ultra low power

wirelessQ

QUARTER 1 | **SPRING 2017**

SoftBank plans a trillion chips

Cellular drives massive IoT

A brief guide to Bluetooth 5

COVER STORY

City parking challenge solved

NORDIC SEMICONDUCTOR

OPINION

Svein-Egil Nielsen

Bluetooth 5 meets unique smart home challenges

Several low power wireless technologies are vying for market share in smart home Internet of Things (IoT) applications but none has yet gained any significant foothold. Legacy technologies such as zigbee and Z-Wave look stale, and Wi-Fi has only carved a niche. However, Bluetooth low energy is gaining momentum and IEEE 802.15.4-based protocols such as Thread show promise. This is one of the reasons why Nordic Semiconductor's latest chip, the nRF52840, supports both these protocols (in addition to 2.4GHz proprietary and ANT+). Nordic has just released a Software Development Kit (SDK) to allow developers to work with the open-source OpenThread protocol, released by Nest Labs. (See *pgs 3 & 8*).

Smart home applications present some unique challenges. Low power consumption is important to limit battery changes and the devices need to be unobtrusive. Smartphone interoperability can be an advantage for applications such as smart lighting, enabling a consumer to control things from the comfort of their armchair, and direct Cloud connectivity is becoming more important as utilities, for example, appreciate the value of customers' electricity usage data.

One drawback of many low-power wireless technologies designed for smart home application is lack of sufficient range (not helped by the presence of walls). One solution is mesh networking whereby data destined for a specific wireless node is routed via several other nodes to reach its destination. Such a system effectively boosts range but multiplies complexity and cost. Another solution is simply longer range wireless.

During my time at the Bluetooth SIG, I was actively involved in the inception and development of a long range form of Bluetooth low energy. The technology was planned to be backward compatible and benefit from the simplicity, low power, and elegance of the proven protocol but endowed with sufficient range to service the whole house. Even big American houses.

Bluetooth 5 introduces a range increase of up to four times that of Bluetooth 4.2, promising whole of home coverage from a central hub, eliminating the need for mesh networking. The clever part is that greater range comes from error-correction algorithms rather than boosting output power which compromises battery life (although Bluetooth 5 does include a new higher output mode option which pushes the radio's sensitivity even higher and helps overcome the effect of walls and ceilings). The error-correction system does reduce throughput but in many smart home applications, trading-off bandwidth for range is worthwhile.

I'm pleased to say that Nordic's nRF52840 is one of first commercial Bluetooth low energy solutions fully-compatible with the long-range and high-throughput (2 Mbps) features of Bluetooth 5. For its part, the throughput boost brings advantages such as a better user experience, and technical advantages such as less time on air reducing power consumption. Greater throughput also makes for faster and more efficient completion of the over-the-air updates that will ensure Bluetooth low energy devices remain robust and secure throughout their lives. You can find out more about Bluetooth 5 in this issue (*pages 16 & 17*).

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 examines low power LTE's potential to support rapid, mass deployment of the IoT

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Sally Ward-Foxton is is a freelance journalist specializing in electronics. In this issue she describes how wireless technology is addressing city parking challenges

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John Leonard is Product Marketing Manager with Nordic. On page 16 he provides an update on Bluetooth 5, the latest incarnation of the wireless standard

Bluetooth low energy is helping drivers find free parking spaces, saving time and frustration

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NEWS

The latest developments from Nordic Semiconductor

Nordic launches secure Thread SDK for smart home applications

Nordic Semiconductor has launched its first Thread networking solution with the release of its nRF5 SDK [Software Development Kit] for Thread, designed to utilize the IEEE 802.15.4 PHY support introduced on Nordic's latest nRF52840 multiprotocol Bluetooth low energy System-on-Chip (SoC). The Nordic nRF5 SDK for Thread adds a unique Device-Firmware-Update (DFU)-over-Thread network feature similar to the Over-The-Air (OTA) DFU feature employed in other Nordic chips and SDKs.

The nRF52840 SoC's class-leading 256 kB RAM and 1 MB Flash memory also enable the chip to run both the Thread and Bluetooth low energy protocol stacks from the same chip. The nRF52840 is also able to run the Thread protocol at accelerated processing speeds by using its built-in ARM CryptoCell-310 cryptographic accelerator—which offers best-in-class security for Cortex-M based Bluetooth low energy SoCs—to run the Thread security algorithms.

Thread was designed to control connected home products such as the Nest Labs' thermostat

Thread was designed to create the best way to connect and control products where people live and work. This includes robust security, low power battery-friendly operation, and scalable reliability based on a developer-friendly IP-based (IPv6 with 6LoWPAN) mesh network.

"We are delighted that Nordic recognizes the developer and consumer value of the Thread specification," says Grant Erickson, President, Thread Group. "With Thread, product developers and consumers can easily and securely connect more than 250 devices into a low-power wireless network that includes direct internet and Cloud access for every device."

The Nordic nRF5 SDK for Thread is now available in an Alpha release with full production scheduled for Q4 2017, aligning with the full production of the nRF52840 SoC.

China employs Bluetooth low energy smart platform that enables 'intelligent parking'

A Chinese 'intelligent parking' company has launched a parking space occupancy platform that allows owners of parking spaces to rent and share their vacant sites with drivers looking for an available parking spot.

Beijing Tong Yu Dao Technology recently announced the launch of Ding Ding Ting Che, a smart parking lock device that is bolted into the parking space and can be raised and lowered automatically to prevent unauthorized access to the space, or to grant access to a driver paying to use the space via the Ding Ding Ting Che app. The app allows drivers to view available parking spaces, and navigate to them, in real-time.

The 6V 7Ah lead acid battery-powered smart lock employs Nordic's nRF51822 SoC to provide Bluetooth low energy wireless connectivity between the ground lock and the driver's iOS- or Android-compatible Bluetooth 4.0 (and later) smartphone or tablet. When a driver approaches a vacant parking space they can lower the locking mechanism via the app on their device, allowing them to access the space and triggering payment to the parking spot owner.

The lock can be lowered automatically, granting paying users access to parking spaces

Ding Ding Ting Che also supports WeChat, a cross-platform messaging, content sharing, and online payment solution with over 700 million active users, available on almost all smartphones in China. When integrated with WeChat, Ding Ding Ting Che enables social media sharing of available parking spaces. ***(See page 14.)***

In brief

Bluetooth low energy set for growth curve

Driven by the Internet of Things and smartphone integration, market research analyst, IndustryARC, predicts revenue for Bluetooth low energy solutions will reach $10.1 billion by 2020, accompanied by a CAGR of 22.4 percent. According to the analyst, the integration of the Bluetooth low energy chips in wearables, smartphones, and autonomous motor vehicles will contribute heavily to the sector's significant growth potential in the coming years.

Smart home devices 'for early adopters'

Adoption of newer connected home solutions is still at the early adopter phase, according to a recent survey by Gartner. The 2016 survey, of nearly 10,000 online respondents in the U.S, U.K, and Australia, found only about 10 percent of households currently have connected home solutions. The survey found that home security alarm systems have nearly double the adoption rates of newer connected home solutions such as home monitoring, home automation, or energy management.

Small form factor AoP module for wearables

MtM Technology Corporation has selected Nordic's nRF52832 Bluetooth low energy SoC for its M905 Antenna-on-Package (AoP) module. The M905 is a fully-integrated Bluetooth low energy module designed to enable a wide range of wirelessly-connected products with a 'plug-and-play' solution. The module is suitable for space-constrained applications offering voice control, pattern recognition, or environmental learning functionality.

In brief

Connected things set for huge lift

Research analyst Gartner forecasts 8.4 billion connected 'things' will be in use worldwide in 2017, up 31 percent from 2016, and will reach 20.4 billion by 2020. Total spending on endpoints and services will reach almost $2 trillion in 2017. Regionally, Greater China, North America, and Western Europe are driving the use of connected things and represented 67 percent of the overall Internet of Things (IoT) installed base in 2017. According to Gartner, the applications most in use by consumers will be smart TVs and digital set-top boxes (STBs).

Wireless module for asset tracking apps

Murata Americas has selected Nordic Semiconductor's nRF52832 Bluetooth low energy System-on-Chip (SoC) for its Wireless System Module (WSM) BL241-ADA-008 module. The Bluetooth low energy module is designed to provide developers with a fully-functional solution for low power wireless connectivity applications. The module is suitable for a wide range of applications, including asset tracking devices, insulin pumps, and whitegoods, across the Industrial IoT, energy, and medical sectors.

Next Nike shoe to track performance

Nike Inc is planning to take sports analytics to the next level with its work on technologies that could give teams access to the real-time performance of their athletes. This revelation comes from two Nike patent applications for a wireless vitals tracking system to be built into an athlete's shoe, according to Maquarie analyst Laurent Vasilescu. The tracking system has the capability of connecting up to 28 Bluetooth low energy devices to a computer that processes the data for further display via a graphical user interface.

Sensor beacon reports real-time temperature and humidity data

Shenzhen Minew Technologies, a China-based manufacturer of Bluetooth low energy beacons, has launched its S1 Sensor Beacon, which monitors real-time temperature and humidity data in industrial, agricultural, and home applications.

The sampling rate for temperature and humidity readings is 1 Hz, with the collected data transmitted via Bluetooth low energy connectivity provided by Nordic's nRF52832 SoC to iOS or Android Bluetooth 4.0 (and later) smartphones and tablets running BeaconSET application.

From the BeaconSET app, users can check real-time temperature and humidity data, as well as view historical temperature and humidity changes represented on a graph. The data can also be transmitted to a network gateway and stored in the Cloud, allowing for online PC-based data analysis.

In the absence of a receiver or network connection, the nRF52832 SoC's 512 kB of Flash memory allows the S1 Sensor Beacon to store data which can then be downloaded from the device at the next opportunity.

Users can check real-time temperature and humidity data

The S1 Sensor Beacon comes in an IP66 rated dust- and waterproof-case with an operating temperature range of -40 to +70°C, making it suitable for use in harsh industrial environments. Temperature readings are accurate to ±0.5°C, while humidity readings are within 2.5 percent relative humidity.

The S1 Sensor Beacon is powered by two FR03 Li-ion batteries providing between three and five years of battery life in standard operation, thanks in part to the ultra low power usage of the nRF52832 SoC.

