ultra low power wirelessQ

QUARTER 1 | **SPRING 2018**

COVER STORY

Safeguarding smart lock security

Cellular for everything

Nordic's gateway to the Cloud

Router delivers enterprise IoT

NORDIC SEMICONDUCTOR

OPINION

Svein-Egil Nielsen

Nordic's cellular IoT project passes milestone

Nordic Semiconductor unveiled more details of its cellular Internet of Things (IoT) solution with a peek under the hood of its nRF91 Series System-in-Package (SiP) in January. That peek revealed a highly integrated, ultra compact, low power LTE-M/NB-IoT solution operating on the 4G network of Norwegian carrier Telia. (*See this issue pg8.*)

Although there is still some work to do before the nRF91 Series is commercially available, the unveiling marked a significant milestone in Nordic's cellular IoT project.

It's just three years since two opportunities coincided and the company embarked on this ambitious initiative. The first was when the 3rd Generation Partnership Project (3GPP), a group that looks after the interests of cellular telecoms companies, released a specification for lower power category LTE. Later, as part of the subsequent Release 13, this became LTE-M and NB-IoT. The intention was to remove complexity from the hardware and encourage development of low cost, low power devices for the wide area networks (WANs) needed to service the IoT.

The second opportunity came in the form of the availability of a group of cellular and LTE experts in Finland. Engineers with deep knowledge of cellular technology are a rare commodity and Nordic moved quickly to add them to its team. (*See* ULP WQ *Spring 2016 pg16.*) While it wasn't easy to restructure the company to ensure seamless collaboration between its ultra low power RF experts and newly acquired LTE specialists, the effort has yielded excellent results. There are just a handful of companies across the globe that employ experienced engineers from both these disciplines. And it is exactly these skills that are needed to design and develop a highly-optimized product like the nRF91 Series SiP.

I can't overstate the potential of low power cellular IoT; it will open up applications that technologies such as Bluetooth Low Energy (Bluetooth LE), Wi-Fi, and conventional 3G and 4G cellular just can't support. Bluetooth LE offers a great solution for local area networks (LANs), but its short range and lack of Internet Protocol (IP) support demand gateways to ensure Cloud connectivity. Wi-Fi features IP interoperability but demands too much power for wireless IoT sensors, and conventional cellular modems are bulky, complex, expensive, and bring power challenges of their own. LTE-M and NB-IoT technologies offer sufficient throughput for the low data rates characteristic of IoT sensors, together with kilometers of range, battery-powered operation, and lower cost.

And that's not all. While no wireless technology can claim total immunity to attack, cellular was built with security in mind from the beginning and does offer a high level of protection to sensitive data. Cellular technology also offers better coverage than any other low power WAN alternative and is highly reliable. Moreover, quality of service (QoS) is underwritten by the regulation, licensing, and management of the spectrum allocations used for cellular communication worldwide. (*See this issue pg10.*)

Yours Sincerely,

Svein-Egil Nielsen
Chief Technology Officer

Contributors

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Peder Rand is Product Manager for Cellular IoT with Nordic. On page 10 he charts cellular technology's evolution and what it will mean for the IoT into the future

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Caroline Hayes is a U.K.-based technology journalist specializing in semiconductors. On page 18 she looks at nRF Cloud, a portal designed to help create IoT designs

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Sebastien Mackaie-Blanchi is an Engineering Manager with Nordic. Here he explains how RAM and Flash help engineers get the most out of their Bluetooth LE SoC

Wireless smart locks are secure with effective Bluetooth LE protocol implementation

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NEWS

The latest developments from Nordic Semiconductor

nRF52840 SoC volume production delivers Bluetooth 5 and Thread

Nordic Semiconductor's nRF52840 Bluetooth Low Energy (Bluetooth LE) System-on-Chip (SoC)—the high-end version of Nordic's nRF52 Series of Bluetooth 5-certified SoCs—is now available in production volume for customers worldwide. The SoC's features and peripherals offer the capabilities and flexibility to support a broad range of networked, connected products for wearables, gaming, VR/AR, and home- and industrial-IoT applications.

The nRF52840 is the first single-chip solution to bring all the benefits of Bluetooth 5, including: 2x raw data bandwidth (2 Mbps); 4x range; 8x broadcasting with advertising extensions that increase advertising packet payload to 251 bytes, and an improved channel coexistence algorithm.

The nRF52840 SoC supports a range of complex applications such as wireless VR remote controllers

The SoC launch is accompanied by the production version of Nordic's S140 SoftDevice (the company's latest RF Bluetooth 5-certified protocol), and a new version of Nordic's nRF5 Software Development Kit with peripheral driver support for the nRF52840.

In addition, the nRF52840 SoC is the only multiprotocol device on the market to offer concurrent Bluetooth 5 and Thread support. The capability is enabled by the SoC's Bluetooth LE and Thread 'Dynamic Multiprotocol' feature which allows simultaneous support of the Nordic S140 SoftDevice and OpenThread RF protocol.

The nRF52840 SoC features a new radio architecture with a +8 dBm on-chip PA; 1MB Flash and 256 kB RAM; full support for Bluetooth 5, 802.15.4 (including Thread), ANT, and proprietary 2.4GHz wireless technologies; a full speed USB 2.0 controller, and a full range of peripherals.

Device-to-Cloud platform cuts development time for commercial IoT projects

U.S. wireless solutions company, Rigado, has launched the 'Edge Connectivity Suite', a device-to-Cloud solution for reducing the cost and risk of commercial Internet of Things (IoT) deployments. The suite comprises Rigado's full line of Nordic nRF52 Series modules—including the new nRF52840 SoC-based BMD-340—as well as its Vesta IoT Gateway, and DeviceOps platform for large-scale IoT deployments.

The BMD-340 module provides smart-device manufacturers with a plug-and-play solution to speed time-to-market, while reducing design, testing, and certification costs. Because it incorporates the nRF52840 SoC, the module is fully Bluetooth 5-certified and features full mesh-networking capabilities, making it ideal for applications such as smart lighting.

The nRF52 Series-powered Vesta IoT Gateway is a cost-effective edge router to connect wireless devices, run edge applications, and integrate with Cloud services. The gateway manages long range connectivity to end devices, and ensures data reaches both public and private Cloud services.

The company's Cloud-based DeviceOps tools allow for faster development and secure over-the-air device firmware updates (OFA-DFU) at scale, allowing developers to quickly push new builds to their gateways during prototyping.

The BMD-340 module provides smart-device manufacturers with a plug-and-play solution

"Many manufacturers and integrators are now choosing Bluetooth 5 for their Commercial IoT applications," says Ben Corrado, CEO at Rigado. "Rigado's Edge Connectivity Suite provides flexibility, interoperability, and security for large-scale IoT deployments."

In brief

Bluetooth Low Energy drives Nordic growth

Nordic Semiconductor has reported full 2017 revenue of $236 million, representing growth of 19.4 percent over 2016 full year revenue. The result comes on the back of continued strong performance in Bluetooth Low Energy which contributed $150 million in revenue in 2017, an increase of 40.1 percent over the previous year. For Bluetooth LE, both the building/retail and healthcare markets grew revenue significantly in 2017 over 2016, up 90 percent and 80 percent respectively.

China pushes cellular IoT market growth

A new report from the IoT market research firm, Berg Insight, estimates global cellular IoT subscribers increased by 56 percent during 2017 to reach 647.5 million. The number is forecast to reach almost 1 billion at the end of 2018. According to Berg Insight, China is playing a key role in transforming the market, as the Chinese government has set a goal to connect 600 million devices to NB-IoT networks by 2020. NB-IoT will replace 2G, which accounted for the bulk of Chinese connections in 2017.

BBC Micro:bit proves its processing muscle

The BBC Micro:bit—the Nordic nRF51822-powered computer given free to 11-12 year old school children in the U.K. in 2016—has won a competition against some computers from the last 80 years, to see which device could produce the most numbers from the Fibonacci sequence in 15 seconds. During the contest, the Micro:bit produced 8,843 numbers in the sequence to beat off rivals, including a modern smartphone, that only produced four numbers in the allotted time.

In brief

Nordic pens Avnet distribution deal

Nordic Semiconductor has signed a new distribution agreement with Avnet, covering sales and support for Nordic's ultra low power wireless solutions in the Americas. The agreement covers Nordic's complete range of wireless connectivity hardware, firmware, and development tools, and extends the existing European and APAC franchise relationships between the two companies. The new agreement covers the U.S., Canada, and Latin America, and will see Avnet provide complete pre- and post-sales support to OEM customers.

Beacon market set to boom by 2024

According to a new research report by Global Market Insights, the market for beacon technology will exceed $25 billion by 2024, on the back of increasing global smartphone penetration and the need for location-based proximity marketing solutions. The report said Apple's iBeacon is expected to account for over 50 percent market share by 2024 owing to large scale early adoption of the platform by key vendors, while Google's Eddystone is projected to exhibit high growth between 2017 and 2024 due to an extensive Android user-base.

WL-CSP module for access applications

LEGIC, a Swiss contactless identification solutions provider, has released its SM-6300 module, designed to support a wide array of highly secure, flexible personal identification and access applications. Employing Nordic's nRF52832 Wafer Level Chip Scale Package (WL-CSP) System-on-Chip, the module offers a development platform for engineers requiring a secure wireless identification process, for example storage or payment solutions, and access to shared-economy assets like bikes and cars.

Long-range Bluetooth LE router enables real time edge processing

Internet of Things (IoT) solutions company, Cassia Networks, has unveiled its E1000 Bluetooth IoTEdge Router, a long-range Bluetooth router designed for enterprise IoT deployments across industrial, healthcare, smart city, retail, and education applications.

Employing Nordic's Bluetooth 5-certified nRF52832 System-on-Chip (SoC), the router significantly reduces the cost, and increases the power, of long-range IoT gateways. Specifically, the number of Bluetooth LE pairing connections to devices increases, providing up to 40 real-time bidirectional links, bandwidth capacity is doubled, and 'edge' processing of third-party applications is enabled. The router is said to extend Bluetooth LE connectivity to over 300 m.

The router reduces the cost and complexity of enterprise IoT deployments, especially when compared with using smartphones as IoT gateways. Moreover, the router's edge processing capability—powered by the Nordic SoC—facilitates new third-party Bluetooth LE applications for enterprise IoT.

The router extends Bluetooth LE connectivity to over 300 meters

In an enterprise IoT application, which may use hundreds of long-range Bluetooth routers, seamless configuration and management is delivered using a local server, or the Cloud-based Cassia IoT Access Controller (AC). The Cassia AC can monitor thousands of connected devices from a single centralized interface. In addition, a dashboard provides a network data display, single click firmware upgrades, device location management, and encrypted end-to-end security.

