ultra low power wirelessQ

QUARTER 1 | **SPRING 2015**

COVER STORY

IoT cuts aircraft maintenance bills

Nordic first with IPv6 over Bluetooth Smart

What's hot in the Nordic devzone

Opening up to open source

NORDIC SEMICONDUCTOR

OPINION

Svenn-Tore Larsen

Industrial applications drive the Internet of Things

Smart watches are perhaps the most glamorous of the current crop of wearables. A device that performs the job of a conventional watch while also offering functions such as interfacing with smartphones, paying bills, and tracking calories has captured consumers' attention. Other wearable products from many major electronics manufacturers are also making their mark, including fitness wristbands and medical products such as constant glucose monitors and fall alarms.

The boom in wearables has in part been driven by the smartphone manufacturers' adoption of Bluetooth v4.0 (comprising Bluetooth Smart Ready and the ultra low power version of the technology, Bluetooth Smart) in their handsets. Bluetooth technology ensures connectivity between devices and allows the wearable to leverage the computational power, software, and Internet connectivity of the handset.

Wearables are perhaps the most appealing example of the 'things' that form part of the developing Internet of Things (IoT). Yet they will only ever form a tiny part of this giant network. The IoT extends the current Internet from a human-centric network to one dominated by autonomous things communicating with each other and the Cloud without our intervention. The overwhelming majority of the things forming the IoT will be used in industrial applications - where IoT connectivity will add intelligence and analytics to processes and services, enhancing efficiency and slashing cost - rather than consumer ones.

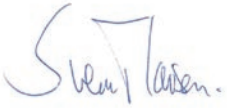
The power of an industrial IoT will be immense. According to a report from U.S.-based industrial giant General Electric (GE), for example, there are approximately 43,000 commercial jet engines in service. Each engine could be automatically monitored using wireless sensors connected via the IoT. Imagine the efficiency gains in maintenance, fuel consumption, crew allocation, and scheduling such monitoring would yield. The savings would be huge; just a one percent cut in fuel consumption across the global commercial aircraft fleet for instance, would slash costs by $30 billion over a 15-year period. (*See this issue page 10.*)

In a second example of the power of the IoT, GE estimates that taking into account productivity gains alone, the industrial segment of the IoT would boost the world economy by over $15 trillion by 2030. (To put that into perspective, the approximate size of today's U.S. economy is $16.7 trillion.)

As a proven, open standard, Bluetooth Smart, together with others such as Wi-Fi and IEEE 802.15.4, is likely to underpin the IoT. But to maximize the potential of a connected world, Bluetooth Smart needs to evolve such that it can connect directly to the Internet. To do that the technology must use the 'language of the Internet', IPv6, to communicate with other networked devices and the Cloud. That evolution is happening right now with the introduction of the Internet Protocol Support Profile (IPSP) in Bluetooth v4.2.

Nordic Semiconductor is the first Bluetooth Smart chip vendor to leverage Bluetooth Smart technology's IPSP in its IoT Software Development Kit (SDK). The SDK allows developers to experiment with IPv6 over Bluetooth Smart technology which enables wireless sensors to communicate directly with other sensors and Cloud services. (*For more about Nordic's IPv6 over Bluetooth Smart, see pages 8 and 18.*)

Yours Sincerely,



Svenn-Tore Larsen
CEO

Page 9

Thomas Embla Bonnerud is Director of Product Management with Nordic Semiconductor. In this issue he considers the growing influence of the software engineer

Page 16

Sally Ward-Foxton is an electronics freelance journalist. Here she explores how open source software for ultra low power wireless applications is fostering innovation

Page 18

Caroline Hayes is a tech writer specializing in semiconductors. On page 18 she describes how IPv6-powered wireless sensors will form the outer reaches of the IoT

The IoT promises to slash the cost of maintenance in the aircraft sector and other industries

***ULP Wireless Q* is published on behalf of Nordic Semiconductor by Ecritech**

www.ecritech.com

Editor
Steven Keeping
e-mail: steven@ecritech.com

Assistant Editor
Andrew Woolls-King
e-mail: andrew@ecritech.com

News Editor
Chris Williams
e-mail: chris@ecritech.com

Art Editor
Tim Plummer
e-mail: production@ecritech.com

Image Editor
Neale Hobday
e-mail: production@ecritech.com

Print & Distribution
Printech Europe

NORDIC SEMICONDUCTOR

2.4 GHz | Sub 1-GHz | ANT+

NEWS

The latest developments from Nordic Semiconductor

Logitech wireless keyboard sets new battery life standard

Peripheral device manufacturer Logitech has specified Nordic Semiconductor's nRF51822 System-on-Chip (SoC) in its Ultrathin keyboard for the iPad Air 2. The keyboard is said to be one of the first to employ Bluetooth Smart wireless technology.

The Logitech Ultrathin is constructed from high-grade aluminum and is only 6.4-mm thick. It magnetically clips on to the iPad Air 2, functioning as both a screen cover and a wireless keyboard with iOS shortcut keys so users can easily navigate and type while on-the-move.