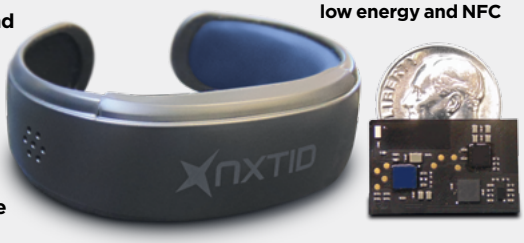
"The nRF52832 has the best performance in its class," says Thomas Ye, CTO, Shenzhen Minew Technologies. "When operating, power consumption is low, and the radio has excellent sensitivity, facilitating significant commmunication range."

Ultra compact module supports plug-and-play security applications

U.S. security technology company, NXT-ID, has unveiled its IoT Stamp module, designed for integration into wearables, portable devices, and Internet of Things (IoT) applications. The IoT Stamp is said to have the smallest footprint of any combined Bluetooth low energy and NFC module on the market.

Powered by Nordic's nRF52832 SoC, the module is designed as a 'drop-in' solution to help manufacturers with little or no RF expertise reduce time-to-market. The module supports identity management, multifactor biometric authentication, and payment methods including Bluetooth low energy, NFC, and dynamic magnetic stripe.

The IoT Stamp can be used with a range of batteries from 10 to 480 mAh or above. With a 10 mAh battery the IoT Stamp can last for several months between recharges, thanks to the nRF52832 SoC, as well as other low power techniques including motion activation, a low power touch control user interface, and patent-pending ultra low power 'buttonless' wake-up.



This module supports a range of payment methods including Bluetooth low energy and NFC

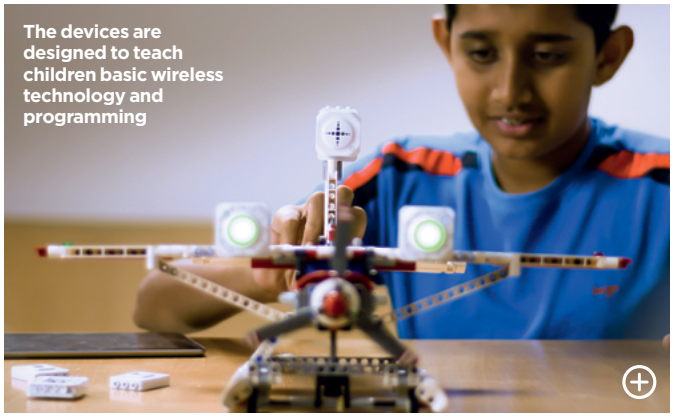
"Nordic's product provided us with both a Bluetooth low energy and NFC solution on a single chip, giving us a smaller footprint as well as the low power consumption we required," says David Tunnell, NXT-ID CTO and Executive VP.

NXT-ID has partnered with WorldVentures to develop the flye smartcard which will be one of the first applications of the NXT-ID IoT Stamp. The flye smartcard can be used for electronic payment, rewards, and other purposes.

Programmable sensor platform introduces children to wireless technology

A platform of intelligent wireless devices designed to teach children basic wireless technology and programming skills has been launched by Indian technology start-up, Plezmo.

The Plezmo platform is comprised of a range of programmable sensors and actuators called 'Elements', including gesture, proximity, color, distance, and movement sensors; a speaker, display, button, and bulb; as well as speed and control motors. Each Element employs Nordic Semiconductor's nRF52832 System-on-Chip (SoC) to provide wireless connectivity between the Elements and 'Plezmo Apps' running on Bluetooth 4.0 (and later) iOS and Android smartphones and tablets.



The devices are designed to teach children basic wireless technology and programming

In operation, Plezmo Elements are designed to work with everyday objects such as existing toys, cardboard-based creations, or whatever base material the user chooses. For example, if the user wants to build a Christmas tree that lights up and starts playing music when someone approaches, they could place Plezmo Bulb Elements in the tree, a Speaker Element under the tree, and a Proximity Sensor Element on a nearby wall.

From Plezmo Apps on their smartphone or tablet the user can then write a program that turns the bulbs on and starts playing music via the speaker when the proximity sensor detects someone nearby. Plezmo Apps are an extensible platform that consists of apps running on iOS and Android mobile devices, as well as desktops. The Apps offer Visual Programming as the primary interface for coding, allowing users to simply drag-and-drop coding blocks to create a logical workflow.

"When we were evaluating SoCs for our architecture we had a range of criteria and only the nRF52832 could match all the requirements," says Plezmo Co-founder, Amol Palshikar. "We needed an SoC with the ability to interface with a broad range of sensor and actuator ICs, as well as a very power efficient platform." (*See page 21.*)

Wireless diagnostic solution for fleet operators

Norwegian telematics company, ABAX, has launched a comprehensive fleet management solution to help operators improve efficiency by monitoring vehicle performance and location.

At the heart of the solution is the ABAX5 'Triplog' main unit which when fitted to a fleet vehicle automatically calculates its mileage and location using GPS positioning. With its Triplog service, ABAX ensures customers are fully compliant with company vehicle tax legislations by automating and simplifying trip documentation.

GPS data is transmitted via GSM to ABAX's servers, allowing fleet operators to effectively monitor and manage their 'live' fleet. Historical movements can be viewed via a web-based software interface or an ABAX app on the operator's iOS or Android Bluetooth 4.0 (and later) smartphone or tablet.

The ABAX5 main unit automatically calculates mileage and location

The ABAX5 acts as the main unit or base station in the fleet management ecosystem, employing Nordic's nRF52832 SoC to provide Bluetooth low energy wireless connectivity between the ABAX5 and the other add-on devices in the system, in part thanks to the Nordic SoC's ability to act as both a Bluetooth low energy 'Central' or 'Peripheral' device.

The ABAX Connected add-on is an OBDII-enabled dongle which connects to the vehicle's diagnostic port and can collect a range of data from the vehicle including speed, RPM, fuel consumption, CO_2 emissions, and Diagnostic Trouble Codes (DTCs). ABAX Connected also employs a Nordic nRF52832 SoC to wirelessly transmit this data to the ABAX5 base station.

"In ABAX we have a wireless policy, if it is possible to make it wireless we do it," says Kjetil Lassen, ABAX R&C Manager.

Content to drive VR shipments

After a content-starved market introduction, virtual reality (VR) is ready to thrive off a host of new and compelling content choices, according to analyst ABI Research. The company forecasts total VR device shipments will reach 110 million by 2021, with mobile device-reliant VR shipments currently dwarfing other VR device types, and set to enjoy a 42 percent compound annual growth rate (CAGR) through 2021. Meanwhile standalone VR devices are anticipated to see a 405 percent CAGR through 2021, according to the analyst.

Micro:bit gets add-on boards

A range of add-on boards for the BBC micro:bit—a programmable hardware coding device powered by Nordic Semiconductor's nRF51822 SoC, and designed to teach U.K. schoolchildren coding skills—were recently unveiled by British hardware engineer Nevil Hunt. Hunt's zbit:connect range slots into a standard micro:bit allowing expansion of the device in the X, Y, and Z axes. According to Hunt, the zbit:connect range includes a proximity sensor, a light sensor, and various wireless connectivity options.

In brief

Mesh network enables long-range communication between devices

Norwegian wireless network solutions company, Vitir, has launched MergeRF, a sub-1GHz self-forming and -healing mesh network of multiprotocol bridges, enabling long-range communication between Bluetooth low energy devices.

Each Vitir 'bridge' includes a Nordic Semiconductor nRF51822 System-on-Chip (SoC) providing Bluetooth low energy wireless connectivity between other bridges, Bluetooth low energy devices, and Bluetooth 4.0 (and later) smartphones and tablets, connecting all devices to a long-range mesh network. The MergeRF bridges also support the KNX RF protocol (an open system for wireless building control) and Wireless M-Bus protocol (for remote gas- and water meter reading).

The bridges act as routers for any payload, irrespective of origin in the network, and regardless of the original RF protocol.

MergeRF is powered by the Tinymesh protocol, already deployed in more than one million devices worldwide

Together with a Central Unit (CU), semantic interoperation between devices using any RF protocol is enabled. This means, for example, a KNX RF wall switch can control a Bluetooth low energy power outlet.

The CU acts as a 'gateway' to the Cloud with a single RF connection point to the mesh, allowing new bridges or new protocols to be added to the mesh without the need to recertify the CU. Such an arrangement significantly reduces RF interference problems.

The MergeRF system supports Bluetooth low energy roaming, important in mHealth applications where, for instance, Continua-certified wristbands can move in the network and be seamlessly connected to Cloud services. And when used in smart buildings, welfare technology and environmental control can be combined using the MergeRF solution.

MergeRF is powered by the Tinymesh protocol, already deployed in more than one million devices worldwide. Using a sub-1GHz RF mesh radio, the MergeRF system has an indoor range per hop approximately ten times greater than traditional Bluetooth 4.2-compliant Bluetooth low energy mesh implementations.

Wearable muscle oxygen monitor helps endurance athletes improve performance via real-time feedback

U.S startup, Humon, has launched a new wearable muscle performance monitor, the Hex, to help people engaging in endurance sports or interval training improve their performance. The unit employs near-infrared spectroscopy to measure the way their muscles are using oxygen.

The Hex uses Nordic Semiconductor's nRF52832 System-on-Chip (SoC) to provide the device with multiprotocol Bluetooth low energy and ANT+ wireless connectivity, delivering real-time feedback to athletes on when and how hard to push themselves.

The device is strapped to the user's thigh—the largest muscle most commonly exerted during athletic activities—from where LEDs emit light into the tissue, and detectors measure the intensity of light that propagates through the muscle, allowing the calculation of the muscle's hemoglobin saturation, a key metric in ensuring appropriate exercise intensity.

The Humon Hex delivers real-time feedback to athletes on how hard to push themselves and when to ease-off training intensity

The generated metrics instantly inform the user via their smartphone, tablet, or compatible Garmin watch. The information shows when users are exerting themselves within the limits of their threshold and are not in danger of 'hitting the wall', or if they need to reduce the intensity of their workout to overcome a deficit of muscle oxygen.