"The new long-range Bluetooth LE edge routing capability solves many of the failure points of older IoT enterprise deployments including connectivity, scalability, complexity, and cost," says Felix Zhao, Cassia Networks CEO. "Long-range Bluetooth LE does this by delivering a worldwide standard. It connects billions of existing Bluetooth LE sensors to existing infrastructure, using low power, over long-range, at an extremely low price point."

Low latency Bluetooth LE Smart Button delivers dynamic content

U.S.-based smart technology company, BEAM Authentic, has launched the BEAM Smart Button, a wearable communication platform allowing users to dynamically display personalized content on the button's 24-bit true color AMOLED display.

Targeted at consumer-facing organizations in retail, hospitality, and entertainment, the BEAM Smart Button employs Bluetooth Low Energy (Bluetooth LE) connectivity provided by Nordic's nRF52832 System-on-Chip (SoC) to display single static images, slideshows, and animated GIFs.

From the BEAM Authentic app on the user's Bluetooth 4.0 (and later) smartphone or tablet, users can find, edit, or create content from a range of sources including their own image gallery, web pages, or other BEAM users. Thanks to the low latency Bluetooth LE wireless connectivity provided by the Nordic SoC, the selected image is instantly displayed on the button.

Smart Button users can find, edit, or create content from library sources

From the app the user can also control several power management features such as button screen brightness, auto-sleep, as well as the button's ambient light sensor, by which the device will adjust brightness.

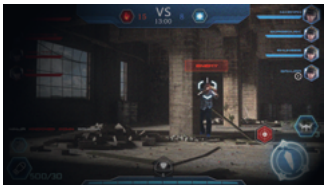
The nRF52832 SoC's 512kB Flash memory provides each BEAM Smart Button with the capacity to store 100 'BEAMS', while ultra low power consumption supports 24 hrs per charge battery life.

"For the best user experience speed of transmission was key, and the datarate provided by the Nordic SoC was a big reason behind our decision to use it," says Andrew Zenoff, CEO at BEAM Authentic.

Portable augmented reality gaming device offers low-latency multiplayer action

Shenzhen Geekplay Technology Co. Ltd, a China-based developer of Augmented Reality (AR) tech-toys and gaming apps, has unveiled a portable AR gaming device called Geek Unit, that attaches to the back of the user's smartphone and converts real-world scenery and objects into a gaming arena via one of two partner apps.

Enabled by Nordic's nRF52832 System-on-Chip's (SoC) support of both Central and Peripheral Bluetooth Low Energy (Bluetooth LE) roles, each device establishes a low-latency link to the user's smartphone as well as up to seven other smartphone-attached Geek Unit devices at the same time. This allows multiplayer AR-based gaming in a diverse range of physical environments.



Geek Unit can support up to eight players simultaneously

Users can launch either the Geekplay app for a large-scale game of AR 'laser tag' where tangible objects act as battle obstacles, or the Geek Unit app to access 360° scalable arena games developed by Apple ARKit, an advanced AR technology platform. The Geek Unit device is supplied with a built-in lithium battery that offers approximately 300 days of standby time and 15 hours of continuous operation thanks in part to the ultra low power consumption of the Nordic SoC.

"By adopting Bluetooth LE wireless connectivity through the Nordic SoC, our products can set up high-speed personal arena networks for smooth communication and cable-free gaming among multiple players," says Spencer Dai, Branding Director at Geekplay.

Multifunction bike computer delivers key performance data

Shanghai-based cycling technology company, DaBuZiDuo, has launched a multifunction bike computer named XOSS SPRINT, offering cycling enthusiasts a comprehensive range of performance benefits including professional workout data recording and analysis, global offline map rendering, and powerful GPS route navigation.

Employing Bluetooth Low Energy (Bluetooth LE) wireless connectivity enabled by Nordic's nRF52832 System-on-Chip (SoC), users can access key riding information via the 'Xingzhe' partner app on their compatible iOS or Android smartphone.

DaBuZiDuo's proprietary "Fusion" Dual Connection technology allows users to choose between Bluetooth LE and ANT+ wireless connectivity when linking complementary third-party devices to their XOSS SPRINT. Leveraging the SoC's 2.4GHz multiprotocol radio and Nordic's flexible RF software protocol 'stack', the bike computer supports peripherals such as a power meter, heart rate monitor, and cadence and speed sensors.

Users can access key riding information via the partner app on their smartphone

The device features up to nine customized, high-resolution data displays and a 2.7-in (69-mm) reflective Memory LCD screen which the company claims supports good readability in sunlight, while its lithium polymer battery provides 37 hours of continuous GPS recording and three months or more of standby time.

"The nRF52832 SoC meets the important power consumption requirements of the XOSS SPRINT, and the multiprotocol compatibility significantly simplifies our hardware design," says Mao Feng, Hardware Leader at DaBuZiDuo.

Nordic and Rigado partner on IoT DK

Nordic and Rigado have partnered to create the Rigado IoT Development Kit (DK), which combines Rigado's Vesta IoT Gateway with Nordic's Thingy:52 IoT Sensor Kit. The Thingy:52 IoT Sensor Kit enables app developers to configure, test, and demonstrate Bluetooth Low Energy IoT devices linked to mobile apps and Cloud platforms. The Rigado IoT DK includes sample software that makes it easy to capture sensor information from the Thingy:52 and analyze and display it through Rigado's Gateway Web app, or stream sensor data to the Cloud.

China dominates cellular IoT share

A new report from the IoT analyst firm Berg Insight claims the ten leading global mobile operator groups have a combined market share of 76 percent in cellular IoT. The top players reported a combined active base of 407 million cellular IoT connections at the end of the first half of 2017. China Mobile was number one with 150 million IoT connections in the period, well ahead of Vodafone in second with a reported 59 million connections. Chinese mobile operators held three of the top five positions, according to the analyst.

In brief

Nordic Semiconductor joins Thread Group's Board of Directors

Nordic Semiconductor has upgraded its Thread Group membership to the Sponsor level, and has appointed Pär Håkansson, Nordic's Product Marketing Manager responsible for the products and strategies for the smart home, to the group's Board of Directors.

The Thread Group is an industry alliance that manages Thread, an IPv6 low power wireless connectivity specification.

Håkansson was appointed to the board in December 2017 and has spent the last decade in the low power wireless industry, holding positions in research, business development, and product marketing. Håkansson joined Nordic in 2015.

Thread addresses device connectivity challenges in the home and beyond with a low-power, open-standard, IP-based approach to wireless networks supporting many applications, many use cases, many devices, and many Clouds.

The technology is designed to operate as one network with no hubs. For the last 12 months, Nordic engineers have been helping to develop the Thread specification.

Nordic's nRF52840 SoC, a high-end, multiprotocol, low power wireless connectivity solution, became a Thread 1.1 certified component in September 2017.

"We are excited to see Nordic strengthening its leadership in low power wireless technology with this step to accelerate and grow the Thread market," says Grant Erickson, President of the Thread Group. "We are confident Nordic's investment will lead to new and innovative Thread-based products that showcase the value of Thread for end-to-end connected devices."

Pär Håkansson has worked in low power wireless for ten years

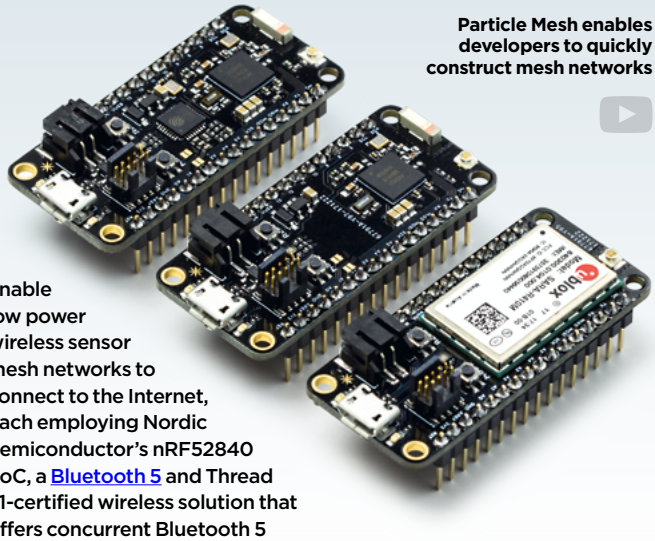
"I believe my technical and marketing expertise in low power wireless will assist in making Thread a success," says Håkansson. "The group has a busy program ahead aimed at increasing awareness of the Thread brand, collaboration with other organizations, and introducing technology enhancements."

Thread development tools enable rapid design of Cloud-connected mesh networks

U.S. developer of Internet-of-Things (IoT) platforms, Particle, has launched its Particle Mesh suite, an end-to-end mesh networking development platform, enabling developers to quickly construct mesh networks comprising IEEE 802.15.4 nodes running OpenThread.

OpenThread is an open-source version of Thread, a low power wireless connectivity specification which includes robust security, reliability, scalability, and support for developer-friendly IP-based (IPv6 with 6LoWPAN) mesh networking.

The Particle Mesh solution includes three IoT gateway variants, the 'Argon' (supporting Wi-Fi/Mesh/ Bluetooth Low Energy (Bluetooth LE)), the 'Boron' (LTE M1 and NB1/Mesh/ Bluetooth LE), and the 'Xenon' (Mesh/Bluetooth LE). These all enable low power wireless sensor mesh networks to connect to the Internet, each employing Nordic Semiconductor's nRF52840 SoC, a Bluetooth 5 and Thread 1.1-certified wireless solution that offers concurrent Bluetooth 5 and Thread support.



Particle Mesh enables developers to quickly construct mesh networks

The Particle Mesh gateways use the nRF52840 SoC's Thread capability to communicate with other Thread devices on the mesh network while the Bluetooth LE connectivity allows developers to use Bluetooth 4.0 (and later) smartphones and tablets for mesh set-up, deployment, and diagnostics in the field.