A key factor in the decision to use the nRF51822 SoC was its contribution to an exceptionally long two-year battery life, equating to around two hours-per-day usage from the Logitech Ultrathin's two lithium batteries.

"The use of the Nordic nRF51822 in this product helped our engineers achieve a new battery-life standard for wireless tablet keyboards," says Alexis Richard, Director of Product Marketing at Logitech.

"Because the nRF51822 SoC is a true single-chip solution, it contributed to Logitech developing one of the thinnest and lightest wireless tablet keyboards on the market to complement the incredibly thin and lightweight iPad."

The keyboard includes an adjustable built-in stand and an instant on/off feature that allows an attached iPad to automatically 'wake' as the user opens the cover, and switch to standby when they close it.

The Logitech Ultrathin has a two-year battery life

Head impact monitor averts risk of long-term brain damage in contact sports

A wireless sensor that can be embedded into a headband or skullcap could mitigate the risk of long-term brain damage to athletes engaging in contact sports, by continuously monitoring and measuring G-force impacts to the head.

The Smart Impact Monitor (SIM) from U.S.-based Triax Technologies measures the severity of all forceful head impacts that occur in contact sports, and logs the results for analysis by medical personnel.

In operation, the 32 by 15-mm non-invasive SIM fits securely into a customized headband and counts and measures all head impacts in Newtons (N), converting the data to G-force before transmitting it in real time to a Triax companion app running on any Bluetooth Smart Ready iOS smartphone or tablet. The wireless connectivity is provided by Nordic Semiconductor's nRF51822 System-on-Chip.

Triax Technologies says given concussions are unpredictable and can be hard to detect, the Triax SIM provides much needed insight into a potential health risk that athletes may not realize they have experienced, and can be used as a critical indicator for further medical evaluation.

The Triax monitor measures G-force head impacts in contact sports

"With the groundswell of data surrounding the risk of head impacts and the availability of accurate technology for discrete monitoring, there is no reason all athletes aren't taking this accessible step to identify when a player may be at risk," says Chad Hollingsworth, Co-Founder and VP of Business Development at Triax Technologies.

Hollingsworth added that Triax benefitted from the high level of 'un-biased' technical-support provided by Nordic, that translated into a rapid 24-hour response to any reported issues.

In brief

Bluetooth Smart to top $10 bn

Market revenue for Bluetooth Smart is expected to increase to $10.1 billion by 2020 on the back of the technology's rapid penetration into electronic devices, a recent market study from IndustryARC has claimed. The analyst said a surge in the number of interconnected devices, alongside increased crowd funding for small companies with new ideas around wireless connectivity were the driving factors behind the predicted growth.

Business adoption drives IoT growth

The number of business-to-business Internet of Things (IoT) connections reached more than 1 billion for the first time last year, according to new research. Telecoms firm Verizon said by 2020 the number of IoT-enabled applications and devices would surpass five billion, with the number of machine-to-machine connections in the manufacturing, finance, and entertainment sectors all more than doubling in the last 12 months alone.

Lonely hearts use beacon tech

A Swiss startup, Blinq, is putting a new spin on the dating app by using beacon technology to notify users if any of their dating matches are in the same location as them. Select venues in Zurich have been fitted out with Estimote iBeacons - incorporating Nordic's nRF51822 SoCs to provide the wireless connectivity. So far around 50 beacons have been installed but the company is in discussions with other venues to expand this footprint further.

In brief

Invisible wearables market to take off

A new report from analyst Juniper Research claims wearable technology that is indistinguishable from 'non-smart' technology will make a significant contribution to the segment's growth in the next five years. The research house estimates the wearables market will be worth approximately $80 billion annually by 2020, with fashion-first wearables – dubbed 'invisible wearables' – having much greater consumer appeal than tech-centric devices. The company noted, however, that smartwatches would remain the most purchased wearable until 2017.

Smartwatch sales set to quadruple

Smartwatch shipments will more than quadruple in 2015 reaching 24.4 million units worldwide, says industry analyst Tractica. The company explained smartwatches had already experienced significant growth in 2014 with global device shipments more than doubling to five million, but the introduction of the Apple Watch would drive growth yet further this year. The analyst said strong sales would continue through to 2020, by which time smartwatch shipments could reach 94.9 million units annually.

Security fears may slow IoT adoption

A study looking at the business and societal impacts of Internet security claims the perceived threat from online attacks is hurting the adoption of Internet of Things (IoT) technology. Almost 60 percent of respondents to the GFI Software study said they believed Internet-connected home devices were too risky to own, or would hesitate to purchase further devices because of the potential threat of an online attack. Industrial installations are perceived to be at risk too with smart electricity grids cited as one of the most vulnerable assets.

Wireless basketball shot tracker helps players reach new heights

U.S. sports technology start-up ShotTracker is employing Nordic Semiconductor technology in its basketball performance tracking and monitoring devices to help players improve their game.