"As a core part of our design, we needed to have both Bluetooth low energy and ANT+, and Nordic provides superior integration over other competitors when it comes to integrating ANT+," says Evan Demers-Peel, Senior Hardware Engineer, Humon. "This on top of all other functionality—the large Flash memory size, the large RAM—is why we chose the nRF52832 chip for the design of the Humon Hex."

ULP WIRELESS TRENDS

The latest developments in technology

By placing the Dial on the screen, digital tools specific to the open app can be brought up

Microsoft unveils wireless interaction tool for fast and intuitive PC navigation

Microsoft recently introduced the Surface Dial, an interaction tool designed specifically for use with its Surface Studio all-in-one desktop PC, but also compatible with any Bluetooth low energy-enabled computer or tablet running the latest version of Windows 10.

According to Microsoft, the Surface Dial provides a faster and more intuitive way to scroll, zoom, and navigate. For Surface Studio users, it also allows for faster access to shortcuts and the ability to seamlessly manage tasks such as adjusting media controls, playing music, or skipping tracks in Groove Music, or scrolling through web pages and documents.

Surface Dial has an intuitive design that requires only three simple gestures: press and hold, click, and rotate. When placed on the screen of Surface Studio, pressing and holding the Dial triggers a larger radial menu which expands to surround the device. Rotating the Dial allows the user to select a specific tool or shortcut, which is then launched with a click. Dial comes pre-loaded with global controls that work across apps like Groove Music, Windows Maps, Microsoft Word, and Microsoft Edge. These include media controls, scroll, zoom, undo/redo, screen brightness, and Narrator. Surface Dial is available from the company's website for $99.99.

Sensors in sports equipment provide real-time analytics

Researchers from the University of Illinois are trialing low-cost sensors and radios that can be embedded into sports equipment, reporting real-time analytics back to the user's smartphone using Bluetooth low energy connectivity.

The team—led by Romit Roy Choudhury, an associate professor, jointly with Sharon Yang from Intel—has developed advanced motion tracking algorithms from the measurements of inertial measurement unit (IMU) sensors and radios, fitted inside a ball and players' shoes.

The sensors, which are wrapped in a protective case and distributed evenly in equipment, employ algorithms that can track movement to within a few centimeters. They can accurately characterize 3D ball motion, such as trajectory and orientation.

The feedback could also help with detecting and analyzing player injuries, such as concussions. The sensor inside a soccer ball, for example, could measure how hard it hits a player's head.

mHealth wearables boost patient healthcare in and out of hospital

A surge in healthcare patient monitoring wearables will help reduce readmission risks and better prevent the occurrence of medical traumas, alleviating growing performance pressures on healthcare services, according to analyst ABI Research.

ABI Research forecasts the patient monitoring wearable market, for both remote and on-site devices, will grow from 8 million shipments in 2016 to 33 million in 2021, including devices such as blood pressure monitors, continuous glucose monitors, pulse oximeters, and fatigue monitoring wearables.

"While previously professional-grade patient monitoring largely limited itself to a doctor's rounds, new wearables allow medical professionals to remotely and continuously monitor patients in the hospital and beyond," says Stephanie Lawrence, Research Analyst at ABI Research. "The devices send real-time alerts regarding any condition deteriorations or fluctuations, in effect reducing response times to potentially life-threatening changes, and saving the healthcare system resources."

Wearables allow medical professionals to remotely and continuously monitor patients

The wearables also, in effect, help to ensure doctors do not overlook any slight changes in condition before granting patients release.

Beyond the hospital, remote patient monitoring wearables, such as blood pressure monitors and telemedicine products, then provide healthcare professionals with continued access to their patients' health, which would have otherwise been inaccessible once they left hospital. As such, doctors can now, like with on-site treatment, monitor their patients' conditions and better diagnose any treatment adjustments that may be necessary.

Nordic launches world's first Bluetooth 5 SoC

Nordic introduced the nRF52840 SoC and S140 SoftDevice, a fully-compliant Bluetooth 5 solution, within days of the new standard's adoption

The latest version of the Bluetooth standard, Bluetooth 5, was adopted in early December 2016. Key enhancements to Bluetooth 5's low energy implementation include longer range, faster speed, and larger broadcast message capacity, as well as improved interoperability and coexistence with other wireless technologies. (*See this issue page 16*).

On the same day, Nordic Semiconductor became the first chip vendor to launch a fully-compatible Bluetooth 5 System-on-Chip (SoC), the nRF52840. The chip is based on the mature architecture of Nordic Semiconductor's existing nRF52 Series SoCs (*see* ULP WQ, *Summer 2015, pg14*) but includes significant enhancements that support complex Bluetooth low energy and other low-power wireless applications that were previously not possible with a single-chip solution.

"The nRF52840 SoC enables wireless product developers to embark on even more ambitious single-chip applications," explains Thomas Bonnerud, Director of Strategy at Nordic Semiconductor. "For example, Bluetooth 5's long range feature makes the technology a genuine contender for smart home applications."

Just one week later, the company released its Bluetooth 5 "developer solution" for the nRF52840 SoC comprising the S140 multirole, concurrent RF protocol software ("stack") 'SoftDevice' - making Bluetooth 5's long-range and high-throughput modes immediately accessible to developers. In addition, the Nordic nRF5 Software Development Kit (SDK) introduced application examples implementing the new functionality.

"Unlike some competitors, Nordic realizes it's critically important to develop all its software in-house to deliver robust, reliable, high-performing, and secure stacks to complement our hardware in this fast-moving sector," says Geir Langeland, Nordic Semiconductor's Director of Sales & Marketing.


Nordic's nRF52840 SoC is fully compatible with Bluetooth 5

"The launch of the nRF52840 enables wireless product developers to embark on even more ambitious single-chip applications"

Under the hood

The nRF52840 SoC employs the nRF52 Series' proven 32-bit ARM Cortex M4F processor running at 64 MHz. The processor enables applications with complex arithmetic requirements to be realized in a single-chip solution and supports Digital Signal Processing (DSP) instructions, hardware accelerated Floating Point Unit (FPU) calculations, single-cycle multiply and accumulate, and hardware divide for energy-efficient processing.

The nRF52840 incorporates a new 2.4 GHz radio architecture with on-chip power amplifier (PA) boosting output power and extending the link budget up to 111 dBm. The radio's current consumption (3V DC-to-DC converter) is 8.7 mA TX (at 0 dBm) and 6.4 mA RX (at 1 Mbps). The radio supports high-resolution Received Signal Strength Indicator (RSSI) measurement and automated functions to reduce processor load, including direct memory access (EasyDMA) for packet data and assembly. The SoC is on-air compatible with existing nRF52 Series, nRF51 Series, and nRF24 Series products from Nordic and supports over-the-air Device Firmware Upgrade (OTA-DFU) - enabling in-field updates of application and/or stack.

In keeping with Nordic's other nRF52 Series SoCs, the nRF52840 is a multiprotocol device capable of supporting ultra low power 2.4GHz wireless protocols such as ANT Wireless' ANT+ and Nordic's proprietary RF software. However, the nRF52840 SoC is the first Nordic device to include support for IEEE 802.15.4. This technology forms the basis of smart home wireless networks such as Thread. IEEE 802.15.4 can also be employed as a Network Adaptation Layer with 6LoWPAN and standard Internet Protocols, significantly extending the nRF52840 SoC's capability as an interoperable foundation technology for IoT, smart home, or industrial wireless sensor networks.

The nRF52840 SoC features 1 MB Flash and 256 kB RAM, a full speed USB 2.0 controller, and a host of new peripherals including a quad-SPI interface. The SoC's power and resource management maximizes application energy efficiency and battery life. The device can tolerate an input range of 1.7 to 5.5 V supporting primary- and secondary-cell battery technologies and direct USB supply without the need for external regulators.

All peripherals have independent and automated clock and power management to ensure they are powered down when not required for task operation to keep power consumption to a minimum.

To address security concerns Nordic has incorporated the ARM CryptoCell-310 cryptographic accelerator into the nRF52840. The accelerator is said to offer best-in-class security for Cortex-M based SoCs and it incorporates a true random number generator (TRNG) plus support for a wide range of asymmetric, symmetric, and hashing cryptographic services for secure applications.

The nRF52840 also integrates Near Field Communication (NFC) Type 2 and Type 4 tag emulation protocol stacks that support NFC payment and Bluetooth Out-of-Band (OOB) pairing.

The nRF52840 is available in a 7 by 7 mm, 73 pin AQFN package with 48 configurable GPIOs. ■

Japan's SoftBank Group promises 'a trillion IoT chips over next 20 years'

SoftBank's acquisition of leading semiconductor IP company, U.K.-based ARM, is a calculated bet on the growth of IoT technologies such as Bluetooth low energy

Internet and telecoms firm SoftBank is extending its reach into the IoT with its ARM acquisition

When Japanese Internet and telecommunications conglomerate SoftBank Group announced a $32 billion deal to acquire the U.K.'s largest listed tech company, ARM Holdings, back in July last year, the global technology sector sat up and took notice.

ARM's embedded processor designs may power more than 95 percent of smartphones on the planet (a market segment that accounted for a significant proportion of the company's royalties up to 2016), but the deal finalized on September 5 was much less about ARM's leadership in mobile, and rather its leadership in the Internet of Things (IoT) into the future.

If the smartphone sector has reached a level of maturity that analysts insist signals a slowdown, not so the IoT. Forecasts for IoT revenue vary depending on which analyst you choose to believe. Consultant McKinsey, for example, estimates the total IoT market will grow at 32.6 percent compound annual growth rate (CAGR) to reach $3.7 billion by 2020. And analyst IHS forecasts the IoT will grow from an installed base of 15.4 billion devices in 2015 to 30.7 billion in 2020 and 75.4 billion in 2025. SoftBank's own forecast, backed by its $32 billion (cash) investment, is perhaps the most spectacular of all.

ARM everywhere

At the recent Mobile World Congress in Barcelona, SoftBank Group Chairman and CEO, Masayoshi Son, said he expected ARM technology to deliver in the region of a trillion chips for the IoT over the next two decades. "This is why I spent $32 billion to acquire ARM," Son told the audience. "ARM is going to be everywhere in the [IoT]." It was, he said, one of the most important acquisitions SoftBank had ever made.

The IoT melds the Internet, the cellular network, billions of Local and Wide Area Networks (LANs and WANs) and (potentially) trillions of wireless sensors into a single entity able to gather and process data at an unprecedented rate.

