

# ultra low power wirelessQ

QUARTER 3 | AUTUMN 2018

## COVER STORY

### Sports monitoring gets serious

The year of  
cellular IoT

Bluetooth 5  
ignites beacons

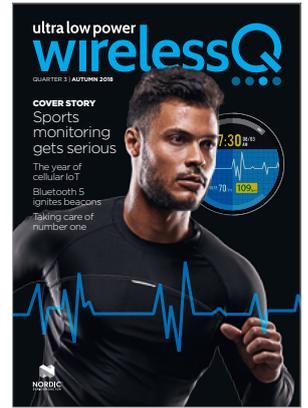
Taking care of  
number one



**NORDIC**  
SEMICONDUCTOR

# OPINION

Geir Langeland



**Nordic SoCs are powering increasingly sophisticated sports monitoring applications**

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## Wireless tech gets personal

Some years ago, I wrote a column for *ULP WQ* where I expressed surprise at the sheer number of applications which were based on Bluetooth Low Energy (Bluetooth LE). Many of these applications were beyond even those which engineers at Nordic Semiconductor, pioneer of the ultra low power wireless technology upon which Bluetooth LE is based, could have imagined.

One catalyst for Bluetooth LE technology's widespread adoption was its interoperability with smartphones. Such interoperability allowed developers to design wireless applications which could leverage software apps hosted on the mobile. Together, the wireless device and the smartphone formed compelling applications which caught consumers' interest.

But interoperability alone is not the only reason for the technology's rapid growth (to 400 million Bluetooth LE chips shipped in 2017 and a forecast 1.6 billion by 2022 according to the Bluetooth Special Interest Group (SIG)). Another driver is Nordic's strategy to dramatically simplify wireless design. With Nordic's development tools, application software libraries, and communities such as the [DevZone](#), engineers with minimal RF experience can successfully design a wireless application. Engineers outside of Nordic are making life easier too; Espruino, for example, now offers a development environment that allows programmers who are familiar only with simple languages such as JavaScript to code novel wireless applications. (See [pg18](#).)

One early smartphone-linked wireless application was the wearable. Early products counted steps and calories; today's devices monitor a host of exercise and wellbeing parameters while offering other smartwatch functions such as notifications. The increase in capability has come in large part because of the power of the Bluetooth LE SoC's embedded processor. Today's Arm-powered chips, such as Nordic's [nRF52 Series](#), have more than enough overhead to run even the most complex application algorithms.

Now a new sector for wearables is opening up. While a little more sobering than tracking exercise or health it is just as vital for wellbeing. That sector is personal safety. One example is Bluetooth LE-powered 'smart' jewelry; fashion products that double-up as alarms for those finding themselves in threatening situations and in part encouraged by XPRIZE, an incentive-based competition designed to address humanitarian concerns. Such products are capable of instantly alerting friends and family via the Bluetooth LE connection with the smartphone. A second example is protective clothing for law enforcement. In this case, embedded Bluetooth LE connectivity notifies back-up units if the police officer suffers an injury. (See [pg16](#).)

It's over seven years since Nordic launched its first commercial Bluetooth LE chip. At the time it was envisaged that the main applications for the technology would be fitness trackers, proximity tags, and remote controls. Now, armed with powerful Bluetooth LE SoCs from the nRF52 Series and tools to ease the design process, developers have extended the technology to thousands of applications in dozens of sectors. Yet I get the feeling that things are still only just getting started.

Yours Sincerely,

**Geir Langeland**  
Director of Sales & Marketing

## Contributors



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**Svein-Egil Nielsen** is CTO at Nordic Semiconductor. On page 9 he predicts 2019 will be the year cellular IoT becomes a large-scale commercial reality



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**Graham Prophet** is a freelance electronics journalist. On page 14 he takes a closer look at how Bluetooth 5 is bringing new life to the beacon sector



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**Kalon Huett** is an Australia-based freelance journalist. Here he examines the company behind a heart rate monitor platform delivering advanced fitness metrics



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# NEWS

The latest developments from Nordic Semiconductor

## Muscle sensor overcomes inability to communicate due to speech loss

A new wearable assistive technology device is providing people suffering from paralysis and loss of speech with a means to communicate with family, friends, caregivers, and clinicians. Developed by Ohio-based Control Bionics, the 'NeuroNode' device is described as the world's first wearable electromyography (EMG) device. The product enables sufferers of diseases such as motor neurone disease (MND), or any other condition causing paralysis and/or loss of speech to use EMG signals to control their paired computer, tablet, or smartphone.

In operation, a small, non-invasive, medical-grade wireless sensor is placed on the skin over the muscle chosen to be the 'switch'. When the user attempts to move that muscle, the



NeuroNode interprets signals sent from the brain to a muscle and uses EMG signals to control the user's paired device

NeuroNode interprets the signals sent from the brain to the muscle—even if there is no visible muscle movement—and uses EMG signals to control the user's paired device.

The NeuroNode system essentially functions as a wireless keyboard by connecting via a

Nordic [nRF52832](#) System-on-Chip (SoC)-based Bluetooth Low Energy (Bluetooth LE) link to the user's compatible device equipped with iOS/OSX, Android, or Windows. The NeuroNode works with most popular assistive scanning software such as Apple Switch Control and Google Switch Access. By using the NeuroNode users with a disability can send emails and text messages, play games, access social media, watch online entertainment, use environmental controls, and operate external devices.

Control Bionics has also developed an iOS companion app, the 'NeuroNode Controller', which allows the user and clinician to customize the NeuroNode to match the user's abilities. The customized parameters can then be used with other platforms.

## In brief

### Nordic reports record Q2 result

Nordic Semiconductor has reported record high revenue of \$71.2 million during the second quarter of 2018. The result represents growth of 21.3 percent over the same period in 2017. Sales of Bluetooth Low Energy solutions contributed \$52.3 million towards the result, growth of over 45 percent year-on-year, thanks to a strong performance across the consumer electronics, wearables, and healthcare markets in particular.

## Cellular IoT growth spikes

ICT-to-service provider Ericsson is currently enabling more than half of the major commercial IoT networks worldwide, the company announced in its *Ericsson Radio System Quarterly Update*. The company said mobile operators have launched more than 60 cellular IoT networks worldwide using LTE-M and NB-IoT. Large-scale deployments, and the resulting high volume chipsets, would bring about a reduction in chipset prices it said, leading to a further acceleration in cellular IoT connection growth.

## Bluetooth 5 put through its paces

Engineers at Rutronik have conducted extensive tests on Bluetooth 5, aimed at determining the performance of the Bluetooth Low Energy standard. The measurements, carried out in an open field, a forest, a shopping mall, and offices, show different connection parameters have an impact on data throughput and energy consumption. For example, the study revealed there was a significant increase in range compared to Bluetooth Low Energy 4.2, with a simultaneous reduction in energy consumption.

## Nordic nRF52840 multiprotocol SoC certified as Zigbee Compliant platform

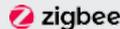
Nordic Semiconductor's [nRF52840](#) multiprotocol System-on-Chip (SoC) and 'nRF5 SDK for Thread and Zigbee' has been formally certified as Zigbee Compliant to the current Zigbee 3.0/Zigbee PRO (R21) and Green Power proxy specification by the Zigbee Alliance.

Nordic customers can now build and ship commercial Zigbee 3.0 products using the nRF52840 SoC. The chip also supports concurrent Zigbee and Bluetooth 5/Bluetooth Low Energy (Bluetooth LE) operation using the Software Development Kit (SDK) and the kit's integrated S140 v6.1 SoftDevice.

During the entire Zigbee Compliance certification



Nordic's nRF52840 SoC is ready to power Zigbee networks



process the nRF52840 SoC remained concurrently connected to a Bluetooth 5/Bluetooth LE network.

Zigbee is a global, standards-based wireless solution that takes advantage of the IEEE 802.15.4 PHY and operates globally in 2.4GHz unlicensed bands (and other frequency bands in some geographical zones). Raw data throughput rates of 250kbps can be achieved and transmission distances range up to 100

meters. The technology supports large mesh networks (which allow nodes to relay messages to other nodes) and low power operation.

"We announced in April that we planned to offer a Zigbee Compliant solution during the second half of 2018 and here it is," says Pär Håkansson, Product Marketing Manager with Nordic Semiconductor.

"What's great about this solution is that the concurrent Zigbee and Bluetooth 5 operation allows Zigbee networks to benefit from all the features of a Bluetooth network including connecting to smartphones to, for example, perform firmware upgrades, or control a Zigbee network remotely."

## In brief

### Wireless proximity tech gains precision

**Leading Netherlands-based nanoelectronics research and innovation hub, Imec, has developed a new secure proximity technology that enables accuracy down to 30 centimeters using a standard Bluetooth radio. The solution improves on existing signal strength-based localization solutions that limit accuracy to within three to five meters. The technology is said to pave the way for improved applications based on location tracking such as asset management, and increased data security in smart-building, -car, and -city applications.**

### Bluetooth 5 module has 'longest range'

U.S.-based module manufacturer, Fanstel Corp., has released its 'BT832X' and 'BT832XE' [long range modules](#), designed for wide-area Internet of Things (IoT) applications, and based on Nordic's nRF52832 System-on-Chip (SoC). The company is also employing the nRF52832 SoC in its 'BWG 832F' Gateway module, designed to work as a proxy node in Bluetooth mesh applications. The BT832X module is said to be the longest range Bluetooth 5 compatible module available thanks in part to the nRF52832 SoC's high link budget radio.

### IoT sensors market to hit \$22 billion

According to analyst, MarketsandMarkets, the global IoT sensors market is forecast to grow from \$5.28 billion in 2018 to \$22.48 billion by 2023, at a CAGR of 33.6 percent, thanks to a dramatic reduction in unit cost and sensor size. The growth in Internet connectivity for sensors is driven in part by wearable and industrial applications. The firm says tire pressure sensors are expected to hold the largest market share, driven by the increased concerns regarding safety, comfort levels, and reduction in automobile emissions.

## Bluetooth LE gateway powers 16 smart-home devices at once

IoT solutions company, Dexatek Technology, has released its 'ΣCASA' smart-home ecosystem based on Nordic Semiconductor's Bluetooth Low Energy wireless technology. The ΣCASA system comprises the 'ΣCentral gateway' and a range of peripheral sensors to monitor smoke, shock, motion, door access, and environmental conditions, as well as devices to remotely control appliances and lighting in the home.