The ShotTracker uses Nordic's nRF51822 Systems-on-Chip (SoCs) to provide Bluetooth Smart wireless connectivity. The product makes full use of the SoC's powerful ARM Cortex microprocessor—backed up with 256 kB of Flash memory—to run on-the-spot motion recognition algorithms to measure and analyze a player's shooting skills.

ShotTracker can be used with any regular basketball and net, and includes a water-resistant net sensor, a wrist-worn sensor or wearable sleeve, and a free partner app running on any Bluetooth Smart Ready smartphone or tablet.

ShotTracker can be used with any regular basketball and net

These all synchronize to create a personal shooting profile for up to four separate users.

The intelligence of ShotTracker derives from a sophisticated, patent-pending software algorithm that analyzes data from a three-axis accelerometer embedded into the net sensor and a second six-axis accelerometer in the wrist-worn sensor or sleeve.

"The ultra low power operating characteristics of the nRF51822 enabled us to achieve a three-month battery lifetime from the net sensor and eight-hours continuous use for the wrist and sleeve sensor from small, on-board rechargeable batteries," says Davyeon Ross, co-founder and COO of ShotTracker.

Presence-detecting power plugs simplify home automation

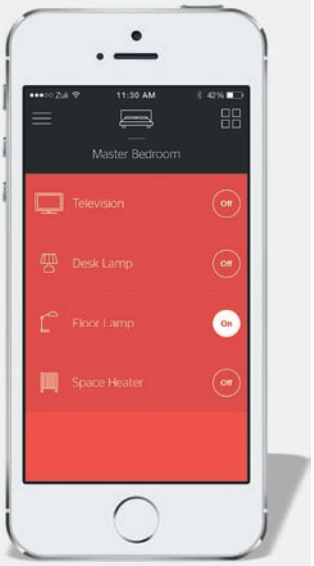
U.S. firm Zuli has taken a big stride towards home automation with the launch of its Zuli Smartplugs. The Smartplugs automatically control lights and appliances by detecting a user's presence.

The Smartplugs employ Nordic Semiconductor's nRF51822 Systems-on-Chip (SoCs) and offer a range of configurable options, including turning on and off appliances, dimming lights, and monitoring power consumption via a free companion app running on any Bluetooth Smart Ready iOS smartphone.

Each plug has a range of up to 30 m, but when three or more Zuli plugs are used, they create a mesh network that further extends the Bluetooth Smart wireless range and work like an "indoor GPS" capable of detecting whether a room is occupied.

The nRF51822 SoC in each plug is capable of acting in either a central or peripheral mode, while also communicating via Bluetooth Smart technology with an iOS smartphone running the Zuli app.

The SoC's hardware and separated RF protocol stack plus application software architecture allows communication with the Smartplugs to be performed at the highest possible data exchange rate, with the application going back into deep-sleep mode as often as possible to save power.



The Smartplugs can be configured from a user's smartphone to automate lights and appliances

"Leveraging Bluetooth Smart ... allows us to detect the user's presence and adjust devices while the app is in the background, maintaining low battery consumption on the smartphone," adds Zulu CTO, Sid Bhargava.

Nordic ANT and Bluetooth Smart chip scoops prestigious China editor's award

Nordic Semiconductor's nRF51422 multiprotocol ANT and Bluetooth Smart System-on-Chip (SoC) has won *China Electronic Market* (*CEM*) magazine's prestigious Editor's Choice Award 2014, claiming victory in the 'Most Competitive Connectivity Product' category.

The judging criteria considered brand influence, sales and market share, technological innovation, as well as product service.

Ståle Ytterdal, Nordic Semiconductor's Director Sales & Marketing in Asia, said the company was honored to receive the award from *CEM*.

"We are now entering the age of wearables and the Internet of Things (IoT). Our nRF51 Series SoCs address these markets with compact high-integration solutions that support the ULP wireless capability these new markets demand," says Ytterdal.

"This award also signals that Nordic is now a leader in the Chinese market for ULP wireless devices, a market to which we are absolutely committed. We are working tirelessly to support our customers in China and grow our presence here."

The nRF51422 multiprotocol SoC has been recognized for technical innovation in applications such as fitness monitors and other sports wearables

The nRF51422 SoC can support either ANT+ RF protocol software or, as the world's first multiprotocol SoC solution, concurrent ANT+ and Bluetooth Smart wireless communication, natively, on a single chip.

The combined nRF51422 ANT and Bluetooth Smart SoC means developers of wearable technology products no longer have to choose between these previously incompatible wireless technologies.

For space-constrained applications, Nordic offers a wafer-level chip-scale package (WLCSP) version of the nRF51422 with a footprint of just 3.8 by 3.5 mm.