That huge network will provide a robust platform for a range of businesses, services, and products embracing smart cities, smart grids, smart homes, autonomous vehicles, artificial intelligence, agriculture, industrial monitoring, predictive maintenance, health care, and practically limitless other potential applications.

ARM's contribution to the fledgling IoT is already significant; more than 16 billion chips powered by the company's technology were shipped in 2016. More than half of those chips are expected to power the connected devices that will enable the IoT. In the Bluetooth low energy sector, for example, SoCs such as Nordic Semiconductor's market-leading nRF51 and nRF52 Series rely on embedded ARM processors, such as the 32-bit Cortex-M0 and -M4F, to provide the devices' computational muscle. ARM is also behind initiatives such as mbed, a collaboration with partners (including Nordic) to develop a platform and operating system for IoT devices based on 32-bit ARM Cortex-M processors.

"SoftBank CEO Masayoshi Son has drafted a 300-year business plan for the company"

The widespread use of ARM's Integrated Development Environment (IDE) among engineers has also established the tools as a mainstay of connected-device design.

Backing vital technology

The SoftBank Vision Fund—touted as the world's largest technology investment fund and backed by Saudi sovereign-wealth and other blue chip investors—backs technologies vital to future trends. And the IoT, SoftBank believes, is first among equals when it comes to placing bets on tomorrow.

With its acquisition of ARM, SoftBank has laid down a very clear marker that it plans to play a significant role in building and maintaining the IoT.

CEO Masayoshi Son may have the dubious distinction of having lost the most money in history during the 2000 dotcom crash, but he remains Japan's second wealthiest man with an estimated net worth of $17 billion, and he harbors a long-term vision for technology.

A former senior lieutenant of Son's told the *Asia Times* earlier this year that in the 1990s Son had a drafted a 300-year business plan for SoftBank. "It was pretty well written," Son's former colleague said. "It didn't have finite details. But it was about world dominance, about how he or his group was going to control a lot of things." Including, it appears, the IoT, some 275 years ahead of schedule. ■

Open cellular standards will drive 'massive IoT' uptake

Several technologies are vying for a slice of the LPWAN sector that will underpin the IoT, but only low power LTE promises to support rapid mass deployment, says Peder Rand

Peder Rand is Product Manager for Cellular IoT with Nordic Semiconductor

The Internet of Things (IoT) will require several wireless technologies if it's to meet its potential. For example, Bluetooth low energy or IEEE 802.15.4 are good choices for battery-powered sensors sending data to the Cloud via a building's Local Area Network (LAN). But for sensors that are constantly moving, or are remote from a LAN, such relatively short range wireless technologies run into problems. Even if a LAN is present, manufacturers might prefer longer-range wireless technology for its convenience and autonomy. For example, a white goods manufacturer could select cellular technology over Bluetooth low energy because it enables a refrigerator or washing machine to connect to the Cloud automatically, eliminating the need for a consumer to enter a password to add the appliance to a home's LAN. In these situations, Low Power Wide Area Networks (LPWAN) promise an answer.

There are several technologies upon which LPWANs can be based. These divide into two camps: those based on proprietary systems and those based on open standards. Low power LTE (also dubbed 'cellular IoT') is among the latter and is the basis of Nordic Semiconductor's nRF91 Series products – due for selected sampling later this year. (*See* ULP WQ *Autumn 2016*, *pg8.*)

Low power Long Term Evolution (LTE) has taken off since the 3rd Generation Partnership Project (or 3GPP, the custodians of the LTE standard comprising a collaboration between telecoms partners) introduced a specification for two forms of the technology—LTE-M (for M2M) and Narrow Band-IoT (NB-IoT)—in Release 13 of the standard. (*See* ULP WQ *Autumn 2016*, *pg9.*) The new specification makes it easier for manufacturers to design and develop the inexpensive, compact, and low power consumption wireless LTE modems that LPWANs demand.

Nordic is backing low power LTE because the company believes it's the most promising technology for kickstarting rapid mass deployment of LPWANs and hence will accelerate growth of the IoT. This belief is built on the fact LTE is an open standard, operates in a licensed portion of the RF spectrum, leverages existing infrastructure for coverage, and has coexistence mechanisms that enable scaling to high-node counts per base station. In contrast, proprietary technologies include components owned

and controlled by certain companies—which incur licence fees when adopted by other vendors and limit room for product differentiation—and operate in unlicensed allocations of the RF spectrum (typically at sub-1 GHz frequencies). Because these bands are shared they present tough coexistence challenges.

Stimulating adoption

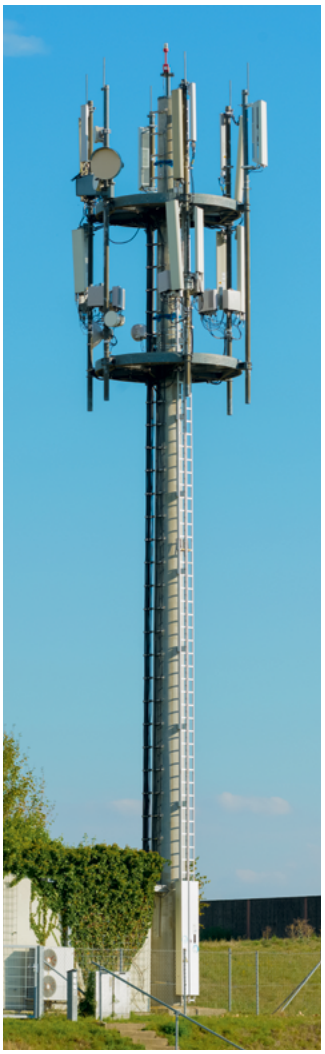
Nordic's experience with another open standard, Bluetooth wireless technology (specifically Bluetooth low energy), has demonstrated that standards stimulate rapid adoption of new technology. Similarly, low power LTE is likely to lead to 'massive IoT' deployment.

Telecoms equipment maker, Ericsson, and mobile operators trade body, GSMA, independently forecast that the market for cellular IoT will expand at around 27 percent compound annual growth rate (CAGR) between 2017 and 2021. Both firms point to low power LTE as a key enabler for this growth.

Low power LTE operates in up to 44 different licensed frequencies across the world, ranging from 450 MHz to 2.6 GHz. The advantages of licensed spectrum are particularly beneficial for many IoT applications; key among these are that the owners of the spectrum allocation (the carriers) can control and prioritize data, and the bands are immune from interference from other sources of RF radiation. Second, because the spectrum allocation isn't shared with other RF transmissions, coexistence between connected devices is much easier to manage. LTE's coexistence technology is based on proven frequency- and time-domain solutions, and other mechanisms such as 'autonomous denials' of conflicting RF signals.

Consequently LTE can support a node density of up to 200,000 active low power modems per base station. Finally, data carried at LTE frequencies is safe from prying eyes because the standard has incorporated advanced security from its inception. These features ensure that carriers can offer reliability and high quality of service (QoS).

Proprietary technologies rely on unlicensed portions of the RF spectrum which must be shared with many other services. While interference avoidance techniques are employed, because so many services are sharing the spectrum allocation it is extremely difficult to approach, let alone match the node density, reliability, and QoS of LTE. Proprietary LPWAN vendors are also faced with the major challenge of building infrastructure to support their networks. These are likely to be expensive and long-winded projects slowing adoption.



LTE's coexistence mechanisms will allow a single base station to support up to 200,000 low power modems

In contrast, worldwide LTE infrastructure is largely in place comprising 480 networks in 157 countries. Some upgrading (mainly of software) is required to support low power LTE, but this is trivial compared to building the infrastructure in the first place. Because the infrastructure is installed, support for low power LTE is likely to be added rapidly, further encouraging its uptake. Test installations are already built and commercial deployments will soon follow. By the end of 2017 a significant portion of the world will feature network coverage.

Companies adopting low power LTE for their IoT-connected products can leverage this infrastructure without bearing its build- or maintenance-costs, instead investing in their own services and business models.

And as the telecoms network evolves from 4G systems to 5G, low power LTE won't be rendered obsolete because 3GPP has ensured there's an upgrade path for the technology. 5G, while some years away, will provide much greater throughput by using higher wireless frequencies (up to 26 GHz) and will impart even greater momentum to the IoT. ■