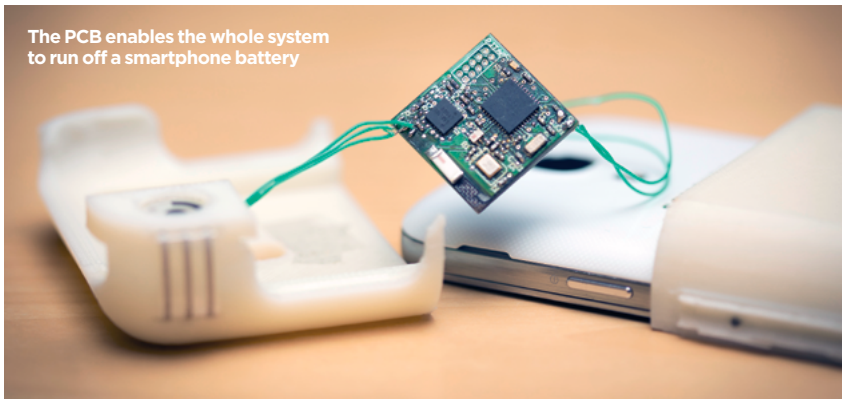
The Particle Mesh development kits are pre-configured to fully integrate with Particle's Device Cloud, a unique set of development tools and Cloud infrastructure, to build, connect, and manage mesh networks.

"We selected Thread over other mesh networking solutions because of its maturity in market, ability to scale to large networks, use of open standards, and the availability of open source implementations," says William Hart, General Manager of Prototyping at Particle. "Bluetooth LE is also a critical component of Particle Mesh and bidirectional communication between a smartphone and the Particle Mesh device to simplify device setup, deployment, and diagnostics.

"Because we needed both Thread and Bluetooth LE support, Nordic's nRF52840 SoC was an ideal choice for our new Particle Mesh hardware solutions."

ULP WIRELESS TRENDS

The latest developments in technology



The PCB enables the whole system to run off a smartphone battery

COURTESY: DAVID BAILLOT/UC SAN DIEGO

Smartphone case tracks blood glucose

Engineers at the University of California San Diego have developed a smartphone case and app that could make it easier for patients to record and track their blood glucose readings. The device, called GlucPhone, comprises a slim, 3D printed case that fits over a smartphone with a permanent, reusable sensor on one corner, and small enzyme-packed pellets that magnetically attach to the sensor.

The pellets are housed inside a 3D printed stylus attached to the side of the smartphone case. The pellets contain an enzyme called glucose oxidase that reacts with glucose. This reaction generates an electrical signal that can be measured by the sensor's electrodes. The greater the signal, the higher the glucose concentration.

To run a test, the user takes the stylus and dispenses a pellet onto the sensor and adds blood. The sensor measures the blood glucose concentration then wirelessly transmits the data via Bluetooth Low Energy to an Android app that displays the numbers on the smartphone screen. The test takes about 20 seconds. A compact PCB enables the whole system to run from a smartphone battery.

"Integrating blood glucose sensing into a smartphone would eliminate the need for patients to carry a separate device," says co-developer Patrick Mercier, from UC San Diego. "An added benefit is the ability to autonomously store, process, and send blood glucose readings from the phone to a care provider or Cloud service."

"This system is versatile and can be easily modified to detect other substances for use in healthcare, environmental, and defense applications," adds Joseph Wang, UC San Diego Nanoengineering Professor, and Mercier's research colleague.

ShopTalk helps blind people navigate through retail stores

Beacons open doors for visually-impaired

A new project called ShopTalk, launched by the Canadian National Institute for the Blind (CNIB), helps blind and partially-sighted people navigate through doors, to service counters, washrooms, and other parts of commercial buildings, by providing step-by-step directions.

The ShopTalk project installs and programs Apple iBeacons that use Bluetooth Low Energy to wirelessly connect with nearby users' phones via an iOS app called BlindSquare. It provides directions to help them safely and independently navigate their way through retail stores and restaurants, or wherever they are installed.

According to Susan Vaile, a visually-impaired resident of Toronto, the beacons make it possible for customers like herself to find their way independently, just by listening to directions on their smartphone. When the user passes by shops or landmarks, BlindSquare provides feedback on how far they are away, and in what direction they need to travel.

The technology has been used in other cities, most notably in Wellington, NZ.

Virtual cocktail digitally simulates smell, taste, and sight

An interactive drinking device called Vocktail, developed by the National University of Singapore, allows users to customize a 'virtual cocktail' that researchers say smells, tastes, and looks like the real thing.

Vocktail digitally simulates distinct tastes, smells, and colors to create new virtual flavors or augment existing flavors in order to achieve the ideal concoction, without physically mixing beverages and ingredients.

Vocktail consists of a cocktail glass seamlessly fused into a 3D-printed base, which holds the electronic control module and three micro air-pumps connected to three scent cartridges. The device is coupled with a mobile application that enables users to create customized virtual flavors by remotely configuring the taste, smell, and color stimuli via Bluetooth Low Energy.

Vocktail allows users to customize a virtual cocktail that smells, tastes, and looks like the real thing

Two silver electrodes on the rim of the glass provide controlled electrical currents of different magnitudes and frequencies to the tip of the tongue in order to simulate salty or sour sensations while drinking. To alter smell, the air-pumps release molecules from the chosen scent cartridges directly onto the surface of the beverage, which is close to the user's nose when drinking. Users can add or change cartridges.

Since visual stimuli form pre-taste perceptions, users can select their preferred color with the mobile application which projects an LED light onto the beverage. The combination of these three stimuli delivers a rich virtual flavor experience, say the researchers. The team is currently working to customize other aspects, such as the fizziness and texture of the beverage, to create a more realistic experience.

First look at Nordic's LTE/NB-IoT System-in-Package for cellular IoT

A sneak peek of the nRF91 Series SiP reveals an ultra compact, low power, multimode cellular IoT solution for everything beyond the smartphone

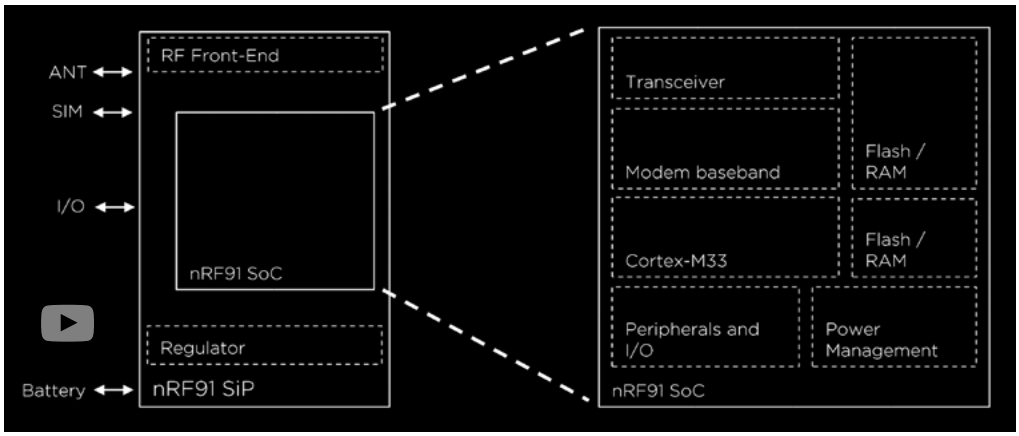
Cellular IoT is a low power, long-range wireless Internet of Things (IoT) technology that leverages the Long Term Evolution (LTE) 4G global cellular network via the latest LTE category M1 (LTE-M) and narrow band (NB)-IoT standards to connect 'things' directly to the Cloud. *(See* ULP WQ *Spring 2017, pg10.)*

Over the past three years, Nordic Semiconductor's engineers have been working hard designing and developing a low power LTE-M/NB-IoT cellular IoT product that will drive massive uptake of the technology and enable brand new markets that can't be supported by traditional cellular technology.

"Back in early 2015, we set out on a mission to create a truly different solution for cellular IoT," explained Thomas Embla Bonnerud, Director of Strategy and Investor Relations at Nordic in a presentation in Oslo during January. "A highly integrated, low power, ultra-compact solution that would foster innovation and accelerate adoption of cellular connectivity."

The result of that mission, the nRF91 Series low power cellular IoT solution, was unveiled at the same Oslo presentation. The product has been jointly developed by Nordic's highly experienced cellular design team in Finland and its low power wireless experts in Norway. The nRF91 Series was developed from scratch to optimize the power, cost, and size savings enabled by the LTE-M and NB-IoT cellular standards. The solution features an unprecedented and unique level of integration by combining a multimode cellular modem and transceiver, as well as application processor, Flash memory, RAM, and power management.

The heart of Nordic's nRF91 Series is formed by the company's low power, global multimode LTE-M/NB-IoT System-in-Package (SiP). The SiP forms a complete low power cellular IoT system in a 10 by 16 by 1.2-mm package that integrates modem, transceiver, RF front end, dedicated application processor, Flash memory, power management, and crystal and passive components.



The nRF91 Series SiP has been jointly developed by Nordic's experienced cellular design team in Finland and its low power wireless experts in Norway. The SiP comprises RF front-end, nRF91 Series SoC, and regulator

The SiP combines all the benefits of traditional cellular modules, including tele-regulatory and cellular certifications, into a form factor with a footprint 33 percent the area, 50 percent the thickness, and 20 percent the total packaging volume of competing solutions.

The SiP is based on an integrated Arm Cortex-M33 host processor. The embedded processor features TrustZone for Armv8-M together with Arm CryptoCell-310 security IP. Such an arrangement secures application data, firmware, and peripherals using an isolated, trusted execution environment across the microprocessor and system. This solution provides an efficient security foundation, and reduces size, bill-of-materials (BOM), and power consumption compared to using an external host processor.

Nordic has partnered with Qorvo, a U.S.-based RF connectivity solutions company as a strategic partner for both the RF front end and the SiP development and manufacturing. The nRF91 SiP employs Qorvo's proven RF front-end, advanced packaging, and MicroShield technology to deliver a compact solution that combines high performance with low power consumption. The nRF91 Series supports global operation with a single SiP variant thanks to the combination of Nordic's multimode LTE-M / NB-IoT modem, SAW-less transceiver, and a custom RF front-end solution from Qorvo.

Nordic's low power cellular IoT solution also features built-in support for positioning via integrated Assisted GPS (A-GPS) technology that combines cellular and GPS technology for fast and accurate positioning.

Encouraging LPWANs

The nRF91 Series is designed to comply with the LTE-M and NB-IoT standards introduced by the 3rd Generation Partnership Project (3GPP) to encourage the development of cellular-based low power wide area network (LPWAN) technologies.

These technologies form a secure, reliable, and globally-supported link between local area networks (LANs) based on low power wireless protocols such as Bluetooth LE or Thread, and the Cloud.

According to a report by telecom equipment maker Ericsson, cellular will power 75 percent of the 1.8 billion LPWAN connected devices in service by 2023. Cellular carriers such as Norway's Telia are already seeing a large appetite for such connectivity.