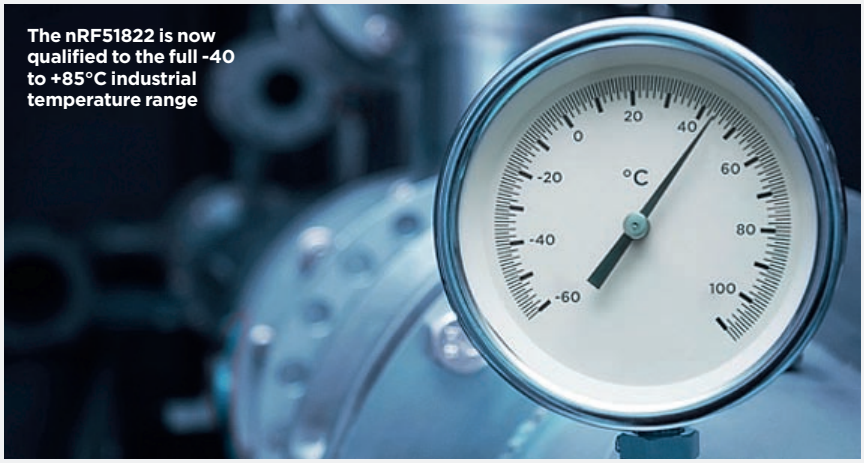
Industrial temperature range for Bluetooth Smart SoCs

In response to the increasing adoption of Bluetooth Smart wireless technology across industrial applications, Nordic Semiconductor's nRF51822 Bluetooth Smart and 2.4 GHz proprietary System-on-Chip (SoC) is now qualified to the full -40 to +85°C industry-standard industrial operating temperature range.

Bluetooth Smart has been gaining increased traction in industrial, home, and enterprise automation applications, and the company says the development of the wider operating temperature range in harness with the existing processing power and flexibility of the nRF51822 SoC will broaden its application base.

The nRF51822 16-kB RAM/256-kB Flash QFN SoC is the first qualified -40 to +85°C industrial temperature range variant to be released, with further variants scheduled throughout the first half of 2015.

"Instead of creating new nRF51 Series variants for [industrial temperature] purpose we decided to re-qualify existing variants for the extended temperature range," explains Thomas Embla Bonnerud, Director of Product Management with Nordic Semiconductor.



The nRF51822 is now qualified to the full -40 to +85°C industrial temperature range

"This enables customers to re-purpose existing designs without modification and immediately benefit from the wider operating temperature range," adds Bonnerud.

Aircraft repair goes wireless

A joint project between the European Commission and the aeronautical industry has developed new wireless sensors to facilitate constant monitoring of European aircraft. The FLITE-WISE project aims to move away from the wired sensors currently used for aircraft maintenance tasks towards a wireless sensor network relying on smart sensors. The sensors are expected to bring both cost and weight down, and will be commercialized within the next three years. (*See this issue page 10 for more on how wireless sensors will cut maintenance costs.*)

Identity and access critical to IoT

Research house Gartner claims identity and access management (IAM) is a potential stumbling block to the successful adoption of the Internet of Things (IoT), with current systems unable to provide the scale, or manage the complexity, that the IoT brings to the enterprise. Gartner said the growth of the IoT meant IAM leaders of digital businesses required a way of defining and managing the identities of people, services and things within a single framework, beyond the capability of traditional people-focused IAM systems.

In brief

Bluetooth Smart encourages adoption of intelligent lighting

A Finnish company is hoping to advance the mainstream adoption of smart lighting by using Bluetooth Smart to make it not only easier to install and use, but also more affordable.

Casambi Technologies claims it has significantly improved the mesh networking performance of its third-party Bluetooth Smart lighting control platform by taking advantage of the dual protocol architecture of Nordic Semiconductor's nRF51822 Bluetooth Smart and 2.4 GHz proprietary Systems-on-Chip (SoCs).

Casambi CEO, Timo Pakkala, says the solution communicates with smartphones using Bluetooth Smart wireless technology, but switches to Nordic's highly-optimized proprietary 2.4 GHz wireless technology using the nRF51822 radio's maximum 2 Mbps raw data rate for internal network communications between lighting fixtures and bulbs. By employing the SoC's dual protocol architecture in this way, Casambi claims its solution delivers at least five times faster mesh networking performance over alternative Bluetooth Smart solutions.

Casambi says the control platform can be integrated into standard lighting fixtures or directly into LED smart bulbs and drivers. It doesn't require any new wiring, switches, devices, networks or configuration beyond plugging in the lighting fixture or Casambi-enabled LED bulb and pairing it to a Bluetooth Smart Ready smartphone.

Users can then control their lights from an app with an intuitive and visual user interface.

"[The platform] offers all the compatibility, ease-of-use, and consumer usability of Bluetooth Smart wireless technology, underpinned by a ruthlessly application-specific, stripped-down, optimized proprietary 2.4GHz wireless protocol designed to offer maximum mesh-networking performance," says Pakkala.

Casambi has also embedded Internet of Things-(IoT) type functionality into its solution including: automatic over-the-air firmware and software updates for the whole network, cloud configuration and monitoring services, advanced security with different levels of access, as well as multi-user support.

Users can control their lights from an app with an intuitive interface

Mesh networking platform targets IoT reliability

Wirepas' network can 'heal' itself in the event of failure

Wirepas, a Finnish university spin-off company, has developed an ultra low power (ULP) wireless mesh networking solution that is claimed to improve network reliability for IoT applications.