The ΣCentral gateway employs Nordic's [nRF52832](#) System-on-Chip (SoC) to provide wireless connectivity between the gateway and the ΣCASA peripherals, as well as the user's Bluetooth 4.0 (and later) smartphone or tablet. Each sensor uses Nordic's nRF52810 base-level SoC for wireless connectivity with the gateway.

The gateway can control up to 16 devices simultaneously, thanks to the nRF52832 SoC's ability to

**This gateway can control up to 16 devices simultaneously**



support multiple concurrent connections. The company has also developed a proprietary solution enabling the gateway to control up to 50 sensors. In this instance, the gateway receives status broadcasts from surrounding sensors and controls them

individually as required. The broadcasts are fully encrypted to ensure security and privacy.

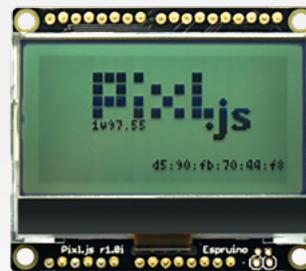
If the user is away from home, the gateway allows the user to remotely monitor and control the sensors from the ΣCASA-SmartHome iOS or Android app on their mobile device via the 'ΣCASA Cloud' server. From the app the user can also schedule on/off times for peripheral

sensors, control multiple sensors, share devices, and create event triggers between multiple sensors. For example, if the 'ΣDoor' sensor is activated when someone opens a door, the user can specify that event to trigger their 'ΣLights' to turn on, and their 'ΣPlug' to activate a heater or fan.

## Programmable display wirelessly monitors and controls Bluetooth LE devices

U.K.-based Espruino has launched its 'Pixl.js' smart LCD display, a programmable device that can wirelessly monitor and control Bluetooth Low Energy (Bluetooth LE) devices in small production run, hobbyist, and educational applications.

The Pixl.js can be used to monitor and control other Bluetooth LE devices, or act as a wireless display, to facilitate fast prototyping. The device includes pre-installed Espruino JavaScript firmware, a Raytac MDBT42 module featuring Nordic's nRF52832 System-on-Chip (SoC) for Bluetooth LE wireless connectivity, and a low power sunlight-readable LCD screen. It also provides Arduino headers, allowing the user to plug in Arduino shields to add



Pixl.js can monitor and control Bluetooth LE devices in hobbyist and educational applications

features such as SD cards, or Internet connectivity.

The device can be paired to Bluetooth 4.0 (and later)-enabled PCs and Macs, and the Bluetooth LE connectivity allows the developer to use Espruino Integrated Development Environment

(IDE) or command-line tools to port their code to the Pixl.js. The wireless connectivity allows the developer to communicate with the Espruino JavaScript interpreter from the desktop computer to upload code, change and inspect functions and variables, and perform line-by-line debugs.

In addition, the user can send JavaScript commands to the device without the need to program it. Any errors encountered while running uploaded code can be displayed on the LCD, enabling quicker debugging and faster prototype iterations. According to Espruino, the use of JavaScript makes writing code much faster and less prone to error than if using other C-based languages.

# Fixture-integrated sensor enables mesh-networked lighting installations

Murata has released its 'Fixture-Integrated Sensor' for the professional lighting sector, enabling manufacturers to develop Bluetooth mesh-based networked lighting products. The sensor employs Nordic's [nRF52832](#) System-on-Chip (SoC) to provide the wireless mesh networking between individual sensors as well as Bluetooth 4.0 (and later) smartphones and tablets which offer a single point from where the sensors can be commissioned, configured, and controlled.

The device combines occupancy sensing, daylight harvesting, and 0-10 V dimming control in a compact form factor, and can be integrated into a wide range of new or existing luminaires. This is said to enable lighting manufacturers to deliver wirelessly-controllable and sensor-equipped lighting fixtures with minimal RF engineering

**This fixture combines occupancy sensing, daylight harvesting, and dimming control**



expertise. The sensor employs Bluetooth mesh software which enables users to instantly and simultaneously control up to hundreds of Bluetooth mesh-equipped lights from

smartphones or tablets.

Once installed, the luminaires just need to be connected to mains power and can then be provisioned, configured, and controlled directly from a mobile device using either smart-light maker Silvair's iOS Platform or Nordic's iOS and Android nRF Mesh intuitive apps. The [nRF Mesh app](#), for example, enables a range of management features for use in Bluetooth mesh networks, allowing simple provision and configuration of Bluetooth mesh networks and devices. Either app allows the user to create lighting zones, enable and disable sensors, pair with switches, as well as set desired lighting levels.

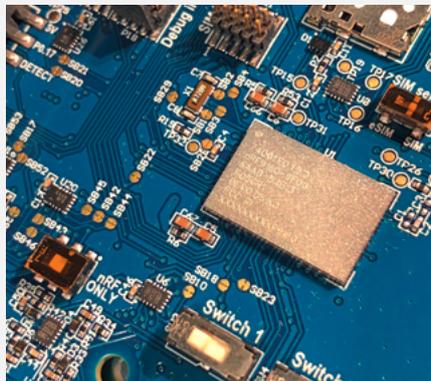
Bluetooth mesh allows devices within a Bluetooth LE network to communicate directly with companion devices without recourse to a central hub device. The topology extends range, flexibility, and reliability.

## Nordic nRF91 Series shortlisted for top telecoms award

Nordic Semiconductor's [nRF91 Series](#) low power cellular IoT solution has been shortlisted by leading communication industry journal *Light Reading* for the "Most Innovative IoT/M2M Vendor Strategy" in the publication's 2018 Leading Lights Awards program. In its category Nordic was nominated alongside Amazon Web Services, Huawei Technologies, Nokia, and Verimatrix.

The nRF91 LTE-M/NB-IoT System-in-Package (SiP) is significantly smaller, lower power, and more secure than any other cellular IoT module launched to date. It offers a range of unique IoT-targeted features, is module-certified for global networks, and is claimed to be simple to design-in.

"Nordic Semiconductor expanded the application range of Bluetooth by



The nRF91 Series is an ultra-compact, low power, global, multimode LTE-M / NB-IoT SiP

abstracting away from the designer all unnecessary technical complexity," says Sverre-Tore Larsen, Nordic Semiconductor CEO.

"The pre-certified, ready-to-drop-in LTE-M/NB-IoT nRF91 solution promises to do the same for cellular IoT.

"It is hard to put into words the amount of hard work Nordic's R&D engineers have invested into developing the nRF91 Series.

"But to see what Nordic as a company has achieved with the nRF91 Series formally recognized by one of the most prestigious technology awards programs in the telecommunications industry is extremely encouraging and further validates the commercial strategy behind this product."

*Light Reading* has a subscriber audience of more than 430,000 qualified telecoms professionals worldwide, while the Leading Lights Awards program is now in its fourteenth year.

## micro:bit online mag launched

The highly popular Nordic-powered micro:bit programmable computer now has a new dedicated unofficial community online magazine. The micro:bit was first launched in the U.K. back in 2016, when one million devices were given away free to every 11-12 year old school child. Titled [Micro:mag](#) the magazine was launched by members of the micro:bit's community of students, makers, hobbyists, and developers, and features user-generated content including student projects, and advice on how to make the most of the tiny computer.

## Robot teaches coding skills

Toymaker The Crafty Robot has completed a successful crowdfunding campaign for 'Smartibot': an educational, build-it-yourself toy robot for children who want to become more familiar with artificial intelligence (AI) and robotics. The company is working with Microsoft to enable the device to be programmed with the MakeCode platform, the same programming environment that is used to program the micro:bit. Smartibot also supports 'micro:bit Radio' which enables two robots to be programmed to wirelessly communicate with each other.

# Multiprotocol heart rate monitor can identify individual heart beats

U.K.-based **Cardiosport** has released a wireless heart rate monitor (HRM) platform which can gather highly accurate heart rate data and 'r-r' intervals (the time between heart beats), thus identifying individual heart beats during intense exercise and meeting the demands of medical electrocardiogram (ECG) recorders.

Designed for modification and rebranding by third-party OEMs developing wearable fitness tracking applications, the 'TP5 Heart Rate Monitor' features heart-rate and movement sensors, along with a three-axis accelerometer. The accelerometer can be programmed for running speed, pace, and cadence device profiles, as well as advanced running metrics like ground contact time, left/right leg balance, and upper body position.

The TP5 HRM features a proprietary CBA9 ECG ASIC and Nordic's [nRF52832](#) multiprotocol System-on-Chip (SoC) to enable data transmission via Bluetooth Low Energy (Bluetooth LE)



**This HRM offers both Bluetooth LE and ANT+ connectivity options**

wireless connectivity to fitness apps hosted on Bluetooth 4.0 (and later) iOS and Android smartphones and tablets. The Nordic SoC's multiprotocol support allows the platform to concurrently transmit data to

both Bluetooth LE apps and ANT+ enabled devices such as smartwatches, bike computers, and fitness equipment.

The Cardiosport platform provides raw accelerometer data so developers are able to design

apps around the TP5's functionality. For example, one Cardiosport customer uses the three-axis accelerometer synced with the r-r intervals to monitor cardiovascular efficiency when the end user is running.

Another customer integrates the TP5 into clothing, through soft fabric ECG electrodes rather than a chest strap, to detect heart rate and r-r intervals in relation to the stillness and composure of the end user during yoga movements.

Regular r-r intervals are also a prime warning of "overtraining" in strenuous sports such as running and cycling so could be used to trigger notifications to an athlete that they should ease off.

"We believe it's essential for heart rate monitors to incorporate support for Bluetooth LE, ANT+, and proprietary 2.4GHz protocols, which is one of the main reasons we selected the Nordic SoC," says James MacGregor, Marketing and Business Development Manager at Cardiosport. (See [pg22](#).)

## USB dongle for Nordic nRF Connect for Desktop PC tool eases design

Nordic Semiconductor has launched a low-cost USB Dongle for its [nRF Connect for Desktop](#) PC tool, allowing developers to connect PCs to a wireless device when only one end of the wireless link is otherwise available. The dongle simplifies the application development because the engineer can see exactly what the wireless device is doing via their PC desktop without having to invest in a comprehensive development kit.

The [nRF52840 Dongle](#) supports all major wireless standards including Bluetooth Low Energy (Bluetooth LE), Bluetooth mesh, Thread, Zigbee, IEEE 802.15.4, ANT, and 2.4GHz proprietary applications running on the Nordic nRF52840 multi-protocol System-on-Chip (SoC). The dongle features a user-programmable RGB LED plus a physical push-button, green LED, and 15



**The nRF52840 Dongle supports all major wireless standards**

GPIO accessible solder points along its edges. To help users get started example applications are available in the Nordic nRF5 Software Development Kit (SDK).