"Telia is experiencing an unprecedented demand for dedicated IoT connectivity represented by LTE-M and NB-IoT," said Andreas Carlsson – Head of Telia Next in a statement.

"That's why Telia has been a supportive partner to Nordic Semiconductor in its development of the new product."

Nordic is sampling the nRF91 Series SiP to selected lead customers now. Start of general sampling is planned for mid-2018, with first production quantities available by end of 2018. ■

Bluetooth Low Energy rapidly expands into industrial markets

Bluetooth LE technology is growing far beyond its consumer roots by underpinning innovative solutions for the Industrial Internet of Things

The industrial sector is turning to Bluetooth LE technology to fuel a smart factory revolution

Until recently, Bluetooth Low Energy (Bluetooth LE) technology was renowned as a low cost, widely available wireless connectivity solution for short-range consumer applications. While this reputation still holds true, the overall wireless connectivity landscape is shifting. Complex Internet of Things (IoT) applications are increasingly looking to the Bluetooth LE protocol to enable sophisticated industrial and consumer applications, and deliver data-driven insights on an unprecedented scale.

Over the past several years the custodian of the Bluetooth standard, the Bluetooth Special Interest Group (SIG), has added enhancements to Bluetooth LE to position it as a foundation protocol for a global IoT market. It's a market that's advancing at a rapid rate. While industry forecasts vary, top-end numbers on IoT spending reach $227 billion by 2021, according to global software company PTC's "*The State of the Industrial Internet of Things 2017*" report.

As a result of its positioning as a foundation IoT protocol, Bluetooth LE technology is directly influencing the market, expanding far beyond its consumer roots into industrial and commercial sectors including building, retail, healthcare, automotive, defence, energy, and aerospace engineering.

The numbers confirm this shift; according to analyst On World Inc's "*Bluetooth Low Energy IoT: A Market Dynamics Report*" annual shipments of Bluetooth LE chipsets for IoT markets will increase by an incredible 524 per cent between 2016 and 2022, with wireless sensor network markets in particular—for example, industrial sensors and building automation networks—increasing three times faster than other Bluetooth LE IoT markets during the same period.

As a leading Bluetooth LE solution vendor, with over 45 percent of Bluetooth LE end-product certifications in Q4 2017, Nordic Semiconductor is experiencing a similar shift in its end markets. Where industrial and commercial marketshare accounted for 29 percent of Nordic's wireless revenue in Q4 2016, in Q4 2017 the figure was 43 percent. Further, revenue from the building and retail sectors increased 89.9 percent while the healthcare sector grew 80 percent y-o-y from 2016 to 2017.

"We keep on winning applications [in the non-consumer sector], which is really where volume will be driven in the years to come," Nordic Semiconductor CEO, Svenn-Tore Larsen, told attendees at Nordic's recent Q4 2017 Investor Presentation. "Non-consumer has much less seasonality than consumer. It's a much more robust market, and we are growing now in the verticals we've been working hard on, but there are still new verticals to get into, which is exciting."

Dynamic market

As the scope of Bluetooth LE-based technology expands, so too do the possibilities for the IoT. When the SIG announced Bluetooth support for mesh networking mid-way through last year, it also released the development shackles of existing 'star' and 'point-to-point' topologies. Mesh networking is redefining the ambitions of IoT builders and customers, fostering an environment of innovation and sustainable efficiency. (*See* ULP WQ *Autumn 2017, pg10*.)

Arrivals like Bluetooth mesh and Bluetooth 5 allow large networks with potentially hundreds of nodes achieve high data rates, using low power, over a long range, and across various industrial or enterprise settings. These are the key advantages of many-to-many networks for complex industrial IoT applications.

Nordic's strategy is to facilitate IoT innovation by prioritizing Systems-on-Chip (SoCs), Development Kits (DK), and Software Development Kits (SDK) product launches to coincide with enhancements to the Bluetooth LE specification. For example, Nordic's nRF52840 advanced multiprotocol SoC is the only fully-capable Bluetooth 5 chip currently on the market, supporting all of the enhanced standard's range, throughput, advertising extensions, and improved coexistence. The nRF52840 is the most powerful single-chip Bluetooth LE SoC available and supports the most complex IoT applications.

While nobody can predict exactly how the evolution of Bluetooth LE technology will impact the future of the IoT, it's certain the technology will continue to diverge into even more non-consumer sectors. ■

Cellular for everything

Cellular technology has been restricted to consumer mobiles and specialist industrial modems. Nordic's nRF91 Series SiP could change all that. Peder Rand explains

Peder Rand is Product Manager for Cellular IoT with Nordic Semiconductor

Decades of development have led to today's high-bandwidth cellular technology

First generation ('1G') cellular communications debuted in the 1970s. Analog systems handled the traffic and the handsets were cumbersome and expensive. But the idea caught on and by 1990 the number of global subscribers reached 20 million. Fast forward 28 years and according to the GSMA, an organization that represents the interests of mobile operators, the subscriber base has just passed five billion. And the latest generation of cellular technology, 4G LTE, now reaches over 50 percent penetration in over 70 countries around the globe and supports inexpensive high-definition streaming services that couldn't have even been imagined a decade ago.

The prolonged gestation and maturation of cellular has allowed engineers to optimize the technology to meet consumer and commercial demands of ubiquity, reliability, security, and ease-of-use. It has also given carriers the revenue and time to build and enhance the huge infrastructure required to support global coverage.

Cellular technology offers better coverage than any other wireless technology. Its reliability comes from the years of constant technical refinement and is underwritten by fierce competition among the carriers. Security—a major consideration for engineers building wireless systems—is an end-to-end priority for cellular networks. And high throughput is built-in to meet the demands of millions of subscribers accessing streaming video and other data-intensive services. These strengths are reinforced by the high quality of service (QoS) that comes as a consequence of the regulation, licensing, and management of spectrum allocations used for cellular communication.

The advantages of cellular technology have attracted the interest of engineers tasked with building the Internet of Things (IoT). Cellular promises a solution for either directly connecting the IoT sensors of long-range, low power wide area networks (LPWANs) to the Cloud or forming LPWANs that facilitate gateways to the Cloud for local area networks (LANs) powered by short-range wireless technologies such as Bluetooth Low Energy (Bluetooth LE) or Thread. But there's still some work to do before the vision turns into reality.

Extending cellular's reach

High-throughput cellular technology is extremely complex and expensive, and the hardware is bulky and power hungry. Consumers are willing to bear the cost and recharge their handsets daily because the technology provides seamless access to the services they crave. But for IoT engineers, high-throughput cellular technology's cost, complexity, and power consumption drawbacks make it tough to build the networks of hundreds of compact, battery-powered sensors that will underpin the IoT.

Cellular modems have found a niche for connecting expensive remote assets to the Cloud. For example, rural Intelligent Electronic Devices (IEDs) used to control smart electricity distribution grids routinely send information back to a control centre. And operators of commercial equipment like vending machines (sited in public places such as rail stations) can cut operating costs by using a cellular modem to

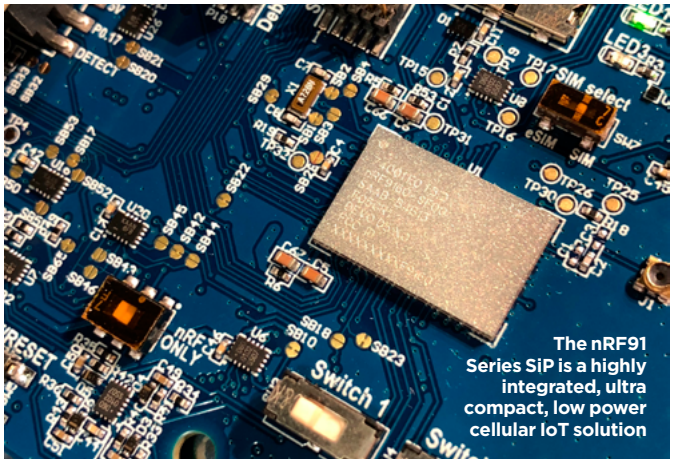
send information back to HQ rather than dispatching a service operative to manually check stock levels. Cellular modems are also popular with security companies who can't take chances with less reliable wireless technologies such as Wi-Fi.

But these devices are unsuitable for IoT applications. First, many use legacy 2G networks which are being phased out—the spectrum allocations are used inefficiently and are sorely needed for 4G and forthcoming 5G traffic—and will have virtually disappeared by 2025. Second, cellular 2G, 3G, and 4G LTE modems are expensive, bulky, and power hungry because they have been designed to meet 3rd Generation Partnership Project's (3GPP) specifications for higher category (higher throughput) operation.

Recognizing the drawbacks of traditional modems for the unique, low-cost, -throughput, and -power demands of the IoT, the 3GPP extended the modem categories to include LTE-M and NB-IoT in Release 13 of its specifications in 2015. Such a move encouraged the development of 4G LTE modems for IoT applications - applications that were impractical when based on higher category units. (*See* ULP WQ *Autumn 2016, pg8.*)

Designed for the IoT

For the last three years, Nordic Semiconductor's Finland-based



The nRF91 Series SiP is a highly integrated, ultra compact, low power cellular IoT solution

engineers have combined their LTE expertise with the company's Norwegian engineers' ultra low power wireless know-how to design an optimized cellular IoT solution complying with the 3GPP's LTE-M and NB-IoT specifications.

The result is the nRF91 Series System-in-Package (SiP), a low power, ultra compact cellular IoT solution. Because it has been designed to meet the unique demands of the IoT, the product's designers have adopted a completely different approach to that employed for conventional cellular modules and have added a host of features never before seen in the cellular market.

For example, the nRF91 Series SiP integrates into a 10 by 16 by 1mm package a powerful ARM Cortex M33

"The nRF91 Series SiP promises to bring cellular technology to everything beyond the smartphone"

application microprocessor, full multimode LTE modem and transceiver, RF front end from Qorvo, power management, Flash and RAM, plus crystal and passive components. (*See this issue pg 8.*) Through this high integration and its precertification for global operation, the nRF91 Series SiP overcomes the drawbacks of cellular for LPWAN deployments as well as satisfying the comprehensive set of qualifications needed to employ cellular technology.

Nordic pioneered simple wireless development and implementation with its Bluetooth LE solutions. There the company masked the underlying complexity of RF engineering by supplying complete single-chip (radio plus processor) wireless hardware and factory-supplied RF protocol stacks. Development was eased by offering tools that used familiar design environments for application engineering and code compilation while keeping the RF protocol stack separated from the application software. Such an approach has enabled thousands of developers who lack RF knowledge to create innovative and commercially-successful wireless products.