Called Wirepas Pino, the solution is a fully automatic, self-optimizing, multi-hop mesh networking protocol stack developed by Wirepas, running on Nordic Semiconductor's nRF51822 Bluetooth Smart and 2.4GHz proprietary System-on-Chip (SoC) hardware.

The solution is said to support high node densities and a theoretically limitless network size with a network topology that continuously self-optimizes to balance network data traffic between nodes and adapt to changes in the nodes' operating environment.

Instead of being constructed of nodes that communicate with a central hub, the mesh network topology employs a 'hubless' architecture that supports intelligent and distributed self-organization and communication between independent nodes.

If a node fails the network will automatically 'heal' by re-routing communications via other nodes around it, while any node can share its connection to the Internet or other devices so users need only connect to a nearby node to access the network.

Network efficiency has been further enhanced as mesh network nodes can automatically and continuously self-reconfigure to maintain optimal network performance.

"Pino is the most automatic, robust, and easy-to-use mesh network available," says Wirepas CEO, Teppo Hemiä.

"[It] shifts the complexity of setting up and maintaining a network away from the end-user and into the network itself which makes it incredibly end-user-friendly."

ULP WIRELESS TRENDS

The latest developments in technology

Live!y's safety watch is targeted at the aged-care sector

Elderly care sector drives home health monitor growth to 600 percent

An increase in elderly care services will drive the growth of the home monitoring wearable device market by more than 600 percent in the next five years, new research has revealed. Growing adoption comes as tech-savvy families increasingly turn to smart home monitoring solutions for aging parents and family members.

According to Jonathan Collins, Principal Analyst at ABI Research, a preference for independent living supported the increased adoption of home monitoring solutions.

"The sports and wellbeing monitoring market has already drawn Samsung, Google, and Apple into developing devices to capture health and activity data," says Collins. "These will increasingly be extended to serve specific markets, primarily elderly care or aging."

US-based start-up Live!y recently launched a safety watch for the aged-care market that not only includes a button for 24/7 emergency response, but also provides missed medication reminders and a pedometer for step counting. The system offers an emergency response range of up to 300 m around the home. The watch can also be paired with a smartphone for emergency response when the user moves out of home range.

Solar-powered chip guards windows

A solar-powered radio sensor that mounts directly onto a window alerting the user if the window has been left open or if an attempted break-in has occurred, has been launched by Germany's Fraunhofer Institute.

Some existing home and building systems can already register the status of windows, but typically the sensors have to be attached by cable to a central alarm.

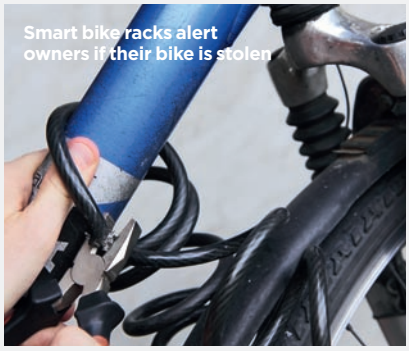
Alternatively battery-operated sensors are used, but changing batteries can lead to considerable maintenance expense. The new wireless sensor, however, is solar powered.

At 10mm, the chip is as narrow as a pane of insulating glass is thick. Integrated in the chip are magnetic field and acceleration sensors that register if the window is open just a crack or all the way. The chip alerts the base station in the building if a window remains open.

The solar chip can store enough power for up to 30 hours of darkness

Prototypes can store power for up to 30 hours of darkness, but future devices should be able to last up to two weeks without light.

Low energy operation and an efficient RF protocol ensures power consumption is kept to a minimum.



Smart bike racks alert owners if their bike is stolen

Bluetooth Smart technology foils campus bike thieves

A group of students from the University of Wisconsin-Madison in the U.S. is using Bluetooth Smart technology to embed sensors in to bicycles and bicycle racks around campus to deter thieves and aid the recovery of stolen bikes.

The students from the university's Internet of Things Lab are using a radio frequency identification (RFID) tag hidden on a bike to communicate with a smartphone that registers when the bike enters or exits the area. Either event triggers a message to a web server that is then texted to the owner of the bike.

The Bike Recovery Network system will tell when a protected bike is left at or taken from a 'smart bike rack' without the owner's knowledge, and alert the police department automatically to the theft.

"If the thief brings the bike to a smart bike rack you'll immediately know the bike is there, and the web server will immediately notify the authorities, and you can get your bike back," says team member Akhil Sundararajan, a mechanical engineering grad student.

According to Sandra Bradley, the lab's Director of Research for consumer and retail applications, it's unrealistic to expect a prototype in a single semester, but rather the aim is to see students innovate and come up with ideas that could then be taken to the next stage.

"The goal is more creation and exploration; it's not really about product design," Bradley says.

"Even more than a technology sandbox, this is a place for encouraging students to think through real-world problems and to have hands-on experience with cutting edge technologies," she adds.