Ultra low power wireless connectivity solutions

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

ICs	Operating Band	Wireless Protocol					IC Type			On-Chip						Peripherals																										Applications											Ref. Designs	Dev Tools	WLCSP Wafer-level chip-scale package option
		Bluetooth 5	Bluetooth LE	ANT	802.15.4	2.4GHz Proprietary	System-on-Chip	Connectivity	Transceiver	CPU	FPU	DSP	Memory OTP: One Time Programmable	MPU	PA	Balun	Oscillators	NFC-A tag	2-Wire	ADC	AES	Analog Comparator	Battery Monitor	I2S	PDM	PWM	Real Time Clock	ARM CryptoCell	TRNG	SPI	QSPI	S/PDIF	Temperature Sensor	UART	USB	PC Peripherals	Sports & Fitness	Gaming	Cellphone Accessories	Consumer Electronics	Automation	Healthcare	Toys	Wearables	Smart Home	Beacon	Wireless Charging	Automotive Graded			
nRF52 Series																																																				
nRF52840	2.4GHz	●	●	●	●	●	●			Cortex M4F	●	●	256kB RAM 1MB Flash	●	●	●	32MHz / 32kHz Crystal 64MHz / 32kHz RC	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		-	Single Board Dev Kit, Power Profiler Kit	
nRF52832	2.4GHz	●	●	●		●	●			Cortex M4F	●	●	64kB RAM 512kB Flash	●		●	32MHz / 32kHz Crystal 64MHz / 32kHz RC	●	●	●	●	●	●	●	●	●	●		●	●		●	●	●		●	●	●	●	●	●	●	●	●	●	●	●			PC Desktop, Smart Remote, Smartphone Demo Apps	Single Board Dev Kit, Power Profiler Kit	●
nRF51 Series																																																			
nRF51822	2.4GHz		●	●		●	●			Cortex M0			32kB or 16kB RAM 128kB or 256kB Flash	●			16MHz / 32kHz Crystal 16MHz / 32kHz RC		●	●	●	●				●	●		●	●			●	●	●	●	●	●	●	●	●	●	●	●	●			PC Desktop, Smart Remote, Smartphone Demo Apps, Beacon	Single Board Dev Kit, Dongle	●
nRF51422	2.4GHz		●	●		●	●			Cortex M0			32kB or 16kB RAM 128kB or 256kB Flash	●			16MHz / 32kHz Crystal 16MHz / 32kHz RC		●	●	●	●				●	●		●	●			●	●	●	●	●	●	●	●	●	●	●	●			Smartphone Demo Apps	Single Board Dev Kit, Dongle	●
nRF51824	2.4GHz		●	●		●	●			Cortex M0			16kB RAM and 256kB Flash	●			16MHz / 32kHz Crystal 16MHz / 32kHz RC		●	●	●	●				●	●		●	●			●	●				●		●			●	●	●			Smartphone Demo Apps	Single Board Dev Kit, Dongle	
nRF8000 Series																																																			
nRF8001	2.4GHz		●					●		-			-				16MHz / 32kHz Crystal 32kHz RC													●			●			●	●	●	●	●	●	●	●					PC Desktop, Smart Remote, Smartphone Demo Apps	nRFgo Dev Kit, Prog. Kit	
nRF8002	2.4GHz		●				●			-			-				16MHz Crystal 32kHz RC					●																●											Key Tag, Smartphone Demo Apps	nRFgo Dev Kit, Prog. Kit	
nRF24AP Series																																																			
nRF24AP2-1CH	2.4GHz			●				●		-			-				16MHz / 32kHz Crystal													●				●			●		●	●									Smartphone Demo App	ANT Dev Kit	
nRF24AP2-8CH	2.4GHz			●				●		-			-				16MHz / 32kHz Crystal													●				●			●		●	●									Smartphone Demo App	ANT Dev Kit	
nRF24AP2-USB	2.4GHz			●				●		-			-				16MHz Crystal																	●			●		●	●									ANT USB Dongle	ANT Dev Kit	
nRF24L Series																																																			
nRF24LE1	2.4GHz					●	●			8051			1kB + 256B RAM 16kB + 1.5kB Flash				16MHz / 32kHz Crystal 16MHz / 32kHz RC		●	●	●	●				●	●		●	●			●			●		●	●		●								PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit, Prog. Kit	
nRF24LE1 OTP	2.4GHz					●	●			8051			1kB + 256B RAM 16kB + 1kB OTP				16MHz / 32kHz Crystal 16MHz / 32kHz RC		●	●	●	●				●	●		●	●			●			●		●	●		●								PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit, Prog. Kit	
nRF24LU1+	2.4GHz					●	●			8051			2kB + 256B RAM 16/32kB Flash				16MHz Crystal				●									●				●			●		●	●		●								PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit, Prog. Kit	
nRF24LU1+ OTP	2.4GHz					●	●			8051			2kB + 256B RAM 16kB + 1kB OTP				16MHz Crystal				●									●				●			●		●	●		●								PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit, Prog. Kit	
nRF24L01+	2.4GHz					●			●	-			-				16MHz Crystal													●							●		●		●			●						-	Eval Kit	
nRF24 Series																																																			
nRF2460 (mono)	2.4GHz					●		●		-			-				16MHz Crystal		●				●							●									●		●			●						Microphone	nRFgo Dev Kit	
nRF900 Series																																																			
nRF9E5	433 / 868 915MHz					●	●			8051			4kB + 256B RAM				4 / 8 / 12 / 16 / 20MHz Crystal			●						●	●			●			●							●									-	Eval Kit	
nRF905	433 / 868 915MHz					●			●	-			-				4 / 8 / 12 / 16 / 20MHz Crystal													●																				-	Eval Kit	

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Smart parking systems liberate drivers from the tedium of finding a space in crowded cities

Smart parking for smart cities

Making vehicle parking more efficient with smart sensor systems eases city congestion and reduces pollution. By Sally Ward-Foxton

Sally Ward-Foxton is a freelance journalist specializing in electronics

Today's cities are fighting serious problems with congestion and pollution caused by unprecedented volumes of motorized traffic. As part of a global increase in connected, smart-city projects, smart parking applications are emerging to help in the fight against vehicle emissions. They can also help make inner city driving a quicker and more efficient mode of transportation.

Smart-parking systems are based on connected sensor technologies that are used to detect whether a parking space is occupied and communicate that information across a wireless network, where it can be used by consumers and parking operators. Motorists can be offered guidance as to how many parking spaces are available in a specific location, and exactly where the spaces are (for example, on which floor of a multifloored parking gagage). Once this data is collected, it can be communicated to drivers via specially designed apps on smartphones, tablets, and GPS systems.

"Instead of driving around looking for a space, you're heading straight for a slot that you know is available," says John Leonard, Product Marketing Manager at Bluetooth low energy chip vendor Nordic Semiconductor. "That works on a number of levels: it saves time and frustration, it's environmentally friendly as less fuel is wasted and pollution generated, and congestion is eased in built-up spaces."

Making parking smarter also means additional features can be offered to drivers.

"Perhaps if you know you're going to a concert or a football match, you'd be prepared to pay extra to reserve a parking space in a specific area," Leonard suggests. Parking operators could then use this capability to develop new pricing strategies based on offering additional consumer choice. "These sensors can also be a great help for things like billing, since fees can be collected by automated systems, and the fees are then 100 percent accurate," he adds.

Automatic, optimized billing systems can help save parking operators money. Personnel costs can also be reduced by optimizing parking attendant time: sensor systems with a properly designed operator interface should be able to tell attendants at-a-glance exactly how long each car has been in each space, reducing the need for 'feet on the street'.

Leveraging 'big data'

Aligning with the trend for generating and using 'big data' to help optimize commercial operations, parking operators can also collect the information these systems generate for analytical purposes. Such data would typically be analyzed to show how parking resources are being used, enhancing allocation and location of facilities such as disabled permit spaces and electric vehicle charging points. The data can also be used to develop dynamic pricing strategies to encourage parking in low-demand areas, at off-peak times, or in certain parts of a town or city to reduce congestion on a dynamic basis.

One such smart-sensor system, operated by Denver, CO based ParkiFi, uses Bluetooth low energy-enabled parking space occupancy sensors to offer benefits for both consumers and parking operators.

"ParkiFi's sensors make the entire consumer parking experience easier. We use Bluetooth low energy to tell our app the sensor location where a driver is parked. This tells drivers which parking spots are open in real time and streamlines the entire parking payment experience," explains the company's Head of Technology and Co-Founder Rishi Malik.

"Drivers no longer have to get out of their cars, walk to a payment kiosk, wait in line, pay,

and go back to their cars to display their parking receipts. With ParkiFi, drivers can use our app to find an open spot, navigate to it, and seamlessly pay for parking without having to enter parking ID codes, or call any 800 numbers."

ParkiFi's parking sensors, which are about the size of a hockey puck, are installed permanently into the ground in the centre of each parking space. They use a magnetometer to sense the presence of a vehicle, and a proprietary long range low-power sub-GHz radio protocol to communicate with basestations placed nearby which collate and transmit the data to parking providers. A Nordic Semiconductor nRF51822 chip forms the brains of the sensor, providing integrated Bluetooth low energy functionality for direct connection to consumer smartphones, while extending battery life to years with ultra low power consumption.

Real-time data collection and analysis is also a big part of ParkiFi's offering.

"Previously parking operators had to use slow, manual methods to view their inventory, and track how it changes over time," Malik says. "Now, they can use our dashboard to see it all in real-time, and improve their bottom line as they go."

Another Bluetooth-enabled parking space platform, Ding Ding Ting Che, takes a slightly different approach to optimizing parking resources in communities near its Beijing, China headquarters. Developed by the Beijing Tong Yu Dao Technology Company, this solution allows customers to rent out their unused parking spaces by installing connected parking locks.

"The difference between Ding Ding Ting Che and other intelligent parking systems is that it's designed to utilise otherwise unused parking resources in the community and among office sites with a high degree of integration of online and offline resources," says Shen Ao, Founder and CEO of the Beijing firm.

"We use a parking app and intelligent parking sharing devices to enable the instant search for and rental of idle

Ding Ding Ting Che's Bluetooth-enabled parking locks allow offices and consumers to rent out their parking spaces

parking spaces, alleviating the difficulties of urban parking and encouraging shared economic development. This also promotes intelligent transportation and the development of an intelligent community able to make the efficient use of parking resources a reality."

A driver looking for a parking space accesses Ding Ding's app to select an available spot. Ding Ding's parking locks have a physical barrier which prevents any unauthorized parking in that space; when the driver paying for the space arrives, they use the smartphone app to communicate with the parking lock via Bluetooth low energy and lower the barrier, allowing them to park. The app also takes care of billing and allows sharing of parking locations on the popular Chinese social media platform WeChat. The parking locks use Nordic Semiconductor's nRF51822 chip for Bluetooth low energy connectivity, allowing secure over-the-air-updates and, crucially, support for WeChat hardware.

ParkiFi's occupancy sensors use a magnetometer to sense vehicle presence, long range radio to relay information about occupancy, and a Nordic Bluetooth low energy chip to connect to drivers' smartphones for payment

A step to autonomy

Parking systems like these are contributing to an overall trend for intelligent city infrastructure, and they could also play a big part in enabling future innovations. Vehicle systems are continuously evolving to take advantage of advanced driver-assistance systems and will eventually enable completely automated driving. One popular vision of the smart city of the future even has cars dropping their owners off at a shop or restaurant and then going off and parking themselves, to be summoned back to pick up the user via a smartphone app.

"Autonomous driving applications are developing fast, but it will be a long time before a car can have as complex a sensor network as a human being," notes Nordic's John Leonard. "Identifying a vacant parking space with cameras and image processing is quite a challenge for autonomous vehicles. Smart parking systems could really help simplify the task, turning a processing-heavy calculation into a simple transmission of data concerning the location of a suitable empty space."

The confluence of sensor technology, low power wireless communications, smartphones, the Internet of Things (IoT), and autonomous driving systems will help enable the future of connected smart cities that work efficiently to improve their inhabitants' quality of life.