While the software architecture of the nRF91 Series remains under wraps for now, Nordic's strategy remains to mask the inherent complexity of RF engineering while making it as simple as possible to code and debug wireless applications. That will make cellular technology accessible to all and encourages developers with little experience of wireless to explore its advantages and unleash their creativity to come up with new products.

Such a strategy has seen Nordic Bluetooth LE technology spread around the globe. The nRF91 Series SiP promises to do the same by bringing cellular technology to everything beyond the smartphone. ■

Ultra low power wireless connectivity solutions

ICs	Operating Band	Wireless Protocol					IC Type			On-Chip						Periph				
		Bluetooth 5	Bluetooth Low Energy	ANT	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	AES	Analog Comparator
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

erals											Applications													Ref. Designs	Dev Tools	WLCSP Wafer-level chip-scale package option
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	
						●			●			●				●	●							Smartphone Demo App	ANT Dev Kit	
										●		●				●	●							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	
						●			●	●	●		●		●	●		●						PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit, Prog. Kit	
						●			●	●	●		●		●	●		●						PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit, Prog. Kit	
						●					●		●		●			●						-	Eval Kit	
●						●							●		●			●						Microphone	nRFgo Dev Kit	
		●	●			●			●							●								-	Eval Kit	
						●										●								-	Eval Kit	

Nordic plans bright future on Bluetooth 5 and cellular IoT

As 2018 gets into full swing, ULP WQ spoke to Nordic's CEO to gain an insight into an important year in the company's growth

It's two years since *ULP WQ* last sat down with Svenn-Tore Larsen, Nordic's CEO. At that time, Larsen spoke about the previous decade of the company's development, how he had driven Nordic to become the leading provider of Bluetooth Low Energy (Bluetooth LE) solutions, and his vision to build a billion dollar IoT company. *(See* ULP WQ *Summer 2016 special supplement.)*

Since that time, Nordic has extended its Bluetooth 5/ Bluetooth LE offering with the introduction of a new nRF52 Series System-on-Chip (SoC) and unveiled more details about its nRF91 Series System-in-Package (SiP), a cellular IoT solution for low power wide area networks (LPWANs). (*See this issue pg8.*)

This year marks a significant point in Nordic's evolution with continued rapid growth in Bluetooth LE particularly into smart home and industry sectors (*see this issue pg9*), expansion of its products and tools for alternative low power protocols, and sampling of the nRF91 Series SiP to key customers. As Larsen took a short break from his busy schedule, *ULP WQ* took the chance to ask him how he sees the year unfolding.

Nordic Semiconductor's CEO, Svenn-Tore Larsen, is leading the company's drive into short-range and cellular wireless technologies for the IoT

ULP WQ: Before we look forward, let's look back – how would you summarize Nordic's performance in 2017?

Svenn-Tore Larsen: In a highly competitive market I'm pleased to say Nordic cemented its position as the leading supplier of Bluetooth Low Energy solutions. Based on the preliminary full-year figures for 2017, around 63 percent of the company's revenue came from Bluetooth LE, a growth of 40 percent compared to 2016. In Q4 2017 Nordic reported around a 45 percent market share for Bluetooth LE (measured by the number of end-product certifications).

The year marked a number of milestones for the company. For example, Nordic was one of the first companies to introduce not only Bluetooth 5-certified silicon and software but also development tools. With the nRF52810 and nRF52832, Nordic can offer baseline and mid-range Bluetooth 5-certified devices. And with the nRF52840 advanced Bluetooth LE SoC, Nordic offers silicon, software, and development kits for one of the first fully-compliant Bluetooth 5-certified chips.

Nordic was also the first company to offer a Software Development Kit (SDK) for Bluetooth mesh – enabling developers to immediately take advantage of this significant enhancement to Bluetooth LE wireless which brings mesh networking to the technology.

ULP WQ: What are Nordic's main plans for 2018?

STL: A key strategy for the company is to make it even easier for developers with limited RF expertise to take advantage of low power wireless technology for any application no matter how simple or complex.

For example, all the nRF52 Series devices are development kit and pin compatible, so a developer can start working with an nRF52810 and then easily migrate to an nRF52832 or nRF52840 when they need greater capability.

And because Nordic SoCs support multiple protocols, a developer can design one product based on Bluetooth LE and, without any significant redesign, introduce the same product based on ANT or Thread.

Nordic is also unique in separating its highly robust SoftDevices (RF protocol software) from the customer's application code. This arrangement means the developer never needs to worry about the integrity of the RF protocol nor the compilation of his or her own code with the SoftDevice.

The ample Flash memory of Nordic's SoCs also makes it easy to make over-the-air device firmware updates at any time. Nordic has also launched the Nordic Thingy:52 IoT Sensor Kit, a fully-functional development tool that makes it simple for an app developer with little or no RF knowledge to take advantage of Bluetooth LE. *(See* ULP WQ *Summer 2017, pg10.)*

Another key strategy for 2018 will be increased support for the organizations that drive wireless

standards. Nordic is a long-time member of the ANT Alliance and Bluetooth Special Interest Group (SIG) and is now a member of the Thread Group. Previously the company significantly contributed to both the Bluetooth LE specification and more recently to OpenThread, an open-source version of the Thread stack.

Our other strategy for 2018 is to work with lead customers, infrastructure partners, and carriers to ensure the nRF91 Series products meet market-, interoperability- and certification-requirements for cellular operation. Low power cellular is both a complex technology and a complicated business. But, as our "sneak peek" in January this year showed, our product will hide all this complexity from customers, making it easy for them to employ it without requiring any previous cellular expertise.

Nordic's Bluetooth Low Energy and Thread solutions are proving popular in the smart home

ULP WQ: How does the company plan to continue its development of its Bluetooth 5/ANT/ IEEE 802.15.4/2.4GHz product range to support its 2018 business strategy?

STL: Bluetooth 5 applications and target sectors remain a key focus. We expect to see some innovative new Bluetooth LE applications spring up and will be ready to offer expert technical assistance for these new areas.

We are also focused on maximizing the benefits our customers can gain from Bluetooth mesh, particularly for those in the smart lighting sector. Some customers have previously worked with Nordic developing proprietary mesh support and now with the adopted version, the lighting market and other sectors that can benefit from mesh networking will accelerate.

Additionally, recent smart-home development will stimulate many new applications. Nordic's focus will be to ensure that whether the base technology is Bluetooth LE, Thread, or another IEEE802.15.4 technology, our customers will have proven hardware, software and development tools to support their end-products.

One of Nordic's strengths is its widespread support for all sectors and applications. Both the nRF51 and nRF52 Series offer products ranging from cost-effective solutions for simple applications such as beacons or wireless desktops all the way up to the advanced devices which can support the most complex wearable or smart-home products. The same can't be said for many competitors.

For example, the nRF51822 and the nRF52810 are cost-effective solutions for applications such as disposable medical products, while the nRF52832 and nRF52840 offer single-chip solutions for the most complex Bluetooth LE applications (where previously a separate microprocessor might have been needed).

Our focus for 2018 and beyond will remain on ensuring we have a product line that offers a solution for every application - no matter how modest or how sophisticated.

ULP WQ: How do you see the market sectors into which Nordic sells its products evolving in 2018?

STL: While consumer electronics and wearables form a big part of our Bluetooth LE business we see 2018 as a year of major expansion of the technology into other IoT and Industrial IoT (IIoT) sectors. For example, in Q4 2017 over 43 percent of our revenue was generated from non-consumer products and this percentage is continuing to grow.

The introduction of Bluetooth 5 (which adds important new throughput, range, advertising extension, security, and coexistence features) and Bluetooth mesh will enable Bluetooth LE to service many IoT and IIoT applications that were previously beyond the scope of the technology. Bluetooth LE is very quickly moving from a consumer-focused personal area network (PAN) technology to one ideally suited to local area networks (LANs).

However, Bluetooth LE is only one of several capable wireless technologies suited to low power IoT and IIoT applications. Other examples include 2.4-GHz proprietary, ANT+, Thread, and Zigbee. Nordic has always supported 2.4-GHz proprietary and ANT protocols on its silicon but with the introduction of the nRF52840, developers can now work with IEEE802.15.4-based technologies such as Thread and Zigbee—both popular in the smart home sector—in addition to Bluetooth LE and the other protocols mentioned.

The nRF52840 has recently been Thread 1.1 Certified and is the only low power wireless SoC in the world that can support concurrent Bluetooth LE and Thread operation.

We also see 2018 as a big year for cellular-based LPWANs. These networks connect technologies such as Bluetooth LE and Thread to the Cloud wherever the sensors are situated.

The key to doing this is low-cost, low power cellular RF modems with kilometer-plus range.

Nordic is working on LTE-M and NB-IoT solutions with its nRF91 Series products because it matches the company's established strategy of adopting an industry standard, and benefits from connecting to mature infrastructure in the form of the global cellular network. These products will dramatically extend both the IoT and IIoT. ■

Wireless smart lock makers react to security scares

An avalanche of media reports has highlighted potential vulnerabilities in Bluetooth Low Energy wireless technology's connections. Is the attention warranted? ULP WQ reports

We've all seen them, scare-tactic headlines that have popped up on online searches since the smart home shifted from gimmick towards mainstream. "If you use smart Bluetooth locks, you're asking to be burgled", or, "Have a smart lock? Yeah, it can probably be hacked", are two examples amongst many, and it is creating the perfect contradiction in growth projections for the smart lock market.

According to analyst Credence Research, the global smart lock market is predicted to be worth $3.5 billion by 2025, as consumers are eager to invest in home automation systems because of increased security concerns for their family and property. At the same time, Credence Research says, a significant factor restraining market growth is also security, and the fear these solutions are vulnerable to hacking. Secure if we do, secure if we don't – which is it?

No vendor of a Bluetooth Low Energy (Bluetooth LE) smart lock can guarantee its solution is 100 percent secure or 'unhackable', but this is not distinct to smart lock manufacturers. No vendor of any online- or wirelessly-networked solution can make that promise, at least not in good faith. But not all Bluetooth LE hardware and software is created equal, and get your Bluetooth LE protocol implementation right and chances of a security breach reduce dramatically. Any potential hackers will hopefully move on to easier targets.

Nokē Pro enterprise allows businesses to remotely operate thousands of Bluetooth LE locks

End-to-end security

"While it's true that no network can ever be 100 percent secure, it's still possible to reach a level of security where the time and effort to break it is greater than the reward," says Pål Kastnes, Technical Marketing Manager with Nordic Semiconductor. "To achieve this, security must be factored into product development from the beginning. Developers can use the secure protocols baked into Bluetooth to create simple, secure IoT devices, but just as a door is only secure if you remember to lock it, Bluetooth is only secure if you implement its in-built security features properly."