"The nRF52840 Dongle is a very clever little piece of hardware that is designed to be the ideal front-end, physical gateway for our nRF Connect for Desktop PC tool," says Pål Kastnes, Technical Marketing Manager at Nordic Semiconductor.

"It supports all the major short-range

wireless standards that can run on the multi-protocol Nordic nRF52840 SoC and can even function as a basic development kit," adds Kastnes.

"That's a lot of value packed into a \$10 device and will often save customers having to buy two separate development kits when developing, for example, a product that involves a smartphone app that communicates with a separate piece of hardware such as an activity tracker."

# ULP WIRELESS TRENDS

*The latest developments in technology*



SAP will help Hong Kong residents avoid getting lost

## Bluetooth LE proximity sensing device helps users stay on track in Hong Kong

A research team at the Department of Urban Planning and Design of the University of Hong Kong (HKU) has come up with a novel solution to the problem of GPS and Wi-Fi navigation positioning errors. This could allow Hong Kong citizens to precisely pinpoint their location either indoors or outdoors.

The team led by Professor Anthony Yeh Gar-On, has developed a device named SAP— or Smart Address Plate—that when installed in front of buildings, shops, or offices, can help users within its proximity to precisely know their own location via a smartphone app, eliminating GPS errors that can be off target by as much as 30 meters in dense cityscapes.

SAP is a Bluetooth Low Energy (Bluetooth LE) proximity sensing device that stores a unique geo-coded Smart Address ID of a building, shop, or office associated with it. When a user is within range, a smartphone app pinpoints the device's precise location, allowing them to not only exactly identify their own location, but also navigate to the SAP device.

The team has also developed what it has dubbed the Smart Address Plate Management System (SAP-MS), containing the SAP database linked with a digital floor plan and navigation system that is connected to the Smart Address Plates of buildings via a gateway. Apart from providing more accurate location information to occupants and visitors, property management staff can use the SAP-MS to carry out real-time updates of information such as occupants and the names of shops.

According to Professor Yeh, possible uses of the invention include enabling delivery persons, firemen, and ambulance officers to find the location of your address more quickly and accurately, potentially saving both time and lives.



Smart pills could soon be powered by stomach acid

## Hobbyist develops stomach acid battery-powered smart pill

A hobbyist device and sensor developer at the Child Mind Institute in New York, is working on a smart pill that's copper-zinc battery can use stomach acid as the electrolyte. Using a small, hacked activity tracker, Curt White stripped out almost everything except the device's Bluetooth Low Energy (Bluetooth LE) SoC. The battery electrodes have been sewn onto a plastic mesh to cut the activity tracker's dimensions.

The pill uses Bluetooth LE wireless connectivity to transmit data including a UUID (Universally Unique Identifier) and a specific device name. The data is transmitted using the specific name, saving power by minimizing the time the pill's Bluetooth radio is turned on. A smartphone app extracts the data from these transmission without ever connecting to the pill.

White's goal in the first instance is to monitor the device's voltage and maximum current. This, he says, will tell him if his stomach acid battery works, and what it can power. Initial tests will use regurgitated gastric fluid, and, if successful, he will then swallow the pill himself to see if it works inside the body.

## 'Black box' chip uses analog hardware to foil digital hackers

University of California (UC) researchers have created a chip that deploys ionic memristors to solve the problem of digital security with an analog memory hardware solution.

Dmitri Strukov, a Professor of Electrical and Computer Engineering at UC and his team want to put an extra layer of security on the growing number of Internet- and Bluetooth-enabled devices with technology that aims to prevent cloning. Cloning is a practice by which hackers replicate nodes in a network and then use them to launch attacks from within that network.

Key to this technology is the memristor, or



The device is invulnerable to hijacking, counterfeiting, or replication

memory resistor, an electrical resistance switch that can "remember" its state of resistance based on its history of applied voltage and current. Not only can memristors change their outputs in response to their

histories, but each memristor, due to its physical structure, is also unique in its response to applied voltage and current.

"You can think of it as a black box," says Strukov. Due to its nature, the chip is physically unclonable, rendering the device invulnerable to hijacking, counterfeiting, or replication by cyber criminals. According to Strukov, the multitude of possible inputs can result in at least as many outputs - the more memristors, the more possibilities. Running each, he says, would take more time than an attacker may reasonably have to clone one device, let alone a network of them.



# Extended RF range boosts Cloud thermostat's credentials

Demonstrating the key advantage of Bluetooth 5, Sikom's thermostat leverages the technology's long-range capability to simplify smart-home installations

**B**luetooth Low Energy (Bluetooth LE) is among the key technologies forming the foundation of tomorrow's [smart home](#). (See ULP WQ *Winter 2017*, pg9.)

And the recent introduction of [Bluetooth mesh](#) has markedly extended its practicality for smart-home applications. (See ULP WQ *Autumn 2017*, pg10.)

One of the key attributes of mesh networking is that it effectively extends Bluetooth LE's range by relaying messages across the network. Such a system allows a consumer, for example, to use their smartphone to switch on smart lights at the far end of a large house when without mesh, the lights would be out of RF range. But there is a downside to mesh networking: It adds complexity and cost. This is justifiable for large networks with many nodes, but less so if fewer devices need to be interconnected.

[Bluetooth 5](#) offers an alternative approach. The latest version of the Bluetooth standard brings increased range (up to four times that of previous versions of Bluetooth) enabling a new-generation smartphone to wirelessly control Bluetooth LE-connected smart-home devices up to 100 meters away. Crucially, the extended range isn't generated by boosting the radio's output with power amplifiers, which would dramatically undermine battery life, rather it's supported by a forward error correction (FEC) mechanism that helps to limit packet corruption as the distance between transceivers increases. There is a minor power consumption increase, and throughput is reduced to either 500 or 125 kbps depending on the range boost mechanism's configuration. But such throughput is still perfectly adequate for the majority of smart-home applications.



**Sikom's thermostat employs Bluetooth 5 for long-range connectivity**

Nordic's [nRF52840](#) System-on-Chip (SoC) with the S140 SoftDevice (Bluetooth LE protocol "stack") is one of very few commercial chips fully compatible with Bluetooth 5 - which means it is among a select group that can support the technology's long-range capability. In addition, the SoC features a 32-bit Arm Cortex M4F processor, 1MB Flash memory, and 256kB RAM. The processor has ample overhead to run the S140 SoftDevice and the most complex application software. The SoC also supports Over-the-Air Device Firmware Updates (OTA-DFU) for future improvements.

## Smart heating control

Sikom, a Trondheim, Norway-based developer of GSM-based Internet of Things (IoT) platforms, has taken advantage of Nordic's nRF52840 SoC to power its Bluetooth Thermostat EP. The wireless capability enables the thermostat to support both smartphone- and smart home appliance-connectivity.

The Nordic SoC's Bluetooth 5 long-range capability ensures

the thermostat can be configured and controlled from anywhere in a large house. From a companion app on a Bluetooth 4.0 (and later) smartphone the user can control thermostat features such as comfort and economy temperature set points, week programs, vacation modes, and temperature logs.

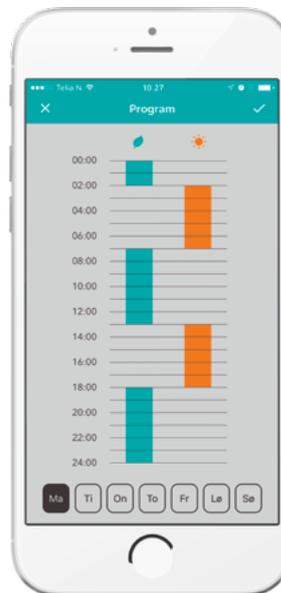
Because the thermostat can be controlled and configured from the smartphone from anywhere in the house, there's no requirement for a mesh relay node between the devices, lowering the cost and complexity of installation and set-up. The thermostat's Bluetooth LE connectivity enables it to communicate directly with other smart-home wireless devices to support advanced features such as power control and limiting. The thermostat can also communicate directly with a gateway using cellular IoT technology for connectivity to Sikom's Cloud platform.

"Bluetooth 5 technology's long-range feature provides superior connection stability in difficult environments, significantly boosting coverage. The advantage is further enhanced by the nRF52840 SoC's radio sensitivity," says Axel Jacobsen, CEO of Sikom.

"But the Nordic chip does more than that, it also provides a lot of freedom in the design and functionality of our thermostat, while simultaneously keeping costs down. The most important features for Sikom are the microprocessor capability and memory capacity, which enable swift development of complex applications running on a single core, without 'hitting walls' and wasting time on fine-tuning the performance or sacrificing functionality," adds Jacobsen.

"Nordic also offers an excellent support team and easy-to-use technical documentation." ■

*"Bluetooth 5's long-range feature is further enhanced by the nRF52840 SoC's radio sensitivity"*





# 2019 will be ‘the year of cellular IoT’

Competing LPWAN technologies are currently on an equal footing, but next year will see cellular IoT leap ahead, says Svein-Egil Nielsen



**Svein-Egil Nielsen**  
is CTO of Nordic  
Semiconductor

It's a bold claim, but 2019 should see cellular IoT finally become a large-scale commercial reality.

This prediction comes even as competitive low power wide area network (LPWAN) technologies, such as those from LoRa and Sigfox, appear to have taken an early lead on the back of publicly-announced commercial successes and cheaper per module prices.

After years of detailed behind-the-scenes planning, development, and testing, Narrowband IoT (NB-IoT)/LTE Cat M1 (LTE-M) modem makers, infrastructure providers, and network operators such as Nordic Semiconductor, Ericsson, and Telenor are working together ahead of major mass-market launches next year.

And while it initially looked like U.S. firms were backing LTE-M and China the NB-IoT alternative, the evidence now points to major networks across the globe rolling-out support for both technologies. This is in part due to each [cellular IoT](#) technology having different advantages. For example, NB-IoT features longer range but lower throughput, making it useful for

remote but less data-intensive applications such as smart meters and crop supervision, while LTE-M offers greater throughput for applications such as traffic control and patient monitoring. The decision to back both technologies is also in part commercial as it allows the network operators to cover all potential customer requirements and applications.

While the network operators and their infrastructure partners have been doing their best to build the foundations of mass cellular IoT adoption, leading modem vendors like Nordic haven't been standing still. For example, one factor that threatened to limit cellular IoT's adoption was its perceived complexity. But while it's true that some vendors' LTE-M products are challenging to design-in (and even then offer limited functionality) that is not the case with Nordic's cellular IoT product.