Connecting Bluetooth Smart IoT sensors directly to the Cloud

Nordic is the first company to introduce a commercial software development kit that allows developers to experiment with IPv6 over Bluetooth Smart applications

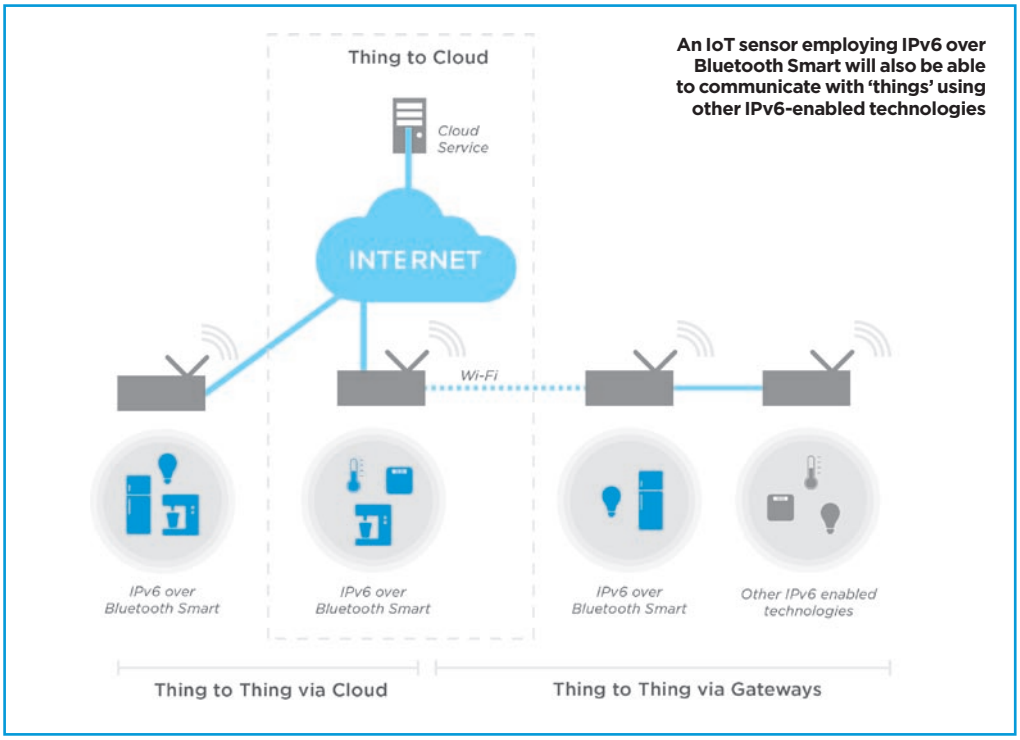
The hype around the Internet of Things (IoT) is huge; for example, analyst ABI Research reports that the installed base of wireless devices exceeded 16 billion in 2014, about 20 percent more than in 2013. The company says the number of devices will more than double over the next five years, to 40.9 billion in 2020.

With the emergence and growth of wearable technology, the low energy form of Bluetooth wireless - Bluetooth Smart - is already an established technology for connecting 'things' to the Internet. However, the current version of Bluetooth technology (v4.1 – of which Bluetooth Smart is a hallmark element) requires the resources of a smartphone or tablet to facilitate communication. But now a new version (v4.2) introduces the Internet Protocol Support Profile (IPSP) which allows sensors to access the Internet directly via Internet Protocol version 6 (IPv6) and the Internet Engineering Task Force's (IETF) IPv6 over Low power Wireless Personal Area Networks (6LoWPAN).

"IPv6 over Bluetooth Smart is a key enabling technology for power, size, and cost-constrained IoT applications," explains Thomas Embla Bonnerud, Director of Product Management with Nordic Semiconductor.

"Bluetooth Smart is the only wireless technology that provides the flexibility to innovate, ability to scale to the market, and trust of a globally recognized standard. All of which are essential to delivering the promise of the IoT," adds Errett Kroeter of the Bluetooth Special Interest Group (SIG).

Nordic Semiconductor's nRF51 Series IoT Software Development Kit (SDK) is the first commercial development tool to take advantage of this revision to Bluetooth Smart. With the SDK, engineers can design IoT sensor applications that only require the services of simple and inexpensive 'headless' routers to relay information to the Internet because the data is already formatted in IPv6 packets.



An IoT sensor employing IPv6 over Bluetooth Smart will also be able to communicate with 'things' using other IPv6-enabled technologies

"IPv6 over Bluetooth Smart is a key enabling technology for power, size, and cost-constrained IoT applications"

The SDK is a complete IPv6-ready Internet Protocol Suite for Nordic's nRF51 Series Bluetooth Smart Systems-on-Chip (SoCs). The SDK enables native and interoperable IP-based connectivity between a Bluetooth Smart thing and a Cloud service for end-to-end IP based communication. An IoT sensor employing IPv6 over Bluetooth Smart will also be able to communicate with things using other IPv6-enabled technologies, such as Wi-Fi, Ethernet, ZigBee IP, and Thread, to form a heterogeneous network.