The two principal hacking risks for Bluetooth LE smart locks are so called 'passive eavesdropper' and 'man-in-the-middle' (MITM) attacks. A passive eavesdropper will passively record all the communication in the key exchange phase, and can then process these packets after the fact. If the hacker is successful in decrypting the key exchange packets, then the security key will be available. In MITM attacks, the hacker acts as a middle man between the smart lock and the user's smartphone or tablet, impersonating each endpoint and compromising the data being exchanged between the two.

These threats are highest during the commissioning process, when the Bluetooth LE lock is paired with the user's smartphone or tablet, and one of the primary commissioning challenges is how to exchange security keys in a safe manner. Strong authentication and encryption is essential, as is the need for it to remain secure throughout its lifecycle, including the ability to be updated securely if any problems come to light post-launch.

The most common way to avoid passive eavesdropper attacks is to use an asymmetric encryption scheme to exchange the security keys. In such a system each node in the link will generate a public/private key pair and send its public key to the peer node. The peer can then encrypt its security information using the public key, and only the private key can be used to decrypt this information. To avoid MITM attacks, systems authenticate the link over a separate (Out-of-Band or "OOB") data channel. (*See* ULP WQ *Winter 2017, pg 11.*)

Unfortunately, as smart lock developers have scrambled to rapidly release Bluetooth LE-based security solutions to take advantage of increasing consumer interest and adoption, appropriate implementation of the Bluetooth LE protocol has often taken a back seat, leaving some solutions vulnerable

to hacking attempts. And as one Bluetooth LE safe lock manufacturer discovered, made worse by their lock's inability to perform over-the-air device firmware updates (OTA-DFU), preventing remedial patching.

Nordic Semiconductor's nRF52 Series System-on-Chips (SoCs) provide developers with a number of security features that with the appropriate implementation, should ensure hackers will go in search of easier victims. As one safe lock manufacturer is now painfully aware, the ability to perform software and firmware updates is an absolute necessity. All nRF52 Series SoCs support OTA-DFU, using secure signatures to authenticate that only updates coming from a verified and trusted source can be made on a given device.

The Advanced Encryption Standard (AES) offers strong protection, especially at the embedded level, but does place demands on the chip's processing power and memory. All nRF52 Series SoCs have both a powerful Arm processor and ample Flash memory and RAM to handle the demands of AES, and simultaneously support challenging, processor-intensive applications.

For additional security, the nRF52832 and nRF52840 SoCs also offer an on-chip NFC-A tag, enabling OOB pairing and simplifying the process of authenticated pairing between two Bluetooth devices by exchanging authentication information over an NFC link. The short range of an NFC connection makes it much harder for signals to be intercepted by a hacker. The other advantage of NFC is that the user doesn't have to manually enter or verify a passkey, which simplifies the commissioning process.

For developers with applications requiring best-in-class hardware and software security, the nRF5240 SoC also incorporates an Arm TrustZone Cryptocell-310 cryptographic co-processor, providing cryptographic functions and incorporating a true random number generator (TRNG), as well as support for a wide range of asymmetric, symmetric, and hashing cryptographic services.

Security first

It is these features—alongside heightened awareness of the need for uncompromising security in Internet of Things (IoT) applications—that has seen Nordic SoCs increasingly specified in Bluetooth LE security applications.

Late last year Danish smart home IoT company, Poly-Control Aps, launched its 'Danalock V3' smart lock that can be retrofitted to a manual door lock to provide a complete door entry and security solution. The Bluetooth LE smart lock eliminates the need to carry door keys or replace a door lock when keys are lost or stolen, and users can configure and control the smart lock via the smartphone companion app.

While the Nordic nRF52832 SoC enables the Bluetooth LE connectivity required to wirelessly control, share, and monitor the door lock, security was an equally important consideration. As Hans Overgaard, Poly-Control Co-founder and CEO, explains: "AES-256 encryption makes Danalock much safer, it is nearly impossible to hack."

U.S.-based Nokē is another smart lock designer and manufacturer that has worked with Nordic for a number of years, migrating from the nRF51 Series to the nRF52832 SoC and its advanced, in-built security functionality.

Nokē recently unveiled its 'Nokē Pro' enterprise software solution, allowing businesses to remotely operate potentially thousands of Bluetooth LE locks via a smartphone app or desktop web portal.

In addition to supervising Nordic's Bluetooth 5-certifed RF software protocol stack, the nRF52832 SoC's Arm M4F processor has ample power to run Nokē's decentralized radio communications protocol, and bidirectional self-optimizing mesh networking software. The mesh software enables remote opening and key changes for Nokē locks, as well as enabling lock activity and alarm notifications to be sent to the Cloud.

"We selected the nRF52832 SoC because it can control everything," says David Gengler, Nokē Founder and CEO. "It is easy to work with, the Software Development Kit and documentation is solid, and it works well with our mesh protocol."

The security scare headlines will no doubt continue, but not every Bluetooth LE lock is created equal. It may be true that no smart lock can be 100 percent secure, but it's also true that a poorly implemented and commissioned Bluetooth LE lock will always be more vulnerable to hacking than one that has implemented end-to-end security appropriately and effectively.

Nordic's Bluetooth LE SoftDevices (RF protocols), tested and re-tested under the most challenging conditions, and complemented by powerful nRF52 Series hardware, are among the most secure in the business. ■

"Just as a door is only secure if you remember to lock it, Bluetooth is only secure if you implement its in-built security features properly"

AES-256 encryption makes the Danalock V3 smart lock nearly impossible to hack

Login to begin developing the next IoT solution

Nordic's nRF Connect for Cloud tool can be used to get an IoT solution up and running in ten minutes. Caroline Hayes explains

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

At its simplest level, the Internet of things (IoT) is a network of devices that gather data and send it to a central point where, after analysis, the information can be acted upon. For example, a wireless temperature monitor might indicate a room is too hot, allowing the control system to send a message back to the heater to back off. But this simple concept is underpinned by complex technology, and developers are asking for help to test and evaluate IoT concepts.

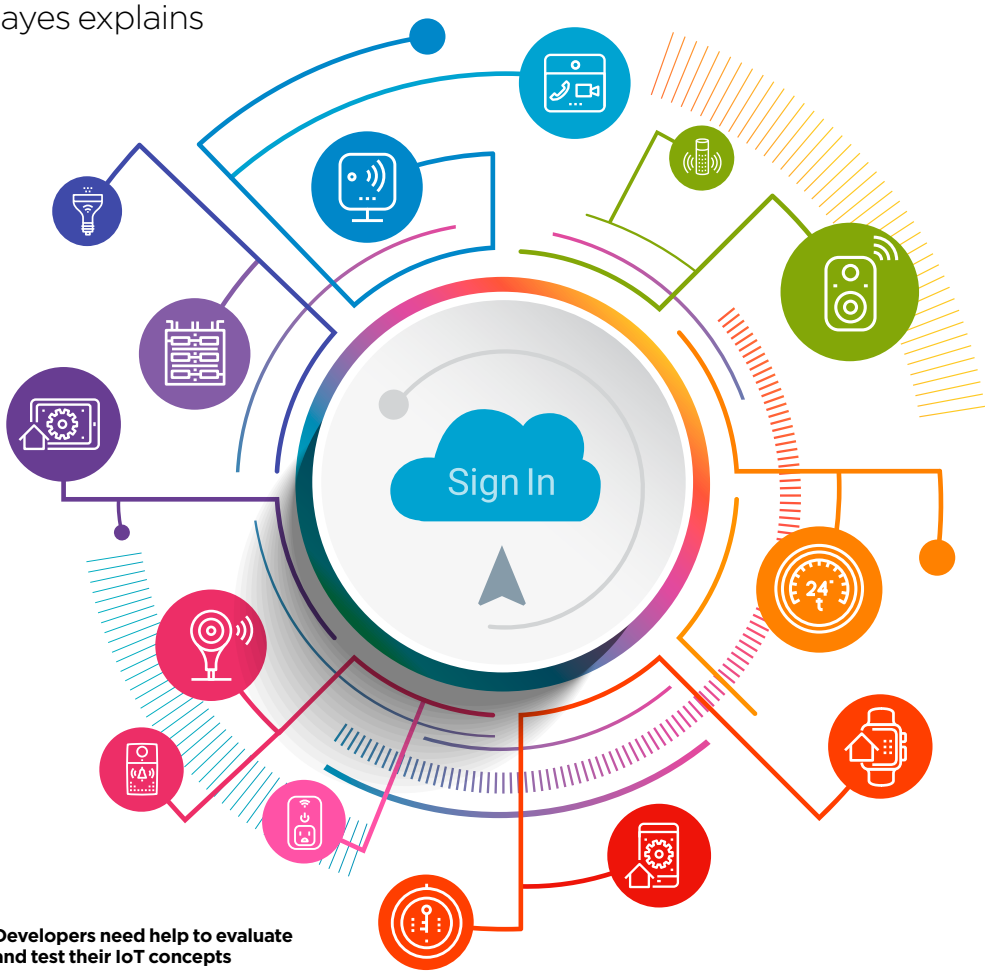
Meeting this demand is the motivation behind Nordic Semiconductor's nRF Connect for Cloud, a Cloud-based service portal designed to help engineers create and verify IoT designs. The service is free for developers using Nordic's technology and stores evaluated designs for future use or enables access for revision before the device enters full production.

The portal has been developed by Nordic's IoT Lab, based in Portland, Orgeon, U.S. *(See ULP WQ Winter 2016, pg16.)* The Lab was created to support developers designing IoT innovations using both Bluetooth Low Energy (Bluetooth LE) and cellular IoT technology. At its inauguration, Nordic IoT Lab director Chris Hansen said that while the IoT was already proving a success in industrial applications, to achieve its forecast growth it would also need to be integrated into consumer products. And that is where nRF Connect for Cloud comes into its own.

nRF Connect for Cloud's application guides users through the development process, using plain, non-technical language. After all, just because a person is not an engineer capable of compiling code, doesn't mean they can't have a good idea, and certainly shouldn't be an obstacle to developing an IoT device founded on that idea. Based on this principle of universal accessibility, nRF Connect for Cloud enables developers to create and test an IoT project.

"nRF Connect for Cloud is a tool for our developers, to help them build IoT solutions using Nordic [Systems-on-Chip]," says Hansen. "As a novice, you can get an IoT solution up and running in ten minutes.