"I think you'll see more sensor systems in general as the IoT industry grows and matures. We're just beginning to understand how data shapes our world, and as we learn more, the industry will grow," concludes ParkiFi's Rishi Malik. "Autonomous cars are certainly a part of that, and integration with parking systems is a boon for driverless cars and the drivers themselves." ■

A brief guide to Bluetooth 5

The latest version of the popular wireless technology boosts throughput and range, and in turn its suitability for home automation applications. John Leonard explains

By **John Leonard**, Product Marketing Manager, Nordic Semiconductor

Bluetooth 5 offers up to four times the range of version 4.2, a key advantage in connected home applications such as external lighting

Bluetooth has come a long way from its early days. Back in 1999, version 1.0 of the technology featured a raw data bandwidth of 1 Mbps, could only support a Gaussian Frequency Shift Keying (GFSK) modulated scheme, lacked adaptive frequency hopping (AFH) spread spectrum, and struggled to meet the promise of interoperability.

Successive versions addressed these weaknesses adding bandwidth, range, security, and improved interference immunity. Bluetooth 3.0 + HS, for example, introduced in 2009, provided a Bluetooth bandwidth of up to 3 Mbps and, by employing a co-located 802.11 channel, could boost speeds up to 24 Mbps.

The 2010 adoption of Bluetooth 4.0 introduced Bluetooth low energy as a hallmark element. This version of the Core Specification detailed two types of chip, a Bluetooth low energy chip and a Bluetooth chip retaining the Basic Rate (BR)/Enhanced Data Rate (EDR) physical layer (PHY) of previous versions in addition to the new Low Energy (LE) PHY.

Previous editions of *ULP Wireless Q* have described Bluetooth low energy in detail, and Nordic's nRF51 and nRF52 Series Systems-on-Chip (SoCs) support Nordic Bluetooth low energy 'SoftDevices' (RF protocol software or 'stacks') on their multiprotocol hardware. In summary, Bluetooth low energy features a lightweight stack, interoperability with Bluetooth from version 4.0 on, and (in the original specification) a raw data bandwidth of 1 Mbps, range of around 10 m, and a high degree of immunity from other 2.4 GHz radio sources.

Preparing for the IoT

Bluetooth 4.0's impressive uptake has been due in large part to smartphone interoperability. A huge range of 'appcessories' such as fitness bands or remote-controlled toys could leverage the mobile device's computational power or use it as a 'gateway' to the Cloud. But this reliance on the smartphone was a weakness in applications such as industrial automation where it's impractical to rely on a smartphone to act as the gateway.

Bluetooth 4.1 started to address this weakness by adding the ability for a device to act as a Bluetooth low energy 'peripheral' and 'hub' at the same time and adding a means to create a dedicated channel, which could be used for IPv6 (the latest version of the Internet Protocol (IP) standard) communications. Independently of the release of Bluetooth 4.1 but advantageously for the technology, the Internet Engineering Task Force (IETF) added the Low Power Wireless Personal Area Networks (6LoWPAN) specification to IPv6 – endowing sensors with a unique IP address and thus connection to the Internet without requiring a gateway.

The IETF's development, together with the dedicated channel introduced in Bluetooth 4.1, enabled Bluetooth 4.2 to include the Internet Protocol Support Profile (IPSP) in the Bluetooth low energy stack. IPSP allows devices to discover and communicate with other devices that support IPSP using IPv6 packets over a Bluetooth low energy transport layer. (*See* ULP WQ *Spring 2015, pg8.*)

Bluetooth 4.2 featured an increase in packet capacity by almost ten times (from 27 to 251 bytes) compared with Bluetooth 4.1, and data range was increased up to 2.5 times. These improvements improved device-to-device communications and enabled faster uploads. Bluetooth 4.2 also introduced some security elements such as Low Energy (LE) Secure Connections, asymmetric Elliptic Curve Cryptography (ECC), and LE Privacy.

At home in the home

Bluetooth 5 (not '5.0' as might be expected based on the previous naming scheme (*see this issue page 20*)), introduced in December 2016, further enhances Bluetooth low energy technology's suitability for IoT applications such as home automation.

The Core Specification now details a 2 Mbps PHY (in addition to the 1 Mbps PHY used in previous versions of Bluetooth low energy). A doubling of PHY bandwidth doesn't translate directly to a doubling of data transmission rate because of changes made to the Bluetooth low energy packet structure for Bluetooth 5, but a data transmission rate of around 1.4 Mbps—compared with 800 kbps from the 1 Mbps PHY—is a reasonable expectation.

Faster throughput is obviously a benefit for many applications, but a key advantage for IoT devices is faster Over-the-Air Device Firmware Updates (OTA-DFU) – an important consideration for IoT sensors that are likely to need regular updates to provide increasing functionality and enhanced security. In addition, a 2 Mbps PHY saves energy because the radio is active for less time than a 1 Mbps device to transmit a given amount of data.

Bluetooth 5 offers up to four times the range of version 4.2 – another key advantage in many IoT applications, particularly the connected home. For example, all the smart lights in a large house and even situated outside could have sufficient range to communicate with a central hub without needing to resort to complex mesh networking or expensive power amplifiers (PAs) to boost range.

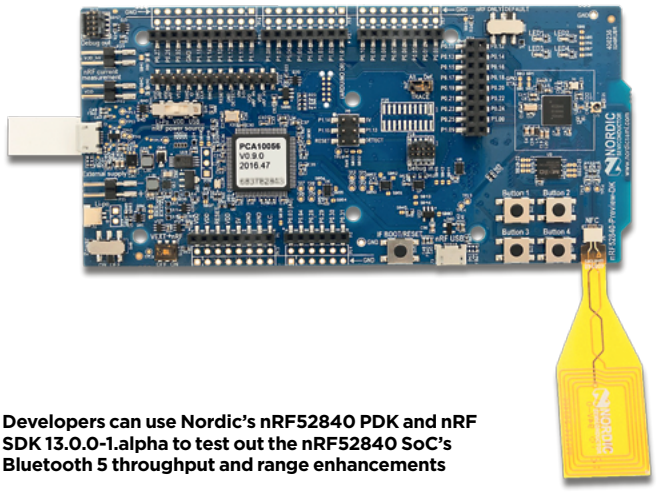
The range boost comes from the use of Forward Error Correction (FEC) to detect and fix packet corruptions during data transfer. This improves the Bit Error Rate (BER), enhancing robustness and increasing range - but at a cost of reduced throughput and increased average power consumption.

Bluetooth 5's FEC offers two coding schemes, S = 2 or S = 8. S = 2 results in an approximately doubled range whilst S = 8 boosts it by around four times. But the cost is the number of bits per unit time which must be transmitted for error correction which then impinges on the overall useful data rate. Specifically, when using the S = 2 scheme, one bit passed through the FEC Encoder becomes two bits which then rises to eight bits when the S = 8 scheme is implemented. Consequently, transmitting a 251-byte data packet takes about four times as long for S = 2, and 13 times as long for S = 8, compared with an uncoded transmission.

Because of longer per packet transmission times, raw data rates are reduced to 500 or 125 kbps depending on the coding scheme, plus the radio has to be in a higher power state for longer (shortening battery life), and there's an increased risk of interference from other 2.4 GHz radio sources.

Beyond the throughput and range enhancements, Bluetooth 5 also introduces advertising extensions which increase payload size for more efficient data transfer. The most likely application of this feature is for beacons allowing retailers to send more information in the advertising packet to consumers' smartphones. A further feature of Bluetooth 5 is the ability to use data channels for broadcasting.

Bluetooth 5 doesn't yet support the mesh networking capability of competing technologies such as ZigBee and ANT+. Mesh networking is a key requirement for IoT applications and the next update of the Bluetooth standard (due late 2017) is likely to add this.



Developers can use Nordic's nRF52840 PDK and nRF SDK 13.0.0-1.alpha to test out the nRF52840 SoC's Bluetooth 5 throughput and range enhancements

5 in action

Nordic's nRF52840 SoC with the S140 SoftDevice is fully compatible with Bluetooth 5 (supporting 2 Mbps PHY, and S = 2 and S = 8 FEC schemes to boost range (*see this issue pg8*)). The nRF52832 SoC is compatible with the throughput requirements of the latest specification.

An nRF52840 SoC-based exhibit demonstrated the chip's range and throughput capabilities at the recent CES 2017 show. The demo was based on the 'ATT_MTU' throughput example in the nRF Software Development Kit (SDK) 13.0.0-1.alpha, which allows developers to configure various Bluetooth low energy parameters to test out their impact on throughput and range. The demo requires two nRF52840 Preview Development Kits (PDK) or nRF52832 Development Kits. (The nRF52832 DK doesn't support Bluetooth 5's long range feature.)

There's a blog on how to set up the demonstration on the Nordic Developer Zone (tinyurl.com/jsh3q2g). There's also a nice demonstration of long-range operation using the nRF52840 SoC on the Devzone (tinyurl.com/hgu9gnw). ■

Sony and Nordic collaboration yields new power design tool

Sony Mobile IoT design team use power management software tool to identify where energy savings can be made to maximize sensor battery life

Smartphone maker Sony Mobile's Research and Incubation department is developing compact, battery-powered Internet of Things (IoT) sensors collecting and sharing data across wireless links. To limit maintenance, the sensors require battery lifetimes measured in months.

"The main challenge is reducing energy consumption," says Peter Lerup, Master Systems Engineer, Research & Incubation, Sony Mobile. "The [IoT] device needs to be small and lightweight, placing major constraints on the battery capacity."

The prototypes are based on Nordic Semiconductor's nRF51822 Bluetooth low energy System-on-Chip (SoC), a device which was designed from the ground up to minimize power consumption. However, careful application code development and hardware design is still required to ensure the SoC's power performance is optimized.

The Otii software energy optimization tool interfaces with Nordic's Power Profiler Kit

Visualizing current

To assist the prototype's developers, Sony Mobile start-up Qoitech created a software-based energy optimization tool, called 'Otii'. The application is a 'plug-and-play' installation running on Windows, Linux, and macOS that helps engineers visualize the current being drawn by the sensor.

