, Nofence allows farmers to: select pasture boundaries based on the qualities of the land rather than its convenience for fencing; replace time spent maintaining fences with time spent looking after animals; utilize non-arable land for feeding animals and use arable land for growing food for human consumption; and generate alternative sources of income, such as renting out goats to help clear wooded areas.

In terms of growth potential, the future for the Nofence system looks promising. "We are developing Nofence collars to be viable for all grazing animals, especially cattle and sheep," says Berntsen. ■

Powerful wireless SoCs meet advanced wearable demands

In the third part of this article, Sebastien Mackaie-Blanchi considers the critical role of firmware for Bluetooth Low Energy SoC operation

Sebastien Mackaie-Blanchi is a Hong Kong-based FAE & Customer Engineering Manager - APAC with Nordic Semiconductor

In the first two parts of this article, we looked at the importance of hardware for complex Bluetooth Low Energy (Bluetooth LE) applications. But hardware is but a single element of Bluetooth LE technology.

The Bluetooth LE stack comprises a three-layer Controller (which includes the hardware, also known as the physical layer or PHY), and three-layer Host. There is nothing to stop anyone coding a Bluetooth LE stack; but it's impractical for most developers to even start. The stack's complexity demands years of coding experience and even when the code is written the software will need long periods of debugging, testing, and verification. A much more practical route for wireless product developers is to select a silicon vendor's PHY and marry it with the same company's own firmware for a complete solution. (Some companies combine their hardware with a third-party's firmware stack and sell it as their "own" product. Such a union can result in a satisfactory solution but can lead to customer problems later if the silicon and software vendors part company.)

Nordic Semiconductor uses its in-house R&D team to forge all of its Bluetooth LE stacks. The company has a good reputation for making sure its stacks feature the latest revisions to the Bluetooth specification, are of the highest quality, and are very robust. For example, Joonho Moon, a Group Leader with Samsung SDS recently said: "Nordic's nRF52832 SoC offered the most up-to-date and stable RF protocol software" for Samsung's SHP-DP930 Smart Doorlock. (*See this issue pg3.*)

It's perhaps not surprising Nordic's firmware has a good reputation. The company has been producing Bluetooth LE stacks for nearly a decade and each goes through an exhaustive testing, debugging, and verification regime before being released. Nordic offers a range of stacks to suit all applications culminating in the S140, (the firmware that accompanies the high-end nRF52840 System-on-Chip (SoC)) a Bluetooth 5-certified stack for building long-range and high-throughput Bluetooth LE applications.

A complete architecture

Many developers enjoy the freedom to write their own application code to optimize the performance of their wireless product and differentiate it from the competition. The application code connects with the stack to form a complete software solution for the end product.

Trasense choose Nordic's nRF52832 SoC and S132 SoftDevice for its high-end sportswatch

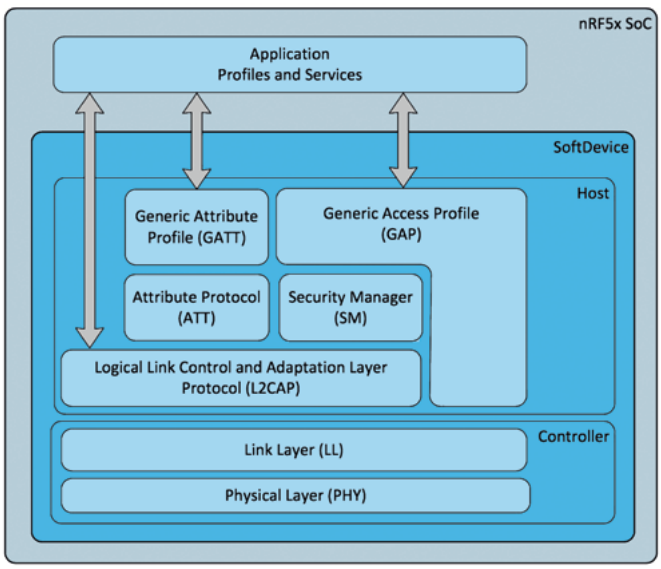
During compilation, the application code and Bluetooth LE stack are interlinked for combined operation. Datasheet images of the Bluetooth LE stack illustrate the application layer neatly positioned atop the stack. It's a nice abstract but with most vendors, the compilation inextricably entwines the stack code with the application code. Such entanglement can make debugging a nightmare and extends the development process. It is also a drawback in the field because over-the-air (OTA) updates require the entire application/stack package to be overwritten. That takes longer, risks corruption of the software, and requires extra (expensive) on-chip Flash memory to handle.

Nordic's approach is uniquely different. The company's stacks (called SoftDevices) are downloaded as tested and verified binary files from the Nordic website. The SoftDevice features an application programming interface (API) which is available to applications for high-level programming language access. This provides the application with complete compiler independence from the SoftDevice implementation. In simple terms this means during application development, compiling, testing, and verification, the SoftDevice remains untouched and the critical dependencies for efficient and reliable stack operation are maintained. (*See* ULP WQ *Summer 2017, pg21.*)

Better yet, because the prequalified SoftDevice is unchanged, it requires no Bluetooth requalification when development is complete. Figure 1, which shows the application code separated from the SoftDevice and only linked where necessary for efficient operation, is a much closer representation of the real situation than other vendors' stack abstracts.