"The IoT is made up of many component parts, and nRF Connect for Cloud is a visualization of those component parts, " adds Hansen.



Developers need help to evaluate and test their IoT concepts

Getting started

The first step is for users to create an nRF Connect for Cloud account at nrfcloud.com. Once the account is established, users can start connecting IoT devices to that account. To do this a gateway needs to be set up to enable the user's Bluetooth LE device to connect to the Internet. There are iOS and Android apps available to allow smartphones to be used as gateways and PCs can also be employed.

To register the gateway in nRF Connect for Cloud the user is required to install nRF Connect software and the nRF Connect for Cloud Gateway plug-in on their smartphone or PC.

nRF Connect is a cross-platform software tool that enables easy set-up of connections with other devices and then uses these connections for reading and writing to the external nodes. It is designed to

be used in conjunction with the nRF51 Development Kit (DK), the nRF51 Dongle, or the nRF52 DK running a specific connectivity application. nRF Connect for Cloud will automatically detect which kit is connected and upload the firmware if it's not programmed into the kit already.

Nordic's Software DKs (SDKs) have pre-programmed code for sensors available for free download. For example, the nRF5 SDK for IoT is programmed with the precompiled nRF Connect for Cloud demo application. The SDK provides drivers, libraries, examples, and application programming interfaces (APIs) for nRF52 Series SoCs and an IPv6 over Bluetooth LE adaption layer (6LoWPAN) and Internet Protocol (IP) Suite, so applications can connect directly to Cloud services.

To test their set-up, the developer programs the precompiled nRF Connect for Cloud demo application on an nRF5 DK and connects the kit through the gateway to their nRF Connect for Cloud account.

"This is the 'Hello World' program for the IoT," says Hansen, referring to the simple program used to illustrate the syntax of a programming language in computing. While the novice can be "up and running in ten minutes," the functionality will also appeal to the more experienced developer, using tools such as the nRF51 DK or the nRF52 DK. Both support the standard Nordic Software Development Tool chain, using Keil, IAR Systems, and GNU Compiler Collection (GCC) tools.

Once connected, the nRF Connect for Cloud front-end application allows the user to manage and monitor all their IoT devices. The dashboard displays the number of gateways and devices connected to that nRF Connect for Cloud account, and for each device tracks live data, logs historical data, and allows the user to receive alerts in real time. As it is Cloud-based, teams can collaborate on IoT designs wherever they are in the world.

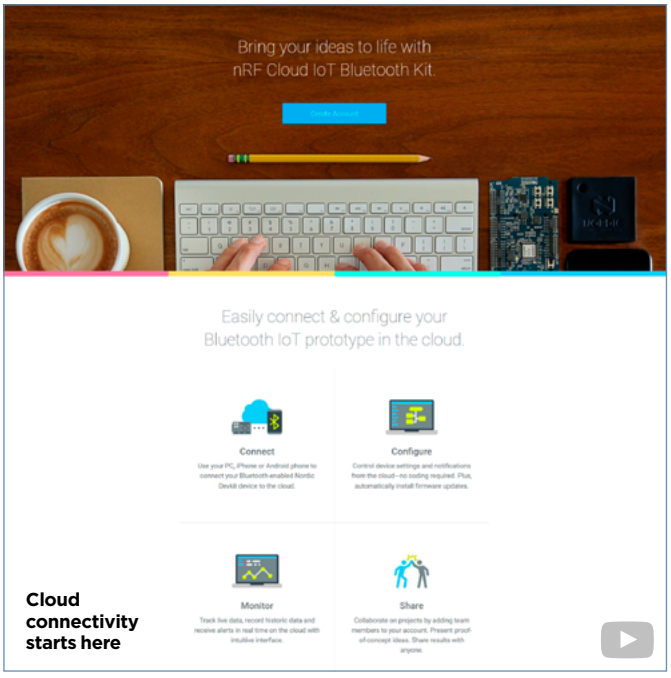
nRF Connect for Cloud supports Nordic's ultra low power Bluetooth LE nRF51 and nRF52 Series SoCs, as

Chris Hansen heads up Nordic's IoT Lab

"While the novice can be up and running in minutes, the functionality of nRF Connect for Cloud will also encourage experienced developers to use it for programming" CHRIS HANSEN

well as the recently launched Nordic Thingy:52 IoT Sensor Kit. This compact, multi-sensor development kit is designed to build IoT prototypes without the need to program, build hardware, or write firmware. Instead prototypes and demos can be configured from nRF Connect for Cloud using a Bluetooth API. Thingy:52 is supplied with a smartphone app, plus a web app.

Most common third-party sensors are supported by this development kit, says Hansen, to bring temperature, motion, sound, heat, and light data to any IoT application. Other sensing applications already supported in nRF Connect for Cloud include cadence monitoring for cycling applications, and heart rate monitoring. Once downloaded, code can be customized to suit the IoT solution, or tailored for a particular company, for example by changing values such as Fahrenheit to Centigrade, or even renaming sensors for the project.



Cloud connectivity starts here

Direct to the network

When Nordic commercially launches its nRF91 Series System-in-Package (SiP), no gateway will be needed. The low power cellular IoT solution is currently sampling to selected customers, with full production scheduled by the end of the year. It is the first product to use Arm's Cortex-M33 processor, which has Arm TrustZone for Armv8-M security technology to protect areas of the SiP's memory from malicious attacks. (*See pg8.*) This is particularly important as access to the Internet is via a network where communication cannot be controlled in the same way it is with Bluetooth LE technology, where connections are restricted to a direct path between A and B.

Support for the nRF91 Series SiP is the next big goal for Hansen. It will add more functionality to support the manufacture and testing of IoT solutions. Support for asset tracking is one example of what the nRF91 Series will bring to IoT development. Asset tracking can be used in industrial and retail environments to detect location and proximity using radio signals. For example, the technology can be used in warehouses to monitor stock and ensure access to secure areas is limited to authorized personnel. In the workplace, the technology can recognize staff as they move, and adjust the environment to suit working conditions.

Connecting directly to the Cloud without the need for a gateway is a "big advantage" says Hansen, although he does point out that LTE will require a subscription to a carrier, with perhaps a cost attached to each device. Direct connection will deliver all the sensor data to the Cloud to enable developers to review it over periods of time, access the data for future use, or to refine an IoT solution.

As the IoT continues to expand, tools like nRF Connect for Cloud have the potential to unleash a new wave of innovation that could see even today's dramatic growth projections for the IoT exceeded. ■

Long-range Bluetooth Low Energy router delivers enterprise IoT solution

Supported by Nordic, Cassia Networks has developed a long-range Bluetooth LE edge processing router for the enterprise IoT marketplace. Kalon Huett explains

Kalon Huett is an Australia-based freelance journalist

Bluetooth Low Energy (Bluetooth LE) technology's inherent low power and low cost advantages have served the protocol well in the grab for marketshare in the home automation sector. However, enterprise Internet of Things (IoT) developers have been more circumspect in specifying the protocol principally because of the range and channel limitations it brings.

Cassia Networks, a dual Silicon Valley and Beijing headquartered company, has focused its expertise on overcoming the developers' objections to large scale Bluetooth LE deployments by introducing the Nordic Semiconductor-powered 'E1000 Bluetooth IoTEdge Router'. The E1000 provides additional computational resources and a gateway to the IoT for networked Bluetooth LE devices with no IPv6 capability. The E1000 delivers a scalable, high bandwidth, wireless connectivity solution for various enterprise IoT applications across the industrial, healthcare, smart city, senior care, education, retail, and sports sectors.

The company claims the E1000 is the first long-range, bidirectional Bluetooth IoT edge processing router of its kind, supporting up to 40 real-time bidirectional channels to paired devices (which the company refers to as 'high connection density'), doubling bandwidth (thanks to the Bluetooth 5's high throughput feature), and bringing edge processing capability for new third-party Bluetooth LE applications. (*See pg4.*)

By integrating the Bluetooth 5-certified Nordic nRF52832 System-on-Chip (SoC), the E1000 Bluetooth IoTEdge Router is able to create low-complexity, cost-effective and powerful IoT gateways, with Bluetooth LE wireless connectivity extending to a range of 300 meters and beyond. The E1000 high connection density and long range significantly reduce the number of edge routers needed for enterprise IoT deployments.

"The new long-range Bluetooth LE edge routing capability solves many of the failure points of older IoT enterprise deployments"

"Combining the E1000's long-range, connection density, and edge computing with the low power and low cost advantages of Bluetooth LE/Bluetooth 5, enables innovative IoT applications, and significantly reduces all the deployment cost and complexity challenges for enterprise IoT customers," explains Felix Zhao, Cassia Networks CEO.

Zhao highlights Nordic's future-proofing approach to its nRF52 Series SoCs as a key factor behind its selection as Cassia Networks' chip family of choice. "The SoC's support for Bluetooth 5 allows us to position the E1000 Bluetooth IoTEdge Router for even greater range, and more powerful enterprise IoT features and applications in the future," he says.

The E1000 Bluetooth IoTEdge Router provides wireless connectivity extending at least 300 meters, enabling long-range IoT gateways

Moreover, Zhao values the close working relationship fostered by Nordic throughout the prototyping and development phase. "Nordic's reputation and ability to work to Cassia Networks timelines is highly valued."

Proven wireless standard

Enabled by the Nordic SoC, the edge processing power of the E1000 allows Bluetooth facilitated third-party applications to deliver new benefits to the enterprise IoT marketplace. "The E1000 delivers new connectivity at the enterprise level, with one-to-many pairings, in a new IoT network environment where real-time third-party applications can deliver services at the edge," Zhao says. "The long-range Bluetooth LE edge routing capability solves many of the failure points of older IoT enterprise deployments including connectivity, scalability, complexity, and cost."

What inspired Cassia Networks to select Bluetooth LE over alternative wireless protocols to provide the connectivity for its smart router? "Long-range Bluetooth LE is a proven and mature worldwide standard. It connects billions of Bluetooth LE sensors to established infrastructure, using low power, over long-range, at an extremely low price point," says Zhao. "Alternative technologies can't offer all those advantages."

The company claims its smart router technology complements Bluetooth LE technology's expansion as an 'enterprise IoT protocol'.

"Traditional Bluetooth LE has served as the 'go-to' solution for home automation due to its low cost, low power requirements, and worldwide standardization," notes Zhao.

Importantly, the E1000 retains these benefits—and adds others—without requiring changes to existing Bluetooth LE devices.