The complexities of cellular IoT design have been addressed with the introduction of Nordic's [nRF91 Series](#) low power cellular IoT module. (See *ULP WQ Spring 2018, pg8.*) The product hides the LTE complexity enabling developers with little or no cellular experience to focus on the LPWAN-based application. As a result, Nordic's module is already

generating significant interest with dozens of lead customers.

## Price isn't everything

But what of the competing LPWAN technologies? History does show that proprietary products such as Sigfox can have significant early success. For example, prior to the introduction of the Bluetooth Low Energy (Bluetooth LE) standard specification—a document that Nordic helped to create, and one that describes a technology in which the company holds a leading market share—Nordic was very successful with its proprietary 2.4GHz wireless connectivity chips. But this success was built in the absence of a standard; once Bluetooth LE was adopted, Nordic and others rapidly drove it to dominance.

Customers prefer the multi-vendor environment that a standard brings to a proprietary monopoly that stifles competition and innovation. They also prefer the interoperability, reliability,

*“The large-scale rollout of cellular IoT around the world will consign proprietary LPWAN technology to a niche”*

quality of service, and continued development that a standard underscores.

And the module cost? It's true that some LPWAN modules sell for as little as \$1 and don't require a subscriber fee. But price is never the making-or-breaking of a technology; how well it solves the problem is what determines success. Customers will pay more if the solution brings greater value and ease-of-use. A cheap wireless IoT module is of little value if it doesn't work in harmony with established infrastructure across the world – not just in the cities that happen to have the network support. In contrast, the global infrastructure for cellular IoT is in place and is working well, and the base LTE technology is proven, reliable, interoperable, and highly secure. No competing LPWAN solution can come near to claiming the same.

In the ultra low power wireless sector, proprietary alternatives are now consigned to a niche. The impending large-scale rollout of NB-IoT and LTE-M cellular IoT in almost every country across the world, backed by high-performing yet simple-to-design-in modems such as the nRF91 Series, will do the same to proprietary LPWAN technologies – whether the modules are cheap or not. ■

# Ericsson predicts ‘massive’ uptake of cellular IoT

On the back of 4- and 5-G networks, cellular IoT is set to provide ubiquitous low power connectivity for IoT applications, according to latest research from telecoms giant

Ericsson, a global leader in telecoms infrastructure, predicts cellular IoT will dominate as the key technology for low power wide area networks (LPWANs). LPWANs are critical to the success of the Internet of Things (IoT) because they form a vital bridge between the wireless sensors used across manufacturing, agriculture, and healthcare (and just about everything else) and the Cloud.

According to the telecoms giant’s highly regarded *Ericsson Mobility Report* (June 2018), the number of cellular IoT connections is expected to grow from 700 million in 2017 to 3.5 billion (of which 2.2 billion will be in North East Asia) by 2023 - a compound annual growth rate (CAGR) of 30 percent.

The report notes that cellular IoT connections are on track to achieve significantly faster growth than the overall market (total connected devices to reach 31.4 billion in 2023 with a CAGR of 11 percent). By comparison, Ericsson forecasts the number of (non-cellular) short-range wireless IoT connected devices will reach 15.7 billion by 2023 at a CAGR of 17 percent, while mobile phones will see a CAGR of only 2 percent in the same period.

## Impact of cellular

Such a remarkable growth forecast for cellular IoT connections is based largely on the recent arrival and immediate impact of new cellular IoT technologies, including the latest LTE Cat-M1 (LTE-M) and Narrowband (NB)-IoT standards, which both support LPWANs via the LTE 4G global cellular network.

“In North America, IoT applications such as logistics and fleet management are mainly supported by [LTE-M].



*“The Ericsson report suggests that in as little as five years cellular IoT will power around 85 percent of worldwide IoT connections”*

In China, NB-IoT technology has been selected for nationwide deployment to support use cases such as smart cities (for example, utility meters) and smart agriculture,” the Ericsson report states. “Both technologies are being deployed in parallel as a complement to each other across regions worldwide.”

According to a separate report by the Global mobile Suppliers Association (GSA), 163 network operators are reported to be actively investing in cellular IoT technology (47 LTE-M/116 NB-IoT) - of which 78 (19 LTE-M/59 NB-IoT) have deployed or commercially launched networks, 46 (12 LTE-M/34 NB-IoT) are planning and/or deploying networks, and 41 (16 LTE-M/25 NB-IoT) are trialing the technology.

There is currently a plethora

of cellular IoT applications being deployed to solve real-world challenges. For example, global supply chain logistics company, FedEx, employs cellular IoT-inspired ‘SenseAware’, a multi-sensor device that allows companies to monitor the progress of important products during shipment. In addition to the location tracking, FedEx’s cellular IoT application measures relative humidity, temperature, light exposure, barometric pressure, and shock detection.

## The rise of 5G

While cellular IoT has competition in the shape of open-standard based LPWANs like Sigfox and LoRa, figures from the Ericsson report suggest that in as little as five years cellular IoT will power around 85 percent of the of worldwide IoT connections.

(See *this issue pg9.*) Major advancements in network coverage, particularly the rise of the 5G global cellular network, should also have a significant impact on the uptake of cellular IoT, as the additional capacity and bandwidth will increase the space available for cellular IoT devices compared with the 4G network which was primarily installed to service smartphone traffic.

Nordic Semiconductor has invested heavily in the design and development of its [nRF91 Series](#) (See *ULP WQ Spring 2018, pg8*), a low power LTE-M/NB-IoT solution designed to accelerate the uptake of cellular IoT. The robust performance of the nRF91 Series is based on Nordic’s System-in-Package (SiP), which integrates all the key features of traditional LTE modules in a much smaller and power-efficient package. ■



# The connected world with no strings attached

A survey by the AirFuel Alliance reveals consumers want to be connected and are prepared to pay for the convenience of wireless charging. Caroline Hayes reports



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

Today's consumers are living increasingly connected lives. And much of that connectivity relies on smartphones, laptops, tablets, and smartwatches with plenty of power in their batteries. But it seems consumers are tiring of plugging their mobile devices into a power outlet for hours each day to top up the cells.

According to a survey of over 1,000 U.S. adult consumers conducted by wireless charging advocate, the AirFuel Alliance, users are frustrated by the restrictions imposed by conventional charging and are keen to embrace the convenience of a completely wireless future.

The alliance champions wireless charging standards based on inductive, resonant, near-field, and far-field RF technologies. (See ULP WQ *Summer 2016*, pg20.)

## Battery anxiety

A profile of the consumer as someone who is increasingly reliant on their mobile device and has constant fear about its battery status and how to top it up emerged from the survey.

Ninety six percent of mobile users are still bound to wall sockets for charging, while others charge via a cord while driving or by plugging devices into the laptop at work. There is a clear sense of "battery anxiety"; most of those surveyed reported that they charge their devices every night, 45 percent said they worry about charge depletion more than once a day, and 21 percent

charge more than once during the day. Notably, nearly half (49 percent) said they did not want to think about plugging in or placing devices in a precise position to charge rather they "just want it to happen".

Many respondents say conventional charging is tedious. Over one third of those surveyed (38 percent) said finding the right charger to match the mobile device is a hurdle. And 76 percent would prefer to take just a single charger for all devices when travelling.

## Cost no hurdle

It's not just the chargers which cause consumer resentment, charging cords require mobile connectors which are

susceptible to water or dust ingress. And 20 percent of respondents worried that such connectors spoil the sleek lines of modern devices.

Wireless charging offers the solution to the tedium of carrying multiple chargers and connection cords and then finding somewhere to plug them all in. According to the survey, consumers are prepared to pay for that convenience.

More than half of those questioned said they would spend at least \$20 to add wireless charging capability to their device, while 12 percent would be prepared to pay up to \$100 extra. And most respondents also said they would pay for wireless charging in

public places. This enthusiasm for the technology is not without conditions, however; for example, 58 percent said that wireless charging is of interest but not at the cost of device durability.

The AirFuel Alliance has introduced a developer program and forum to accelerate resonant technology design and commercial adoption. The first forum was held in Shenzhen, China, in March 2018. The same city was among the first to deploy resonant wireless charging in a [smart city initiative](#) at the end of last year. (See ULP WQ *Summer 2017*, pg9.)

Bluetooth Low Energy (Bluetooth LE) SoCs form an integral part of AirFuel Alliance-compliant wireless charging solutions. Nordic Semiconductor is part of the AirFuel Alliance and supports engineers with design tools such as the nRF5 Software Development Kit for AirFuel for nRF51 and nRF52 Series Bluetooth LE SoCs. The SDK includes examples of the Power Transmitting Units (PTUs) used in charging pads and Power Receiving Units (PRUs) such as those employed in consumer devices like smartphones. AirFuel Alliance certification ensures interoperability between devices and chargers.

Other major cities and technology hubs, including Silicon Valley, are expected to follow Shenzhen's example. In the AirFuel Alliance survey, 93 percent of consumers believe wireless charging will be "the new norm" within three years. Such demand will further encourage industry's willingness to develop, support, and deploy wireless charging projects, making a world with fewer wires not that far away. ■

*"Consumers are frustrated by the restrictions imposed by conventional charging"*



**Nearly half of all smartphone users in the U.S. wish charging was simpler**





Bluetooth 5's long range is enabling beacons to track assets



# Bluetooth 5 ignites beacons

Bluetooth 5's longer range and advertising extensions are reinvigorating a beacon sector that was in danger of stagnating. Graham Prophet reports



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

The formal introduction of [Bluetooth 5](#) in mid-2016 was a key milestone in the development not only of the standard in general, but also for the emergence of services based on Bluetooth beacons. (See *ULP WQ Spring 2017, pg16*.) For the consumer, smartphones and tablets that support the standard are coming to the market – Samsung and Apple led the way with, respectively, the Galaxy 8 generation and onwards, and the iPhone 8 and X. For the developer, chips such as Nordic's [nRF52810](#) and [nRF52840](#) SoCs are in place to build beacons providing extended range, exploiting increased data capacity and, crucially, delivering long battery life to underpin the proliferation of beacon technology.

Bluetooth Beacons are now an established market, with a range of manufacturers, specialist suppliers and distribution

channels in place. In a 2017 market analysis, the Bluetooth Special Interest Group (SIG)—custodians of all things Bluetooth—cited a study that forecast a compound annual growth rate of over 130 percent, out to 2021. The report anticipated, for example, the 2017-to-2018 figures for units shipped would rise from 26 million to 83 million. 2018 also finds the market for Bluetooth beacons in a state of transition: no sooner had the original concept of a beacon taken hold, then the updated specifications have become available, opening a far wider range of potential applications.