In the field, Nordic's software architecture, with its unique separation, allows either software block to be uploaded without disturbing the other. That dramatically shortens OTA update time and reduces the risk of corruption during the upload. ■

Figure 1: Nordic's Bluetooth LE stack and customer application code remain separated during development



D.O.T Dot Watch

This Bluetooth Low Energy smartwatch wirelessly displays a smartphone's functions and notifications in Braille for vision-impaired users

According to analyst Modor Intelligence, the global smart wearable market was valued at approximately $8.3 billion in 2017, and is expected to reach $35.4 billion by 2023, with the arrival of new sensors and low power radio chips transforming the industry. High growth countries such as India and China are said to be significantly driving the projections

The Dot Watch uses electrodynamic cells to power a refreshable four-cell (24-dot) Braille display on the watch face which relays information transmitted from a smartphone to users with partial sight or blindness, including time and date, incoming calls, and text message notifications

The Dot Watch employs Nordic's nRF52832 SoC to wirelessly relay information from the user's smartphone to the watch via a low-latency link. The smart watch provides a battery life of approximately two weeks, thanks in part to the nRF52832 SoC's ultra low power characteristics

Born in France in 1809, Louis Braille developed the 6-dot finger tip reading system known as Braille after a meeting with Charles Barbier, a captain in Napoleon's army, who shared a communication code called Night Writing he invented in response to Napoleon's demand for a code that soldiers could use to communicate silently and without light at night

In 2001, American Erik Weihenmayer became the first blind person to reach the summit of Mount Everest, a year later becoming only one of 150 mountaineers to complete the 'Seven Summits', the highest peak on each continent in the world. In 2014 he kayaked the entire 277 miles of the Grand Canyon, considered one of the most formidable whitewater challenges on the planet

PEOPLE & PLACES

Jakub Rzeszutko

Martial artist wrestles with software development challenges

Hi, I'm Jakub Rzeszutko and I'm a Senior Firmware Engineer based in Kraków, Poland. Since joining Nordic in January 2017 I have worked primarily on software development, and my main responsibilities include implementing new features and bug fixes in Software Development Kits (SDK) and ensuring delivered products are of the highest quality.

Recently I have also taken on added responsibilities as a team leader for a new initiative. I enjoy working with great people and helping to foster a healthy team spirit. At Nordic I never feel like a cog in the wheel; I know my opinion matters and I'm encouraged to take the time to do things right. When I wake up in the morning, I feel genuinely enthusiastic about going to work.

Last year, myself and two colleagues, Piotr Zięcik and Krzysztof Chruściński, worked very hard on an important and challenging project for a major customer that required a customized method of interacting with software called a command-line interface (CLI). While it can be difficult to remain objective about your own work, I am certainly proud of the results we achieved, and I have received very positive feedback from other Nordic teams using the tool we created.

When taking a break from software development, Jakub (centre) loves practising Brazilian Jiu Jitsu

Outside of work, I am passionate about practising Brazilian Jiu Jitsu (BJJ), which is a full contact martial art limited to submissions by joint locks, chokes, and throws. Kicks and punches are not allowed, so it is a relatively safe sport. Over many years of training I have only ever broken two ribs and one big toe. Unfortunately I have also earned a small cauliflower on my ear, but at the same time I've lost 15 kilograms of fat, so it's been worthwhile! My next goal in BJJ is to gain a purple belt.

When I am on the mat I can forget about the whole world and any problems in my life. While it requires a lot of energy, it's actually a very relaxing experience for me. I always take my gi (kimono) on vacations and business trips because I like visiting other BJJ clubs and sparring with different BJJ practitioners. One time, on my first visit to Trondheim, I turned up for training at the wrong club—this was a traditional Jiu Jitsu club, and the Brazilian Jiu Jitsu club I wanted to visit was actually 2km away. I only had 20 minutes to get there on time, but I didn't want to miss out so I ran the whole way up a steep hill. It's fair to say I was well warmed up by the time I stepped onto the mat.

When I'm not practising BJJ, I enjoy football, tennis, shooting, and skiing, especially in the Alps. It's wonderful to admire the winter landscape, breathe in the fresh air, taste French or Italian cuisine, and take on some long and challenging ski routes. It is also a great opportunity to spend quality time with my family.

Looking ahead, from a professional perspective I would like to continue working on my self-development, and acquiring new skills and knowledge I can use in my career. I am quite a stubborn person, but I see this as a positive trait because I never give up on my goals and I believe patience is eventually rewarded. ■

Personal Profile

NAME:
Jakub Rzeszutko

JOB TITLE:
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JOINED NORDIC:
January 2017

BASED:
Kraków, Poland

INTERESTS INCLUDE:
Brazilian Jiu Jitsu, skiing, football, tennis, shooting

"I am quite a stubborn person, but I see this as a positive trait because I never give up on my goals"

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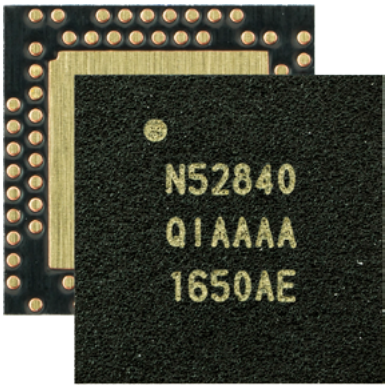

nRF52840 SoC

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Bluetooth® 5

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connect:anything