As for the future, Zhao is backing Bluetooth LE to thrive as a leading connectivity profile. "Bluetooth LE technology has several advantages as a more mature and rapidly accelerating business eco-system. Historically, protocols eventually converge on a dominant player," he says. ■

Powerful wireless SoCs meet advanced wearable demands

In the second part of this article, Sebastien Mackaie-Blanchi explains the importance of Flash and RAM in Bluetooth Low Energy SoCs

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

Without an embedded device such as the 64-MHz, 32-bit ARM M4F processor found in Nordic's nRF52832 and nRF52840 Systems-on-Chip (SoCs), a single-chip Bluetooth Low Energy (Bluetooth LE) solution would struggle to cope with today's complex applications such as high-end wearables.

To get the most out of a powerful Bluetooth LE SoC, the processor requires sufficient memory. In an architecture pioneered by the Nordic nRF51 Series in 2012, high-end Bluetooth SoC makers typically opt for a combination of RAM and Flash.

RAM (Random Access Memory) is the processor's "working memory". Information can be quickly written to and read from this memory allowing the processor to go about its business at high speed. But RAM is volatile; when the power is switched off, the information is lost.

In contrast, Flash is non-volatile, retaining its content for years even when there is no power. In a Bluetooth LE SoC, Flash stores the RF protocol software (or 'stack') (Nordic calls its stacks "SoftDevices") together with the application software required to optimize the performance of the end product. Another big advantage of Flash is that information can be repeatedly written to, and read from, the memory thousands of times during a product's life.

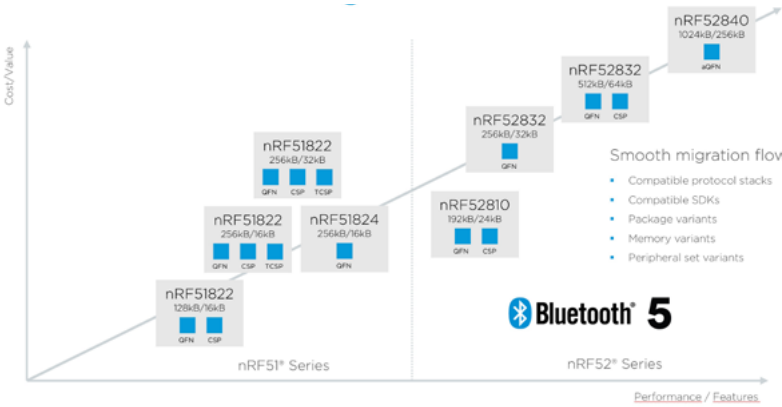
The downsides of Flash are its cost and slightly higher power consumption than other types of memory. Some manufacturers produce chips with ROM (Read Only Memory); this is both less expensive and less power hungry than Flash. But the big disadvantage is that ROM contents are fixed forever once the chip has been manufactured.

Memory capacity

RAM and Flash add to the cost of the Bluetooth LE SoC. The amount required depends on the end application. A high-end wearable, for example, could need the full 256 kB RAM and 1 MB Flash offered by Nordic's flagship device, the nRF52840 SoC. In contrast, a simple beacon product could easily get by with the 24 kB RAM and 192 kB Flash of the nRF52810 SoC. (One cool feature of Nordic's nRF51 and nRF52 Series is that a developer can start working with one chip and if the application proves to need a different amount of memory the developer can swap to another chip in the family without having to write new code or invest in new development tools. (See Fig. 1.)

A Bluetooth LE SoC will require much less RAM than Flash because the former is used only to store the limited amount of data and variables that are needed immediately (or at least very soon) by the processor to feed the computations demanded by the stack or application. There is no need for the RAM to retain the actual stack- or application-programs. In contrast, sufficient Flash is needed to hold the stack and application software during code execution and when the power is turned off. For a complex application and a stack such as Nordic's S140 SoftDevice (a fully-compatible, multirole Bluetooth 5/Bluetooth LE stack) the Flash requirement can measure up to several hundred kilobytes.

Figure 1: Nordic offers a range of memory options for its nRF51 and nRF52 Series allowing the developer to balance performance against cost



"An advantage of Flash is that information can be repeatedly written to, and read from, the memory thousands of times during a product's life."

Estimating the Flash requirement for a given application is more involved than just estimating the stack and application code size, adding some contingency, and choosing the appropriate chip. That's because a key feature of Flash-based Bluetooth LE SoCs is the ability to upgrade the software via the chip's wireless link. (This is something that's not possible with ROM-based devices.) This is useful, for example, to replace the stack with an enhanced version, to fix a bug in the application code, or to apply a security patch.

To perform upgrades, the chip requires sufficient Flash for the new software while using the previous software to run the link and verify new code. Once the code is verified the previous software can be deleted to free up Flash for the next upload. Consequently, a developer is likely to need more than double the Flash capacity than that used for stack and application code alone.

Nordic's unique software architecture—which cleanly separates the SoftDevice from the application code—offers an advantage over competitors' solutions when performing Flash-based over-the-air device firmware updates (OTA-DFU). Competitors' stacks and the application code become inextricably linked when compiled - requiring both to be uploaded when a change is made to either. The nRF51 and nRF52 Series software architecture allows either stack or application software to be uploaded without disturbing the other. That dramatically shortens OTA-DFU duration and reduces the risk of corruption during the upload. ■

Merge VR Moonshot Motion Controller

This Bluetooth Low Energy three-degrees-of-freedom universal motion controller wirelessly connects to smartphones for a more immersive VR experience

According to analyst, Zion Market Research, the global virtual reality (VR) market was valued at approximately $2 billion in 2016, but is expected to reach close to $27 billion by 2022, in part due to the increasing use of head-mounted displays. The Moonshot motion controller and goggles from Merge VR provide a full freedom of movement VR experience

American Morton Heilig made a working VR headset called the 'Telesphere Mask' as early as 1957. Described at the time as a telescopic television apparatus for individual use, the Telesphere was in every way like the VR headsets we're used to today, except that instead of connecting to a smartphone, Heilig's used miniaturized TV tubes. The device was a commercial failure

While already popular with gamers, VR may soon have a less expected user base – lawyers. VR applications that offer a way for members of a jury to look inside a crime scene have already been developed. Some versions even allow them to interact with the elements inside, picking up objects or examining a situation from different angles

The Moonshot wireless motion controller is held by the user during play to translate their movements in the real world to movements within the virtual world of a smartphone-based VR app, viewed through the user's device inserted into the Merge VR Goggles

Powered by a rechargeable Li-ion battery, the motion controller provides 'all day' game play between recharge, thanks to the ultra low power nRF52832 SoC. The SoC has been engineered to minimize power consumption and features a fully-automatic power management system

PEOPLE & PLACES

Wendell Boyd

Family man with a plan for sales growth

Hi, I'm Wendell Boyd and I'm an APAC Sales Manager based in Hong Kong, where I have lived for the past 16 years. My work takes me principally to China, Taiwan, Korea, and Japan, as well as Singapore, India, New Zealand, and Australia, my country of birth and the place I began my career in sales.

While I only joined Nordic 20 months ago, I have been a distributor of Nordic products since 2002. In my previous role with Memec (now Avnet), I always had a soft spot for RF technology. Joining Nordic represented a great opportunity to work with a company focused on the technology I was most interested in, whereas in distribution one tends to work across multiple technologies. At Nordic, my product knowledge has increased dramatically in quite a short space of time.

My core objective is to drive Nordic's sales—both out in the field and through our network of distributors—towards the right target customers. I am focused on expanding the resources within our sales organization and preparing the team to enter the next phase of growth. Since I started, we have approximately doubled our sales teams in Japan, Korea, and China.

Moving forward, the goal is to achieve double-digit growth across Asia. We are preparing for exciting expansion into the Cellular IoT market, while at the same time remaining focused on Bluetooth Low Energy, which still drives our business. Our challenge over the next 12-18 months is to grow faster than the market.

From a personal perspective, I am grateful that Nordic shares many of my own values. The company appreciates the balance between work and family, the people are honest and hard-working, and everyone recognizes that life enjoyment is just as important as business growth.

WING - OWN WORK, CC BY-SA 3.0

Boyd enjoys relaxing on the beaches of Sai Kung

Personal Profile

NAME:
Wendell Boyd

JOB TITLE:
APAC Sales Manager

JOINED NORDIC:
2016

BASED:
Hong Kong

INTERESTS INCLUDE:
Hiking, swimming, reading, travel, family

As a husband, father, and fairly young grandfather, that type of family-oriented culture is important to me. Helping to raise a family is my part-time job! Fortunately, my role with Nordic allows me to visit Sydney regularly for work and spend quality time with my grandkids as well.

Outside of work and family, I like to keep fit, stay healthy, and be as active as possible. I started playing soccer when I was five years' old and I am still playing almost 45 years later, but for the first time ever I've recently been restricted by knee problems.

My wife and I live in a region of Hong Kong called Sai Kung, which is very lush and green, with no high-rise buildings. We've lived in the area for 16 years now and absolutely love it here. On weekends one of my favorite things to do is go hiking in the hills, or swimming at the local beaches.

I am turning 50 this year, and that means finding a good venue to celebrate the milestone, which is one of my main short-term goals! Otherwise I'm focused on staying happy and healthy, and making sure the family is happy and healthy too.

I would also like to do some international travel with my wife. We are planning to spend more time exploring Europe, particularly Spain, Italy, and France, as my wife has a French background. That should keep us busy for the next couple of years! ■

"Nordic is preparing for the exciting expansion of the Cellular IoT market, while at the same time remaining focused on Bluetooth Low Energy, which still drives our business"

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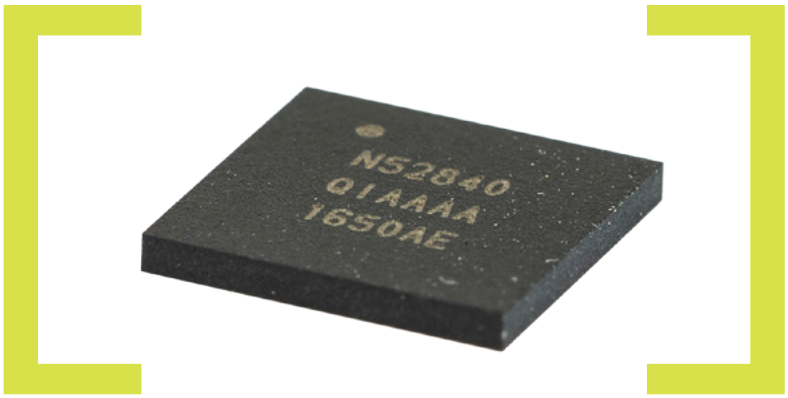

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