## Better with 5

The basic beacon technology supported by Bluetooth Low Energy (Bluetooth LE) versions 4.0, 4.1, and 4.2 defined a simple device that uses, in effect, one side of a full Bluetooth exchange. Any Bluetooth device that wishes to be discovered sends a periodic "advertisement" message that invites initiation of pairing, and subsequent data exchange. A beacon's advertisement contains a reserved address that identifies

it as not soliciting pairing, and that precedes a fixed-length, short, data "payload" that is to be acted on directly. Consumers automatically received the short beacon communication when in close proximity, but such was the limitation on payload that an associated app had to be triggered or browser opened to provide useful information. This restriction limited beacon applications.

In Bluetooth 5, the available payload of the advertisement [channel](#) is increased in size eight-fold, from 37 bytes to 255 bytes, and a concatenated mode can string packets together for even longer messages. (See *ULP WQ Autumn 2017, pg21*.) That means consumers can receive useful information from the beacon transmission alone, without having to open an app. (Bluetooth 5 also handily offers improved channel coexistence making it somewhat easier for a beacon to negotiate a crowded radio environment which ultimately saves power and extends battery life.)

iBeacon and Eddystone, from

Apple and Google respectively, are in effect "special cases" of the Bluetooth LE beacon specification targeted at developers, and both are evolving. Eddystone is an open format that supports a variety of data frames for specific tasks. For example, it can alert a feature called Nearby Notifications in Android, without the need for a specific app to be running the handset. (Although the handset does still need its Bluetooth transceiver switched on.) On the Apple side of the fence, one of the changes in iOS 11 is that turning off Bluetooth now disconnects running apps from the radio but does not shut down the transceiver (that takes some deeper delving into the handset's UI.)

## Finding the way

The advertising extension capability of Bluetooth 5 has seen a recent upswing in developments that center on the location-determining aspect of beacon technology, especially in the Industrial Internet of Things (IIoT) space. Determining the



location, at any given time, of a mobile entity—either a person or an object—enables people- and asset-tracking. Location fixes are enabled by estimating the distance from beacon to receiver, using received signal strength indication (RSSI). Knowing the transmitted signal strength, and the rate at which the signal strength diminishes with distance, enables a simple calculation that gives the distance of the receiver from the beacon.

Ideally, this strategy might provide “indoor GPS” functionality, where GPS signals are unavailable; the reality is somewhat more complex, as signal propagation is strongly affected by building structure, internal walls, furnishings and even people. Within a specified area, beacon signal strength can be mapped, and that map—sometimes termed a signature—can be made available to an app. Using measured rather than calculated signal profiles offers improved accuracy – the app can access the profile of the signal strength map to refine its determination of where its host is located. A reasonable expectation of accuracy in such solutions is in the one-to-several meter range. However, the Belgian semiconductor and systems research centre, IMEC, has recently published claims of accuracy to as good

as 30 cm, using Bluetooth LE beacon technology. (See pg4.) The improved performance rivals that currently achieved by (considerably more expensive) ultra-wideband (UWB) and, say the developers, can be applied to high precision track-and-trace and industrial applications.

### Beacons for asset tracking

For asset tracking, the beacon deployment strategy is reversed. The beacon is fixed to the item to be tracked and its signal is received by a network of Bluetooth LE nodes distributed around the infrastructure. When a beacon’s signal is received by three (or more) terminals, triangulation allows a location fix to be obtained. The asset in question can be almost anything – or anyone, as beacons are already deployed in, for example, healthcare to track patients, or on sensitive sites to verify the movements of staff and visitors.

When the beacon becomes the mobile element in the system, it is termed a tag, which brings the possibility of overlap with Near Field Communication (NFC) tags. In practice there is likely to be little conflict, with Bluetooth 5 applications using the version’s extended range feature expanding to exploit increases in range of tens to hundreds of meters, while NFC is associated with close-proximity, present-to-

**Beacons such as this Sensoro unit take advantage of Bluetooth Low Energy’s low power consumption to extend battery life**



reader use cases. The concept of an unpowered or “passive” Bluetooth tag has been floated, and at least one start-up company asserts that it is feasible, in environments where there is sufficient ambient RF energy to be harvested. Using a “conventional” System-on-Chip

(SoC) such as Nordic’s nRF52810, the designer of a beacon/tag always has the option of employing an energy harvesting source such as a photovoltaic cell, to dramatically extend battery life. Nordic has a reference design for such a solution available from its “Infocenter”. ([infocenter.nordicsemi.com](http://infocenter.nordicsemi.com).)

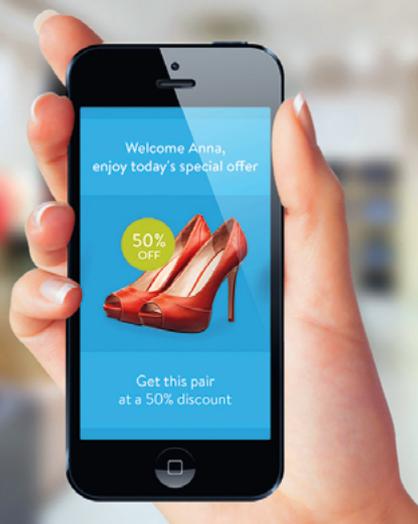
The additional data payload of the beacon message in Bluetooth 5 means that a useful amount of data (for example, some measured parameter, or status) can be transmitted, still without recourse to an app or browser. Temperature measurement is one example allowing, for instance, a check of whether a pharmaceutical package has been stored outside its temperature limits. One difference of this application compared with the fixed, preset message of the basic beacon, is that the host microcontroller must re-assemble the message frame for every transmission. As part of that, it must compute and include a checksum to verify the message’s integrity – but this is typically not a significant burden for an MCU of ARM Cortex class such as that employed in the Nordic nRF52 Series.

As more services come to depend on location information determined by Bluetooth, attention is also turning to the question of security. A beacon signal is not immune to assorted malicious attacks (any more than are other technologies, including GPS). A degree of hardware security (tamper detection) can be built into devices using Nordic’s silicon, and software security suites are promised.

In 2018, Bluetooth beacons are finding their place in a spectrum of location-determining technologies that includes GPS, Wi-Fi, and NFC (RFID). While all have a role to play, none of the alternatives can offer the range that comes with Bluetooth 5, together with months-to-years of battery life from a small battery cell. For its part, Nordic was quick to support Bluetooth 5 for beacon applications with its ARM Cortex M4 CPU-powered nRF52810 SoC positioned to meet both the performance demands yet price-sensitivity of the sector. ■

*“Bluetooth Beacons are now an established market, with a range of manufacturers, specialist suppliers, and distribution channels in place”*

**In a retail environment, advertising extensions now allow beacons to send useful amounts of data without recourse to an app or browser**



COURTESY: ESTIMATE



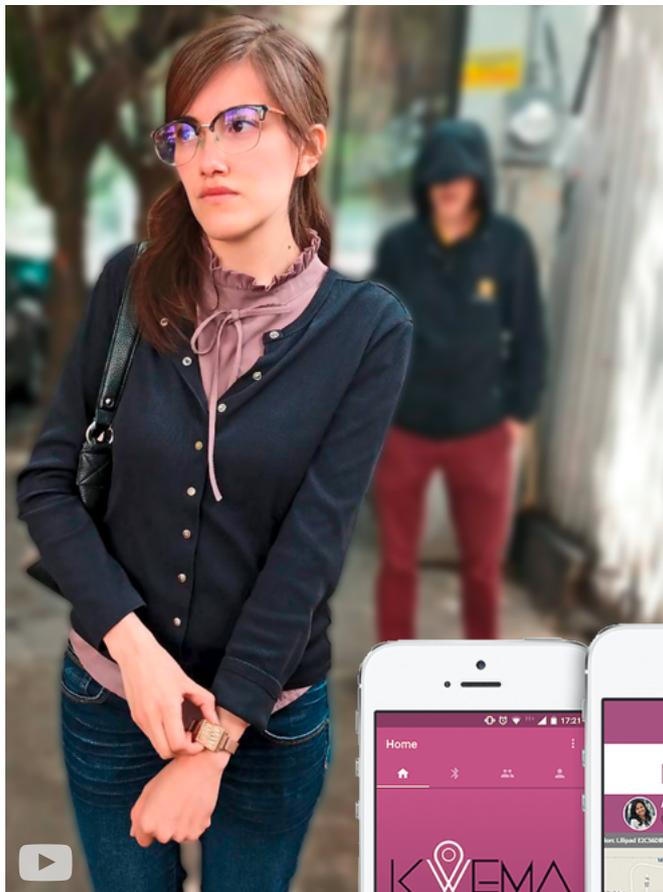
# Safety wearables take care of number one

Wearables for fitness and healthcare have dominated, but another category is emerging, and it's ensuring our wellbeing in an entirely different way. ULP Wireless Q reports

In the past ten years wearable technology has enjoyed a rapid trajectory. It began with fitness devices—coupled with medical advice—that nudged users to get off the couch and hit their 10,000 steps a day. More recently, increasingly sophisticated healthcare solutions have emerged, for applications such as home diagnostics and remote monitoring. While that market segment is forecast to continue its significant contribution to the growth of wearable tech, looking after our personal welfare is moving beyond devices that enable better long-term lifestyle decisions or supervise the health of a greying population.

That's because wellbeing can be challenged not just through lack of exercise or lifestyle- and age-based diseases, but also through a threat to one's immediate personal safety. Wireless solutions are now finding a niche mitigating this threat and at the same time creating a new vertical for wearable tech: Personal protection.

Philanthropist entrepreneurs Anu and Naveen Jain have been pioneers of the adoption of technology for personal protection. In 2016, the husband and wife team launched a million dollar prize using the XPRIZE platform, an incentive-based competition designed to address humanitarian concerns. The "Anu & Naveen Women's Safety XPRIZE" challenged developers to create a device that can inconspicuously trigger an emergency alert if a woman is facing a threat, and transmit information to a network of community responders, all within 90 seconds and costing under \$40. Teams had six months to put together a deployment-



**Kwema's jewelry doubles as a wireless personal safety device and links to other members of the community via smartphone**

ready prototype, and 85 teams from around the world registered to compete.

"Safety is a fundamental human right and shouldn't be considered a luxury for women," says Anu Jain. "With so many advances in innovation and technology today, it was unacceptable to us that we didn't have a solution to help curb this [global problem]."

In June this year, New Delhi, India-based Leaf Wearables was

a panic button that when 'long-pressed' transmits the alert using Bluetooth Low Energy wireless connectivity to the user's smartphone, that in turn relays the notification to their trusted contacts via the Leaf Wearables app.