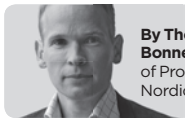
Based on open standards

In contrast to other IoT solutions based on proxies or proprietary Internet gateway bridges, the nRF51 IoT SDK is based entirely on open standards and extends IP addressing all the way to the sensor. The first release of the protocol stack includes: IPSP, 6LoWPAN adaption layer, IPv6 Internet routing layer, User Datagram Protocol (UDP) and Transmission Control Protocol (TCP) transport layers, Constrained Application Protocol (CoAP), and Message Queuing Telemetry Transport (MQTT) application layers, plus a range of application examples. The complete protocol stack can run on the nRF51 Series SoC in a single-chip configuration, minimizing the power, size, and cost of end products.

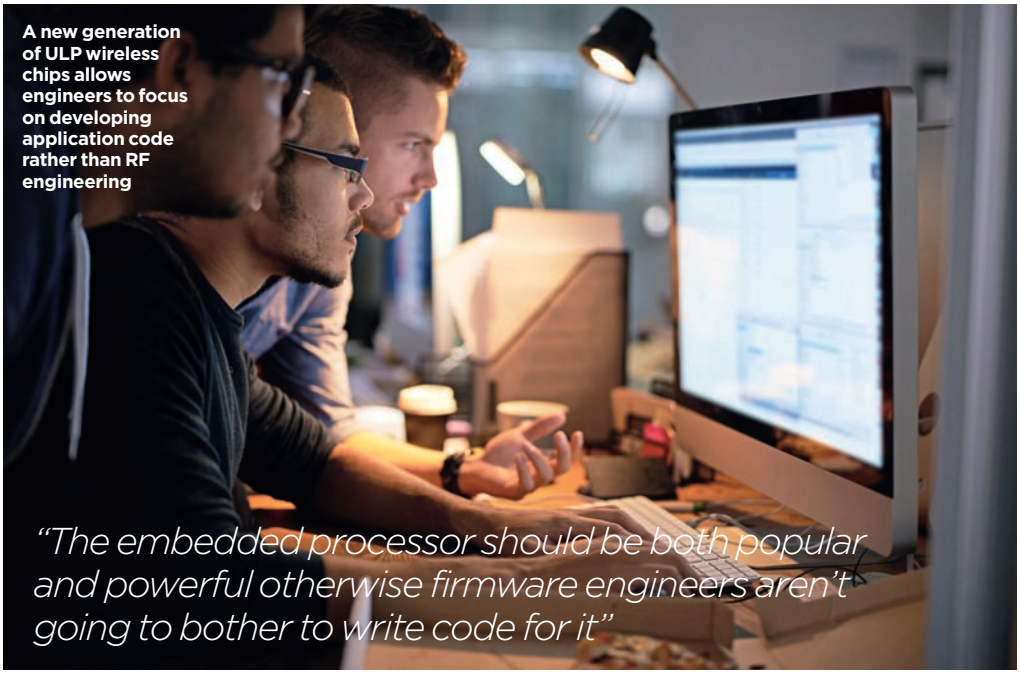
Complementing the SDK is a software set-up for emulating a headless router with support for IPv6 over Bluetooth Smart using a Raspberry Pi (Model B), a Bluetooth Smart Ready USB dongle, Raspbian GNU/Linux Kernel 3.17.4, and a radvd daemon. The combination of headless router set-up, nRF51-DK (*see ULP WQ Winter 2014 pg 8*), and the nRF51 IoT SDK provide developers with a complete platform for developing Bluetooth Smart-based IoT applications.

Rise of the software engineer

A not-so-subtle shift is underway in ultra low power wireless product development



By Thomas Embla Bonnerud, Director of Product Marketing, Nordic Semiconductor



A new generation of ULP wireless chips allows engineers to focus on developing application code rather than RF engineering

"The embedded processor should be both popular and powerful otherwise firmware engineers aren't going to bother to write code for it"

From amateurs working on a bench in their garage, to professionals in start-ups and blue chips alike, engineers are focusing more on what they can do with the latest generation of wireless chips and a little less on the RF engineering.

That's leading to a wave of innovation in products using wireless connectivity. These products include appcessories - wireless peripherals teamed with a smartphone app - and emerging "cloudcessories" - wireless peripherals that can communicate directly with the Cloud.

This change has come about for three key reasons: RF design has become easier, innovative chip architecture has simplified application development, and increasing availability of open source software for wireless chips has shortened design cycles.

Enlightening the black art

A decade ago, designing wireless circuitry was a "black art" performed by specialist engineers in darkened cubicles surrounded by stacks of test equipment. But ULP wireless chip vendors such as Nordic Semiconductor have worked hard to provide reference designs, evaluation kits, and online support that, while not making the process trivial, has opened up wireless design to non-expert RF engineers, including the amateurs of the maker community. (*See ULP Wireless Q Winter 2014, pg 16.*)

The launch of Nordic's nRF51 Series in June 2012 further eased the design process by introducing new software architecture that separated the complexities of the RF software protocol (the 'stack' which manages communication between wireless chips) and the application code (which customizes the wireless product to suit a particular application). Prior to the nRF51 Series, engineers had to deal with the challenging complexities of harmonizing the operation of both protocol and application. Now, the chip itself looks after this task allowing the engineer to focus solely on developing the application code.