Better yet, Qoitech has ensured that Otii interfaces with Nordic's Power Profiler Kit (PPK), via a USB cable, to form an intuitive tool for tracking how the sensor's application software affects its power consumption. (The PPK is a development tool comprising PC-based software and an extension board for Nordic's nRF5 Development Kit (DK) which plugs directly into the DK via Arduino Uno pin headers. (*See* ULP Wireless Q, *Winter 2016, pg 4.*)

Otii's user interface enables engineers to easily detect power spikes and statistics, either in real-time or as a recording. The user can zoom in on certain parts of the test cycle and compare it with previous recordings by overlaying them in the same graph. Analysis is eased because Otii synchronizes the debug output of the device-under-test's application software with the power measurement, enabling rapid identification of software events that cause current spikes.

Without a tool such as Otii, narrowing down the causes of peaks in power consumption is via trial and error, extending project timescales. And multimeter readings lack resolution and don't allow test sequence recording. Alternatively, a top-end lab analyzer is expensive and requires experience to operate and interpret.

"Without Otii, finding the causes of peaks in power consumption is via time-consuming trial and error"

Otii's detailed analysis enabled the Sony Mobile research team to pinpoint any discrepancies between the sensor's predicted and actual power consumption, and identified where energy savings could be made. The tool was then used to ensure the total power budget for the sensor was not exceeded, even after changes were made to the software.

The analysis allowed the team to develop software algorithms to balance power consumption against the volume of data collected by the sensor. For example, more frequent measurements may require the nRF51822's Bluetooth low energy radio to be operated in a different mode to keep within the power budget.

A beta version of the Otii energy optimization software for Nordic's PPK is available for a free trial from the Qoitech website. ■

Benchmark reveals efficiency of Bluetooth low energy 'end nodes'

Industry-backed benchmark allows developers to directly compare Bluetooth low energy SoC power consumption in wireless 'thing' applications connected to the IoT

Low power wireless 'things' dutifully monitoring their surroundings at the very edges of the IoT are likely to reside in inaccessible places. That makes it important that their batteries last a long time because changing them might be inconvenient and time consuming.

Bluetooth low energy, as the name suggests, was designed to minimize power consumption (*see this issue page 16*) and modern SoCs from a range of manufacturers perform well, typically drawing milliamp peak currents and microamp average currents. Such modest power consumption enables batteries to last for months in low duty-cycle applications. But some chips are better for certain applications than others, and even a few percentage points difference in performance can extend battery life by weeks.

Silicon vendors include power consumption data for a range of Bluetooth low energy radio modes in their data sheets, but these are often measured in optimum conditions for limited applications. That can make it difficult for a developer to make an unbiased comparison between shortlisted components for his or her specific application based on the data sheets alone.

Benchmarks to the rescue

Now the Embedded Microprocessor Benchmark Consortium (EEMBC) has come to the rescue. The organization, formed in 1997 to develop industry-standard benchmarks for embedded system hardware and software, has recently announced the availability of EEMBC IoTMark-BLE, a benchmark and analysis tool that measures the energy efficiency of Bluetooth low energy SoCs used in IoT 'end nodes'. (The organization defines an end node as comprising four parts: sensor; processing (including the RF protocol firmware); interfaces connecting sensor and processing; and a communication mechanism used to transmit/receive information.)

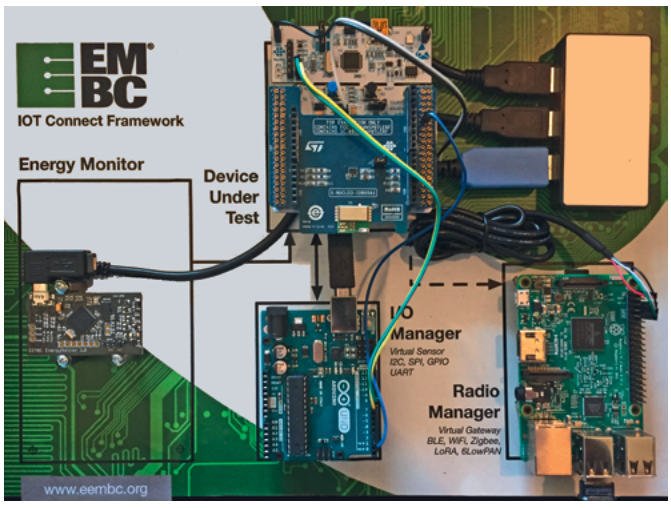
"Datasheets ... tell only part of the story," said Brent Wilson, co-chair of the EEMBC IoT-Connect working group, in a statement. "[The new benchmark] measures the energy used by the full [radio] system ... while it performs real-world tasks. Each part of the system impacts energy efficiency, so evaluating the whole radio system provides the most realistic evaluation of its battery life."

The organization says the benchmark allows developers to make comparisons between embedded microcontrollers, radio physical layers, and modules, as well as between RF protocol firmware. The framework supporting the benchmark includes an energy monitor, a radio manager to coordinate the communication with the device under test (DUT), and an IO manager to synchronize activities and to simulate a sensor input on the DUT's I2C or serial peripheral interface (SPI).

Applications determine a range of parameters including packet payload, frequency of packet transmission, and transmit power. EEMBC members agreed on specific tests and measurements to cover a wide range of applications.

EEMBC claims the framework "makes it easy for developers to select parameters and functions to ensure equitable comparisons while providing valuable insight beyond datasheet specifications".

"Benchmarks lead developers to informed decisions, rather than having to demystify unsubstantiated claims from competitors"



EEMBC's IoT Connect framework comprises an energy monitor, a radio manager to coordinate communication, and an IO manager to synchronize activities and to simulate a sensor input

The Bluetooth low energy benchmark is the first of several IoT wireless technology comparisons planned by the EEMBC's working group. The clever part of the organization's strategy is that the benchmark framework can be applied to other RF communication protocols allowing new benchmarks to be rolled out quickly. Next up are benchmarks for Wi-Fi, 6LoWPAN, and Low Power Wireless Area Networks (LPWANs).

"The framework ... has the flexibility to accommodate various communication protocols, and is also sufficiently portable to work with any vendor's microcontroller and radio-module products," said Peter Torelli, EEMBC director of technology, in a statement. "Industry-standard benchmarks [lead developers] to informed decisions, rather than having to demystify unsubstantiated claims from competitors."

The working group includes Nordic Semiconductor, embedded microprocessor IP vendor, ARM, and other major wireless chip manufacturers. EEMBC is encouraging other interested parties to join the group to ensure it covers all envisaged applications.

"Nordic, along with other major RF chip makers, supports the EEMBC's IoTMark benchmark initiative because it means network developers can choose the best wireless device for their specific application based on impartial comparison against alternatives," says John Leonard, a Product Marketing Manager with Nordic. "That can only result in the roll-out of higher quality IoT infrastructure." ■

What's in a name?

Be it Classic Bluetooth, Bluetooth v4.0 or Bluetooth low energy, Bluetooth's various guises aren't always obvious from the name. ULP Wireless Q clears up the confusion

Over a decade ago, an enterprising group of technology companies, encouraged and led by Nokia, and including Nordic Semiconductor, spotted a market opportunity for an ultra low power (ULP) wireless technology that could run for months from batteries as modest as CR2032 3V coin cells.

Nokia's vision was for a range of ULP wirelessly-connected accessories sending information to the company's handsets via a Personal Area Network (PAN). Nokia dubbed its innovation "Wibree".

At the time, Nordic was the leader in proprietary 2.4GHz ULP technology and its chips were commonly found in products as diverse as sportswatches, heart rate monitors, and wireless desktops. However, the company appreciated that an open standard for ULP wireless would dramatically extend the reach of ULP RF technology and was willing to share its hard-won technical expertise.

Meanwhile, The Bluetooth Special Interest Group (SIG), promoters and custodians of the Bluetooth Core Specification, the standard that governs Bluetooth wireless, shared a similar vision. The SIG's popular short-range 2.4 GHz technology had proved successful linking headsets to handsets but was struggling to expand into other sectors. Bluetooth technology offered good bandwidth and range, but, as a 'connection-oriented' technology consumed far more power than Nordic's proprietary asynchronous ULP wireless.

Both groups quickly appreciated that Bluetooth's advantage of adoption by handset manufacturers (who were hardly keen to add yet another radio chip to their products) complemented the Wibree Alliance's low power consumption technology. And so, in a merger between the Nokia-led grouping and the Bluetooth SIG, "ultra low power Bluetooth" was born. The prototype technology was not yet interoperable with "Bluetooth 3.0", the latest version of the SIG's original product which itself had recently been upgraded to a bandwidth of 24 Mbps.

Consumers don't care, and engineers can get confused about what a device 'complying with Bluetooth 5' actually is

Ultra low power Bluetooth was soon renamed "Bluetooth low energy" to better describe its ability to extend battery life. (The Bluetooth SIG insists that the technology is always written as Bluetooth low energy (lower case 'l' and 'e') and there is no abbreviated form - although many silicon vendors and technical journalists commonly refer to it as "Bluetooth Low Energy", "Bluetooth LE" and "BLE".)

A hallmark element

Bluetooth 4.0 was adopted in June 2010, with Bluetooth low energy described as "a hallmark element of the [new] Core Specification". The revised specification described two types of Bluetooth chip: "single mode" (Bluetooth low energy, only interoperable with other Bluetooth devices complying with version 4.0 and later); and "dual mode" (conventional or so-called Classic Bluetooth chips that retained the functionality of Bluetooth 3.0 BR/EDR devices and retrospective interoperability, but also included Bluetooth low energy interoperability to enable communication with single-mode devices).

"For the consumer, a single name for the technology—that doesn't discriminate between the two chips that make up the Bluetooth ecosystem—makes sense"

The Bluetooth SIG later dropped the single-mode and dual-mode description, rebranding single-mode devices as "Bluetooth Smart" and dual-mode chips as "Bluetooth Smart Ready". Today, those references have also largely been deprecated (although remain prevalent in many chip manufacturers' datasheets).

Meanwhile, the Core Specification itself underwent several name changes. Bluetooth version (or "v") 4.0 and the subsequent v4.1 and v4.2 updates are now referred to as "Bluetooth 4.0", "4.1" and "4.2" respectively (i.e. without the 'v') and the latest version is known simply as "Bluetooth 5" (rather than the "Bluetooth 5.0" which might have been expected based on the traditional naming scheme). It's not clear if the next interim update will be called "Bluetooth 5.1" or the SIG will simply opt for "Bluetooth 6".