The device is also GSM- and GPS-enabled, allowing panic alerts to be communicated directly to their trusted contacts in the event the user doesn't have their smartphone with them, as well as pinpointing their location and providing navigation to the nearest hospital or police station. It also records audio of an incident in progress from the time of the alert.

"We have been working tirelessly to solve the problem of



announced as the winner. The company's 'Safer Pro' device comes in a smartwatch form factor but is also available as a module that can be embedded into other devices or regular jewelry. The smartwatch provides

safety using technology," says Manik Mehta, Leaf Wearables Team Leader. "The XPRIZE gave us the incentive and focus to continue to work toward our mission and help make the world a safer place."



## Safety meets style

Leaf Wearables are not alone, and many developers have seen the opportunity for wearables to expand into personal protection, and have done so with success. Last year, U.S.-based technology start-up, [Kwema](#), launched two jewelry collections that double as smart personal safety devices when the user perceives a potential threat, or is in an emergency situation.

The Eve and Pacific Ocean jewelry incorporate Nordic's [nRF52832](#) System-on-Chip (SoC) enabling Bluetooth LE wireless connectivity between the jewelry and the Kwema app on the user's Bluetooth 4.0 (and later) iOS or Android smartphone. By pressing and holding a button on the device for three seconds, wearers can alert an unlimited number of pre-selected smartphone safety contacts of their precise location in an emergency.

The app either notifies contacts via Internet connectivity or sends a text message via the cellular network ensuring 'guardians' promptly receive the emergency notification and GPS location of the wearer. In addition, users can employ an optional feature on the app that locates and immediately alerts other members of the Kwema 'community' who are within 500 meters.

For Kwema CEO, Carmiña Santamaria, the motivation to develop jewelry with in-built smart safety was a personal one. "Two years ago a friend of mine was kidnapped in broad daylight in Bolivia," says Santamaria. "I was so obsessed with my friend's disappearance I told my co-founder, 'what if we could create a bracelet to call for help?'. We called it Kwema, a Swahili word for 'I'm fine'. Our target customers are 18 to 35-year-old women, because that is the age group that has the highest risk of being attacked."

Singapore-based [Smartfuture](#) is another company that has seen the opportunity to merge fashion with function. Last year the company released its Nordic nRF52832 SoC-powered IVY smart jewelry range, designed as a dual fashion accessory and personal safety device. IVY can



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

be worn either as a silver chain necklace or as a leather bracelet, and features a stone set in a silver-plated frame attached to a touch sensor and haptic vibration motor.

Once paired to the user's smartphone, IVY is activated by tapping the stone. In the event of an emergency, double tapping the stone emits a loud alarm, while a triple tap sends an SOS audio message and the user's location to nominated guardians. Four taps on the stone and a phone call to the guardian is triggered. In the event the guardian does not have the IVY app installed on their device, they

will receive the user's location and audio recording via SMS.

## Law enforcement

The applications for wearable personal protection don't stop at women's safety. Arizona, U.S.-based [DataSoft](#), for example, has recently launched its Automatic Injury Detection (AID) wireless sensor, a gunshot detection system integrated into 'man-down' vests for law enforcement and military applications. The AID panel features a thin film sensor with an enclosed conductive ink trace inside the body armor

that detects any piercing to the wearer's front or back, from projectiles such as bullets and shrapnel, or attack with a knife. In the event the wearer suffers an impact, the vest automatically connects to a paired device using Nordic Bluetooth LE wireless connectivity, up to a range of almost 70 meters. The smartphone then sends an emergency alert to nominated first responders and/or agency backup units via SMS, or directly to the dispatcher.

Emergency notifications include the user's name and accurate personal medical information, the linked device's GPS location, and where on the vest the impact occurred, allowing medical responders to assess the urgency and seriousness of the potential injury. AID can also automatically and instantly initiate one call to a selected phone number via DataSoft's companion app on the user's smartphone, as well as activate a wireless body camera to record the incident. The application proves the inherent advantage of wearable technology over alternatives.

"There are gunshot detection systems that 'listen' for a gunshot and send out a notification, but they are installed onto infrastructure such as buildings and lightpoles, and they aren't wearable," says John Bohlke, Director of Business Development at DataSoft Corporation. "AID ensures accurate emergency information is sent immediately so the agency can get back-up and medical attention to the injured person as soon as possible.

"When a person has been shot or stabbed they may be incapacitated, have to flee, or fight back. Even if they can get to their radio or smartphone, they often have difficulty providing accurate information in a clear manner. AID solves this issue."

While fitness and medical wearables will continue to have their place, equally forward-thinking developers have found another niche with personal security solutions. After all, there is more to looking after yourself than just walking 10,000 steps a day. ■



*"Wellbeing can be challenged not just through lack of exercise, but also through a threat to immediate personal safety"*

**Smartfuture's IVY jewelry ensures personal safety at all stages of a woman's life**



# The fast lane to the IoT

Nordic customer Espruino is making it easier for developers to use simple high-level languages like JavaScript to program their IoT devices. ULP WQ reports

The Internet of Things (IoT) offers such promise as a platform for new applications it's attracting the attention of hundreds of thousands of entrepreneurs across the globe. These innovators are keen to quickly move their ideas from blueprint to reality but many come unstuck because they lack the resources to write the microcontroller code to power their IoT inventions.

Nordic Semiconductor and others have worked hard to lower this barrier to the fledgling IoT with hardware reference designs, development kits (DK), and software DKs (SDK). Such support tools have eliminated the need for wireless expertise and simplified design but still demand competence with programming languages such as C and application programming interfaces (API) to get things humming.

"Despite the excellent efforts of the chip makers, developing software for the embedded microcontrollers at the heart of today's wireless Systems-on-Chip [SoCs] remains hard," explains Gordon Williams, Founder and Lead Engineer of Espruino, a development tool for embedded microcontrollers based on a JavaScript interpreter. "More than that, toolchains are hard to install and every manufacturer has their own API. The developer also needs external hardware if they want to write new firmware quickly or debug existing programs. Such restrictions quickly stall the launch of an exciting IoT innovation."

Williams' desire to make things easier for would-be IoT entrepreneurs encouraged him to develop an Espruino ecosystem. This comprises the JavaScript interpreter (open-source firmware residing on the target microcontroller), Espruino



Espruino is making it much easier to build home automation and other IoT applications

hardware with pre-installed interpreter, and the Web-based IDE. Support documentation, tutorials, and modules complete the Espruino line-up.

## Simple coding

JavaScript forms the heart of Espruino's ecosystem because it is simple to learn and write. Originally designed for building websites, the language's specification called for a lightweight structure, running just a single thread, and spending the majority of the time idling, reacting only to occasional

events. Such attributes make JavaScript popular with a large community of web developers and a good fit for coding a microcontroller with modest memory capacity operating in a system with a very low duty cycle such as a Bluetooth Low Energy (LE)-connected device.

Williams explains that such ease-of-use opens up wireless connectivity to a huge new cohort. "While C or C++ programmers are rare and expensive, most companies have easy access to someone who can code in JavaScript," he explains. "JavaScript programmers can construct their application in a familiar language and Espruino then interprets the code directly on the microcontroller."

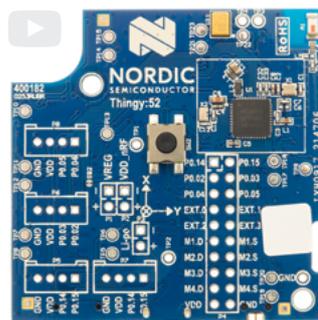
Moreover, coders can upload the program via the chip's wireless connection, inspect and modify functions and variables while the program is running, and step through the program line by line without needing external debugging hardware.

There is, however, a compromise: JavaScript's execution is slower than that

of a more efficient language such as C. However, as Williams explains, this isn't a big problem for the majority of simple wireless applications. "If the application is [for example] a Bluetooth beacon, the Espruino device might only spend one millisecond executing JavaScript when it powers on, and from then on the operation is handled by the Bluetooth LE firmware."

For more complex applications, Espruino allows for the introduction of C functions in-line with the JavaScript. To do so, Williams explains, the developer need only add C code inside a special JavaScript function and the IDE will automatically detect and compile it.

A second compromise is that the Espruino interpreter takes up valuable Flash memory space on the wireless SoC which could otherwise be used by application software, limiting the complexity of the application. This is less of a problem when the developer is using a Nordic [nRF52832](#) or [nRF52840](#) SoC as these devices feature generous memory allocations, but it could place a



Espruino makes coding Nordic Thingy:52 IoT Sensor Kit applications much easier



restriction on the application of lower specification chips.

During development, Espruino is able to catch errors and save them to a log for debugging, or once deployed in the field the error log can be wirelessly transmitted to a server for further analysis. And because Espruino is open source, more experienced developers can even use it to build their own firmware with customized functionality built-in.

## Doing more with Thingy:52

Espruino's latest hardware is the Pixl.js, a 'smart' LCD with Bluetooth LE connectivity. The product can be used to monitor and control other Bluetooth LE devices and act as a wireless display. Pixl.js is supplied with the Espruino JavaScript firmware, a Raytac [MDBT42](#) Bluetooth LE module (based on Nordic's nRF52832 SoC) and a low power sunlight-readable LCD screen.

Once switched on, the coin cell-powered Pixl.js can be paired to Bluetooth 4.0 (and later)-enabled PCs and Macs with the wireless connection enabling the developer to use the web-based Espruino IDE to upload their JavaScript code directly to the Pixl.js. The developer can even send individual JavaScript commands to the device without the need to program it. A key advantage of the Pixl.js is that any errors encountered while running new code can be displayed on the LCD, facilitating faster debugging.

It's no accident that the Pixl.js and other Espruino products such as Puck.js are based on Nordic wireless technology. The nRF51 and nRF52 Series hardware and firmware ideally complement Espruino.

"The nRF52832 chip brings robust Bluetooth LE connectivity, coin-cell power consumption, large memory capacity, and affordability," says Williams. "And Nordic's Bluetooth RF protocol software dovetails with the Espruino firmware beautifully. The Bluetooth stack [SoftDevice] doesn't try to take over the microcontroller, instead it uses interrupts to execute code only when it needs to. This fits in very well with JavaScript's event-based architecture and makes it

simple to write code that draws minimal power."

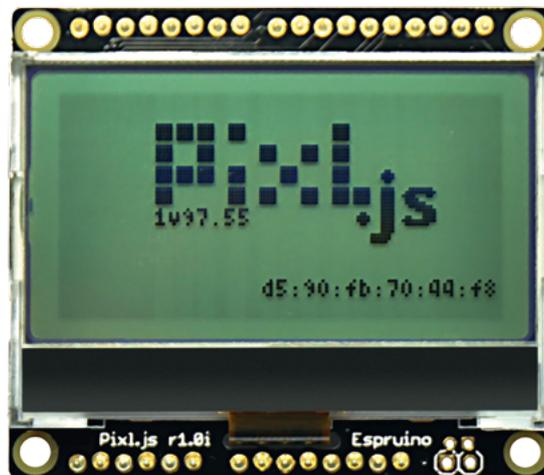
But developers don't have to use Espruino's own hardware to take advantage of the technology. The Espruino JavaScript interpreter is available on preprogrammed modules and can be ported directly to Nordic's Bluetooth 5/Bluetooth LE SoCs. Such compatibility is increasing the appeal of the nRF52832-powered [Nordic Thingy:52](#), a self-contained IoT Sensor Kit.

Thingy:52 is equipped with a family of the most popular wireless sensors, including a built-in digital microphone and speaker, nine-axis movement sensor, accelerometer, and pressure, temperature, humidity, air-quality, and color sensors.

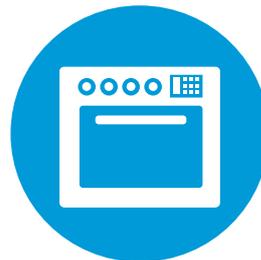
A developer can configure Nordic Thingy:52 in order to demonstrate IoT applications to interested parties and the device can even form the basis of a hardware prototype, eliminating the need to assemble and solder RF circuits and antennas.

From the supplied and easy-to-use Bluetooth API, developers can quickly develop IoT devices for a range of applications. For example it's easy to alter the air-quality sensor's sample rate or switch on the color sensor with no need to interact directly with Thingy:52's firmware code. (See *ULP WQ Summer 2017*

**Pixl.js can be used to monitor and control other Bluetooth LE devices and act as a wireless display**



*"It's no accident that the Espruino Pixl.js is based on Nordic wireless technology"*



*pg10.)* However, it's proven more difficult to program the Thingy:52 for more complex applications. To do that developers require a Nordic DK and experience of higher-level programming languages.

"I wanted to make Thingy:52 much easier to program," says John Leonard, a Product Marketing Manager with Nordic Semiconductor. "And I wanted to make it easier to configure the built-in sensors for real-life applications. Espruino now makes that possible because it runs perfectly on the nRF52832 SoC and enables the Thingy:52 to be programmed with JavaScript - opening up the device to a much wider developer community than the C or C++ specialists."

Leonard explains that the Espruino IDE runs on a PC or Mac using most modern browsers, eliminating the need to download and install software before starting programming. Beginners can even start programming with Espruino using a graphical editor that allows the program to be built-up from pre-written code 'blocks'. But Espruino doesn't limit the complexity of applications and more experienced developers can mix C and JavaScript to speed up the operation of Thingy:52.

Running Espruino on the Thingy:52 does require the developer to download the firmware because it is not factory-installed. But this is relatively easy to do over-the-air using a Bluetooth 4 (or later) enabled smartphone or tablet. And once Espruino is in place a web developer can easily code, configure, and commission thousands of powerful wireless IoT sensor applications without requiring any RF software or hardware expertise.

Williams is already considering where to go next: "One of our partners already offers an early Bluetooth LE/Narrowband IoT (NB-IoT) option for Internet connectivity, but Nordic's nRF52 Bluetooth 5 and [nRF91 Series](#) LTE-M/NB-IoT solutions promise a very exciting way to elegantly integrate Bluetooth LE and low-power cellular technology in a very small, cost-effective package," he explains. "We're definitely looking at combining this technology with Espruino for a comprehensive IoT solution that people with only modest JavaScript knowledge can easily exploit. Once that happens the IoT could really boom." ■



# Powerful wireless SoCs meet advanced wearable demands

In the final part of this article, Sebastien Mackaie-Blanchi explains how to get started developing with Nordic's Bluetooth LE SoCs



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

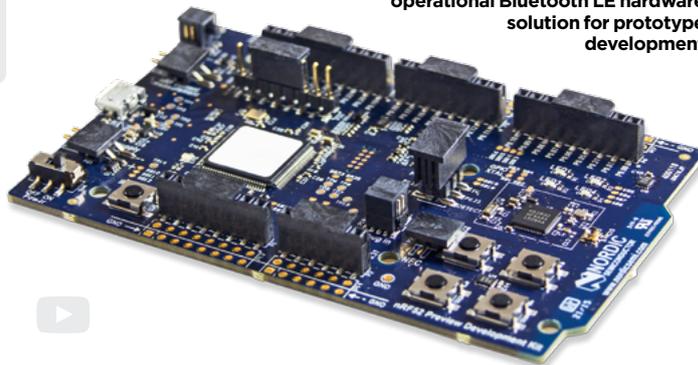
In the first three parts of this article, we looked at how hardware (Systems-on-Chip (SoCs)) and firmware (RF protocol software) form a platform for complex Bluetooth Low Energy (Bluetooth LE) applications. But a discrete Bluetooth LE SoC and 'stack' is of little practical use on its own. Some development work is required to come up with a working prototype. The good news is that one of Nordic's key strategies is to make this development process as simple as possible such that everyone from makers and hobbyists through to highly-experienced engineers can design wirelessly-connected products.

There's no need to embark on time-consuming and difficult hardware prototyping to start developing a Bluetooth LE product; Nordic supplies fully-operational hardware in the form of the nRF52 Development Kit (DK). The kit can be connected to a PC or Mac and forms all the hardware for designing with the nRF52832 and nRF52810 SoCs. (There's a separate DK for the high-end nRF52840 chip.)

The DK provides simple access to all the SoC's I/Os and interfaces via connectors and includes four user programmable-LEDs and -buttons. Another handy feature is that the DK is hardware-compatible with the Arduino Uno (Revision 3) standard, enabling the use of any of the many commercially available third-party shields to enhance functionality.

The DK's Bluetooth LE SoC is blank on delivery. The developer is thus free to choose the best

**The Nordic nRF52 DK is a fully-operational Bluetooth LE hardware solution for prototype development**



SoftDevice (Nordic's RF protocol software) for their project. The preferred SoftDevice can be downloaded from Nordic's website as a precompiled binary file and seamlessly ported to the DK's SoC using nRF Connect, a cross-platform tool from Nordic that enables testing and development with Bluetooth LE. nRF Connect comes in desktop and mobile versions which allow the developer to use Bluetooth LE connectivity to communicate with their prototype from a PC or smartphone respectively.

## Creating application code

Application software development—whereby the engineer writes his or her own code to optimize the functionality of the wireless product for a particular application, for example a heart

*"There's no need to embark on time-consuming and difficult hardware prototyping"*

rate monitor—requires three essential components. The first is an integrated development environment (IDE) with a Nordic-supported compiler, second is Nordic's [nRF5 Software DK](#) (SDK), and third is the company's nRF5x Command Line Tools.

There are four IDEs that can do the job: SEGGER Embedded Studio, MDK-ARM Keil, GNU/GCC, and IAR (all these IDEs support Windows, but only SEGGER and GNU/GCC also support Linux and OSX). The nRF5 SDK contains application examples, source files, and other

useful development items. (There are also specialized SDKs that add to the generic SDK and extend functionality to things like mesh networking and wireless charging.) The nRF5x Command Line Tools allow the developer to do extra things like program Nordic SoCs with things like SEGGER J-Link programmers and debuggers or combine up to three HEX files into a single file.

The IDE supports all the development activity while the Nordic SDK and Command Line Tools specifically support application coding for Nordic chips. The IDE then looks after application code compilation for porting straight to the Nordic SoC. (Remembering that Nordic's unique software architecture means that during application development the SoftDevice remains untouched and the critical dependencies for efficient and reliable stack operation are maintained.)

The programmed DK can then be used to check out the functionality of the design (by, for example, wirelessly sending data from a sensor connected to the DK to a smartphone or other nRF52 DK). The developer can then use the development tools to easily debug his or her code, add more functionality, and optimize its performance.

Nordic's development tools make it easier than ever to prototype a wireless product. But as with all engineering design, things can sometimes get challenging, particularly for the inexperienced. The good news is that someone has typically been down the path before and has shared the experience on Nordic's [DevZone](#). If that's not the case, the developer can ask for help and one of a community of over 25,000 fellow designers will soon come up with the answer. ■



Shenzhen Geekplay Technology used Nordic development tools to design its portable AR gaming device

# BEAM Smart Button

This Bluetooth Low Energy smart button wirelessly displays personalized information offering users an innovative new communication platform