For the consumer, a single name for the technology—that doesn't discriminate between the two chips that make up the Bluetooth ecosystem—makes sense. Consumers are just interested in a technology that works and not what's under the hood. But for engineers today it's not always immediately obvious whether a device described as "complying with Bluetooth 5" is a Bluetooth low energy chip designed to run from modest power sources, or a fully-functional Bluetooth 5 device typically found in smartphones and tablets. For its part, Nordic specializes in the low energy form of the technology and *ULP Wireless Q* keeps things unambiguous by referring to the company's chips as Bluetooth low energy devices compatible with Bluetooth 4.0 (and later versions). ■

Programmable sensor platform future-proofs students

The next generation will be more reliant on technology skills for their job prospects than any before. Nordic is helping one start-up set students on the right path

In the decade after 1981 the proportion of U.S. schools using computers for educational purposes rose from 18 to 98 percent, and it didn't take long for the other two percent to catch up. While the rapid development of technology-based learning in the 1980s and 1990s drew skepticism from parents and teachers at the time, there are few dissenting voices now. Science, Technology, Engineering, and Mathematics (STEM) skills are today considered not only critical to the competitive edge of knowledge-intensive economies, but increasingly to the job prospects of the next generation.

It's a reality not lost on Indian technology startup, Plezmo. The company has developed a platform of intelligent wireless devices designed to teach children basic wireless technology and programming skills. The Plezmo platform is comprised of programmable gesture, proximity, color, distance, and movement sensors, as well as speed and control motors for actuation, and a speaker, display button, and light bulb. Each 'Element' incorporates Nordic's nRF52832 System-on-Chip (SoC) to provide wireless connectivity to other Elements and the smartphone, tablet or desktop computer-hosted 'Plezmo Apps'.

The apps offer Visual Programming as the primary interface for coding, allowing users to simply drag-and-drop coding blocks to create a logical workflow and easily troubleshoot any problems with a built-in debug capability. Plezmo Apps also include a simulator that allows users to test out their creations.

For example, a child could use the Plezmo Proximity Sensor, Bulb, and Speaker elements to build a Christmas tree that lights up and starts playing music when someone approaches, based on the program they have created in Plezmo Apps.

Children need to learn how to create as well as consume technology

Teaching logic

"Most of the professions we foresee our children working in have two things in common," says Plezmo Co-founder, Amol Palshikar. "All of them require problem solving skills, which require an ability to think logically and structurally. These skills are something that programming or coding helps build.

"And all professions use computers as an irreplaceable tool. Building these skills from an earlier age will help children be better prepared for challenges they will face in the future."

According to Palshikar, while children have become expert consumers of technology, they also need to learn how to create it, which he sees as analogous to only teaching children to read, and not write.

"To create with computers, the ability to code is a basic requirement. Practicing programming, like practicing music, helps us improve our abilities to create complex logical workflows," suggests Palshikar.

Palshikar sees Plezmo as a step-change in the way technology education is consumed by children, moving beyond wired electronics and robotic kits. Wireless, he says, is key.

"The landscape of available products in the technology education space primarily consists of traditional architectures which have some central device, and an array of sensors and actuators which are connected to this central device with wires," says Palshikar. "Plezmo reduces the barrier-to-entry to computer science basics since the focus shifts to creation instead of set-up complexities of wired electronics.

"With the introduction of Nordic's Bluetooth low energy technology into each Element, we can distribute the intelligence across all devices. This allows creations that can be built across walls, rooms, and possibly buildings, expanding the possibilities to a level comparable with best-in-class IoT [Internet of Things] devices.

"[Nordic's] wireless functionality also allows us to deliver new features through over-the-air software upgrades to the devices which significantly improves the user experience."

If any skeptics of technology-based learning remain today, then the words of twentieth-century Swiss psychologist Jean Piaget should serve as caution and instruction. "The goal of education is not to increase the amount of knowledge but to create the possibilities for a child to invent and discover [and] to create men and women who are capable of doing new things." ■

Nordic's Bluetooth low energy technology distributes intelligence across all Elements used in the Plezmo platform

Mi-Pulse Smart Bra

This integrated sports bra and heart rate strap offers ANT+, Bluetooth low energy, and legacy wireless connectivity to enable heart rate tracking on virtually any fitness monitoring device

According to analyst Technavio, the global market for heart rate monitoring devices will grow at an average of 13 percent each year up to 2020, as increased health and fitness awareness continues to drive growth, with chest straps remaining the most popular choice due to their accuracy. The Nordic Semiconductor-powered Mi-Pulse Smart Bra has an integrated heart rate monitor to provide the user with both a comfortable and accurate means of monitoring

People who exercise could dramatically improve their performance if they consume dark chocolate. At least that is what researchers found happened in mice that were fed the flavonol epicatechin, an ingredient found in dark chocolate. Researchers noticed both metabolic and structural changes in cardiac and skeletal muscles in the mice, leading to greater endurance in treadmill tests

The Mi Pulse Smart Bra is constructed from advanced conductive smart fabric and is said to be the first commercially available 'smart bra' for female athletes integrating a 'tri-mode' heart rate monitor (HRM) into the bra itself. Powered by a CR2032 coin cell battery, in normal operation the cell provides power for more than nine months before requiring replacement

The resting heart rate of the average person is between 66 and 72 beats per minute (bpm). A well-trained endurance athlete has a resting heart rate of 40 bpm. Cyclist Miguel Indurain, a five-time Tour de France winner and 1996 Olympic gold medalist, once recorded a resting heart rate of just 28 bpm

The powerful, highly flexible multiprotocol nRF51422 SoC ensures interoperability between the Mi Pulse Smart Bra and iOS and Android smartphones, sports and smartwatches, bike computers, and gym equipment employing either ANT+, Bluetooth low energy, or analog 5.3 kHz connectivity

PEOPLE & PLACES

Magnus Pedersen

Nordic's new Director of Sales for Europe loves the thrill of the hunt

Hi, I'm Magnus Pedersen and I'm Nordic's new Director of Sales for Europe tasked with growing Nordic's revenues in the region and further expanding our sales team.

My professional background includes 13 years in the Royal Norwegian Air Force where I started as an electronics specialist and left as a Captain/Deputy Officer of the communications and electronics squadron. I then spent six years at a Norwegian company called Q-Free in Trondheim (that develops intelligent transportation systems) in various roles, leaving the company as CTO. And for the last 10 years, prior to joining Nordic, I worked as a Product Marketing Director responsible for wireless and microcontroller product lines for Atmel Corporation. When they were acquired by Microchip I decided it was a natural opportunity to move on.

It's a real pleasure to be working for a Norwegian company again, especially one with leading-edge products, great colleagues, and a team that is willing to go the extra mile to protect existing business and win new customers.

I had been keeping a close eye on Nordic for some years since they were my competitor in the ultra-low power wireless arena at Atmel and I had been hugely impressed by the company's presence in the market, their aggressive execution on product roadmaps, and their ability to win customers against the big players.

Personal Profile

NAME:
Magnus Pedersen

JOB TITLE:
Director of Sales, Europe

JOINED NORDIC:
October 2016

BASED:
Trondheim, Norway

INTERESTS INCLUDE:
Skiing, hunting, fishing, African Nature Reserve

Pedersen is happy to be working at a Norwegian company again

I am now tasked with becoming an active part of that success story by helping Nordic grow its Bluetooth low energy revenue and market share in Europe at a faster pace than the overall market growth. Next year, this focus will expand to include Nordic's forthcoming low power LTE (LTE-M and NB-IoT) cellular Internet of Things (IoT) solutions.

To handle the increased level of customer engagement in Europe, we have recently started to hire additional Regional Sales Managers (RSMs). These will be building on the tremendous efforts that Roger Pedersen and Thomas Holmberg have invested over the years in the European market. I am happy that we now have Claire Steed on board as our new RSM for UK & Ireland.

Sales success is all about building excellent relationships with the customers, and one thing Nordic is particularly good at is building trust that the company will support them through their entire design process, even if things get really tough. In fact, most Nordic customer design issues have nothing to do with the Nordic part but we still believe it as our duty to help the customer solve them.

One of the parts of my job I enjoy the most is being involved in the 'top secret' development of next generation products. But as a salesman, the best part of all is when the customer informs you that your team has won their project. That excitement and satisfaction has never faded.

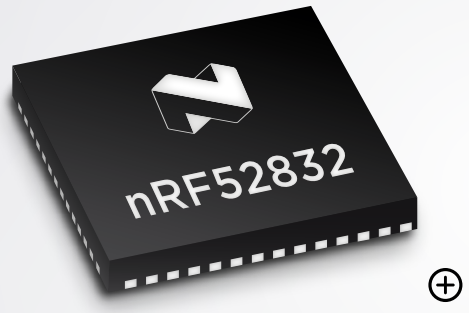
Outside of work I enjoy outdoor activities like skiing, hunting, and fishing. Skiing favorites for me include cross-country skiing in the mountains around Trondheim, and alpine skiing on the slopes of Åre in Sweden.

I also spend a lot of time hunting at my parents' farm as well as in the Norwegian and Swedish mountains.

Beyond this, a few years ago I made an investment in an operation at Selwane Nature Reserve and Great Letaba Safaris, at Limpopo in South Africa. It's a bit of a journey, and I am not able go there as much as I might like, but if you ever get a chance, seeing the wildlife in Africa is definitely an experience second-to-none! ■

Bluetooth® 5

Bluetooth 5 ready SoCs from Nordic



Cortex M4F

512kB flash / 64kB RAM

Bluetooth 5:

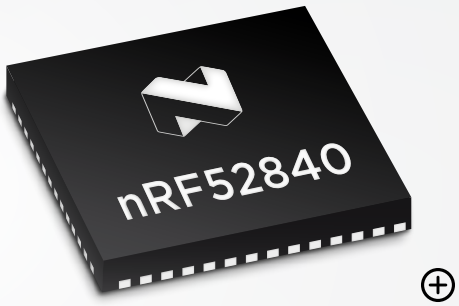
5 High throughput

5 Advertising Extensions

NFC transceiver

Unique Power management system

Unique DMA system



Cortex M4F

1MB flash / 256kB RAM

Bluetooth 5:

5 High throughput

5 Advertising Extensions

5 Long Range

IEEE 802.15.4

USB 2.0

ARM CryptoCell

NFC transceiver

› For more info go to nordicsemi.com

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