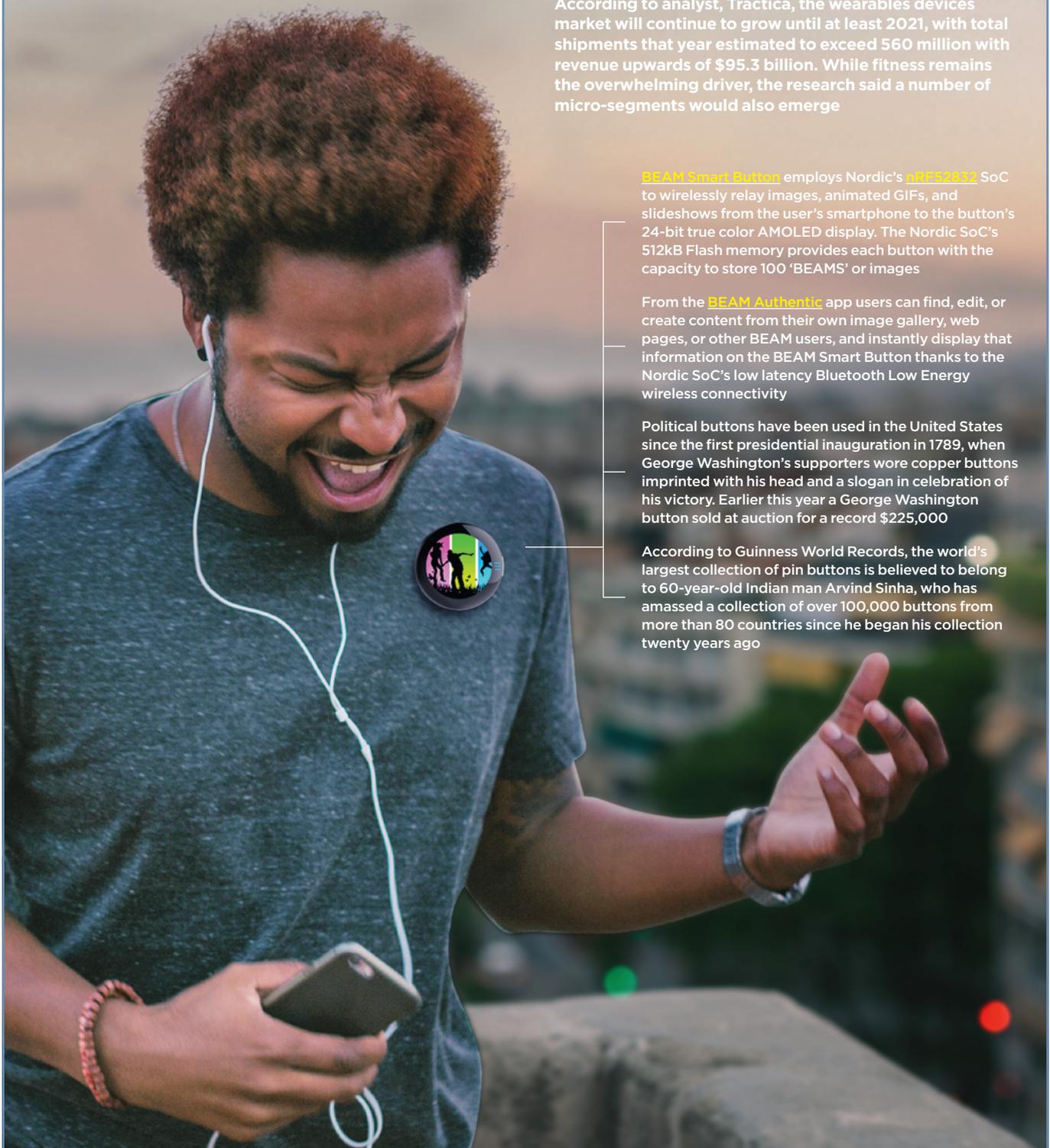
According to analyst, Tractica, the wearables devices market will continue to grow until at least 2021, with total shipments that year estimated to exceed 560 million with revenue upwards of \$95.3 billion. While fitness remains the overwhelming driver, the research said a number of micro-segments would also emerge

**BEAM Smart Button** employs Nordic's **nRF52832** SoC to wirelessly relay images, animated GIFs, and slideshows from the user's smartphone to the button's 24-bit true color AMOLED display. The Nordic SoC's 512kB Flash memory provides each button with the capacity to store 100 'BEAMS' or images

From the **BEAM Authentic** app users can find, edit, or create content from their own image gallery, web pages, or other BEAM users, and instantly display that information on the BEAM Smart Button thanks to the Nordic SoC's low latency Bluetooth Low Energy wireless connectivity

Political buttons have been used in the United States since the first presidential inauguration in 1789, when George Washington's supporters wore copper buttons imprinted with his head and a slogan in celebration of his victory. Earlier this year a George Washington button sold at auction for a record \$225,000

According to Guinness World Records, the world's largest collection of pin buttons is believed to belong to 60-year-old Indian man Arvind Sinha, who has amassed a collection of over 100,000 buttons from more than 80 countries since he began his collection twenty years ago



# Sports monitoring gets serious with advanced HRM platform

Using an novel algorithm and wireless connectivity, Cardiosport's heart rate monitor enables sports wearables to transmit medical-grade data, reports Kalon Huett



**Kalon Huett** is an Australia-based freelance journalist

In the ultra-competitive world of fitness and movement tracking wearables, it takes something special for a heart rate monitor (HRM) to split from the pack of effective devices and stand out. For Hampshire, U.K.-based Cardiosport, an OEM specializing in the sports and healthcare sector, the goal has always been to develop advanced, fully customizable platforms within a framework of open collaboration, allowing third party OEMs to achieve their own product release goals, on time and to budget.

That drive for industry-changing innovation led Cardiosport to develop the ['TP5 Heart Rate Monitor'](#), a Bluetooth Low Energy (Bluetooth LE) and ANT+ HRM platform, versatile enough to be modified for a range of advanced applications and devices across a raft of different market sectors including sports, fitness, and healthcare.

At its core, this small and lightweight device (63 by 34 by 8.8 mm/12g) features everything one might expect in an HRM: Heart rate and movement sensors, a three-axis accelerometer for measuring running speed, pace, and cadence, as well as more advanced running metrics such as ground contact time, left/right leg balance, and upper body position.

So, what makes the TP5 HRM different? Most significantly, the TP5 features a proprietary 'CBA9' ECG ASIC chip—able to detect small input signal amplitudes, discerning valid signals from artifacts and noise with active filtering, while using a very small amount of power—and a

proprietary 'r-r' interval (the time intervals between heart beats) algorithm. These capabilities enable HRM products to gather precise, medical-grade heart rate data and record individual heart beats when the end user is moving or exercising.

The functionality means Cardiosport's OEM customers can take advantage of an accelerometer that broadcasts raw data movements, alongside the TP5's r-r reading capabilities, to design apps for

intense exercise and in day-to-day life," explains James MacGregor, Marketing and Business Development Manager at Cardiosport. "During intense exercise and recovery, being able to see the changes in time between successive heart beats is vital for determining an accurate 'HRV score'.

"We have one customer that uses the TP5 integrated into clothing to detect heart rate and r-r intervals in relation to the end user's stillness

product that can monitor the signal with the best accuracy and with minimal power usage."

Cardiosport claims the TP5 HRM's CR2032 coin cell provides "industry-leading" battery life in excess of 900 hours; a significant benefit for wearables developers and one in part made possible by the ultra low power capabilities of Nordic's [nRF52832](#) System-on-Chip (SoC) used in the product.

To ensure interoperability between multiple related devices in the health/fitness sphere,

the Cardiosport platform leverages the Nordic SoC's 2.4 GHz multiprotocol radio - which supports Bluetooth 5, ANT+, and proprietary 2.4GHz RF protocol software. The multiprotocol support enables wireless data transmission not only via Bluetooth LE to customer apps hosted on smartphones and

tablets, but also to ANT+ enabled devices like smartwatches, bike computers, various types of fitness equipment, and more.

As for the future, Cardiosport expects the movement-tracking wearables market to continue its growth cycle over the next 24 months, as end users crave ever more insightful data.

"Our focus is to develop the best wearables to ensure all the valuable biometric data is gathered accurately," says MacGregor. "Sophisticated software can really dig deep into the user's fitness and health data to establish trends and make recommendations to improve the user's experience. However, these platforms still require accurate data from the wearables, which is why we are developing new products that can detect more biological metrics like respiration rate, temperature, and EMG [electromyography]." ■



## The TP5's built-in accelerometer enables the HRM to track movement

specific scenarios; for example, counting push-up/sit-up reps, or monitoring cardiovascular efficiency during a run. More impressively, the HRM platform measures heart rate variability (HRV - fluctuations in the r-r interval) as an indicator of either effective training or over-training, a condition which is particularly common in strenuous cardiovascular exercise programs for cycling and running.

"There are many benefits of monitoring r-r intervals during

and composure during yoga movements," explains MacGregor. "The customer's app can see correlation between intervals and movements, which helps with various breathing exercises. By recording this data over time, the end user can see that specific yoga/exercise routines reduce their stress and improve their HRV," says MacGregor.

## Unique value of r-r

MacGregor explains that the unique value of live monitoring r-r intervals is demonstrated when customers use the information to calculate previously hard to measure information such as parasympathetic and sympathetic Autonomic Nervous System (ANS) reactions.

"How the r-r interval and HRV data is used and presented is what our customers do best; our priority is being able to offer a

*"A sophisticated algorithm can really dig deep into the user's fitness level but does rely on accurate data from the wearable"*

# PEOPLE & PLACES

David Day



## Sales leader is competitive by nature

**H**i, I'm David Day and I'm a Regional Sales Manager for Nordic based in Boston, Massachusetts.

My main responsibilities at the company include prospecting for new customers, identifying new business opportunities with existing and new customers, and overseeing the sales cycle for each customer opportunity. I also manage a new business development report and the distribution sales channel in my assigned territory. A key element of my role is to prioritize tasks involving Nordic management and Nordic technical resources.

I thoroughly enjoy the personal aspect of my job, which involves teaming up with Nordic colleagues and assisting our customers to achieve success with their product development objectives. I regularly encounter so many different people, personalities, backgrounds, and cultures. I have been fortunate enough to cultivate great business and personal relationships with my colleagues as well as our many customers and partners. I also appreciate the positive team atmosphere and culture in Nordic that makes acquiring new customers and managing our global business significantly easier.

We typically start by targeting a specific customer based on their market segment, volume, and market share, before working to gain a complete understanding of their technical and commercial requirements through insightful,



### Personal Profile

NAME:

**David Day**

JOB TITLE:

**Regional Sales Manager**

JOINED NORDIC:

**2008**

BASED:

**Boston, MA, U.S.**

INTERESTS INCLUDE:

**Cycling, hiking, cross-country skiing, live music, cooking, reading**

*"The positive team atmosphere and culture in Nordic makes managing our global business significantly easier"*

open-ended questioning and consultation. From this point, we can steer the customer toward a solution that leverages key advantages of Nordic technology.

In many cases, specific software features or software demonstrations developed by our technical support resources are key differentiators for Nordic. One such example involved an existing customer that we helped migrate from one of our product families to another using the new capabilities to improve their product, while maintaining compatibility across product lines. This team effort resulted in a successful high-volume project for both the customer and Nordic.

I strive for a healthy professional- and personal-life balance. Outside of work, I love gathering with family and friends at live music and sporting events, or simply to enjoy good food.

I also like hiking and cycling, which is a great way to exercise, briefly disconnect, and see different places. The nearby beaches, forests, and mountains provide many recreational opportunities and always reward physical activity with beautiful scenery.

With no interruptions on a long bicycle ride, I find myself thinking about goals, objectives, and different approaches to both work and personal challenges along the way. I have even formulated new ideas and strategies for certain business situations that I may not have otherwise considered.

I am quite competitive by nature, and I believe this trait helps me achieve our personal and professional goals. However, I must admit that sometimes personal competitiveness can be taken to extremes and lead to rather risky situations, as some of my colleagues may recall!

Professionally, I hope to continue making a valuable contribution to the growth and success of Nordic in a sales leadership capacity. I am proud to be a part of the company. I believe we have exceptional people and a unique company vision that will help us grow faster than our competitors and the overall industry. I am always learning from the world-class managers and engineers at Nordic and am excited about our future potential.

I'm also looking forward to visiting some different countries and spending quality time with my family and friends. ■



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