By offering wireless Systems-on-Chip (SoCs) that use popular embedded processors such as ARM devices, supported by cheap and available toolchains that are independent of the wireless SoC maker, plenty of Flash memory, open standard stacks such as Bluetooth Smart, and easy-to-use Software Development Kits (SDKs) vendors like Nordic Semiconductor have ushered ULP wireless into the open source era. Engineers are able to share code, improve it, and make it available to their colleagues in the same way that their peers in the mainstream-computing world have been doing for years.

These three developments have lowered the barrier to entry for professional engineers and amateurs alike enabling the focus to switch to creativity.

That's not to say a wireless chip vendor can get away with half-baked hardware. For starters the manufacturer needs to ensure that the radio performs reliably and offers sufficient link budget while not rapidly draining batteries. Second, the embedded processor should be both popular and powerful otherwise firmware engineers aren't going to bother to write code for it. (If the device proves popular, then software rapidly proliferates, shortening development cycles and encouraging re-use of proven code.) And third, the chip should include sufficient Flash memory to support innovative applications and allow for consumer-friendly features such as over-the-air (OTA) software updates. (*See ULP WQ Winter 2014, pg 18.*)

With the advent of devices such as the nRF51 Series SoCs, such hardware is readily available to any company developing a wireless product. Open standard stacks like Bluetooth Smart are also available to all. That makes the application software the true differentiator between wireless products and accounts for the growing prominence of the software engineer over his hardware counterpart.

Recognizing this trend, Nordic has focused on making its chips the easiest on the market for application code development. Nordic has invested heavily in software development teams in Krakow, Poland, and Oulu, Finland to supplement the existing team in Norway. And the company is working hard to supply a range of SDKs such as the nRF51 Series IoT SDK. (*See page 8.*) Resources like the Nordic Development Zone also aid software development engineers working with our products. (*See page 14.*)

But don't make the mistake of thinking we don't care about hardware. Right now, Nordic engineers are sweating over wireless chip designs that will lead to Nordic products that consume less power and take up less space while at the same time offering more powerful processors, larger memory resources, and enhanced radios. But that's a story for another day.

(For more on open source software, see page page 16.)

The power of one percent

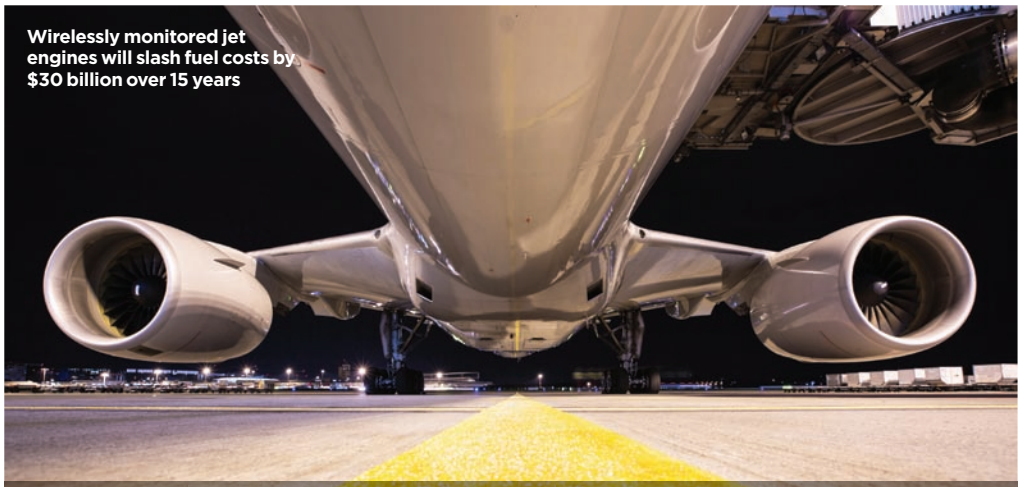
A wirelessly connected Internet will lead to massive economic gains. ULP Wireless Q reports

The Internet of Things (IoT) represents a lofty vision that will be realized by fusing the conventional Internet with the cellular network and adding a third layer of billions of wirelessly-connected 'things'. These things will comprise the objects we use everyday - washing machines, fridges, coffee machines and even more humble products like pens and spectacles - but instead of today's dumb products, that operate in glorious isolation, these things will be connected and 'smart'.

How will this make life easier? Imagine, for example, an umbrella equipped with a Bluetooth Smart chip connected through the household router to a Cloud server. That umbrella will be constantly fed information about the local weather. The owner looks outside and sees blue skies but the umbrella knows differently. As the umbrella's wireless chip detects the proximity of its owner's smartphone it sends a text message reading "take me, otherwise you're going to get wet!".

Examples of the IoT's promise such as this make fun reading but miss the bigger picture; the real power of the IoT will be realized in industrial applications. When he coined the phrase "the Internet of Things" back in 1999, Kevin Ashton got it exactly right when he said that if computers knew everything using data gathered automatically it would greatly reduce waste, loss, and cost.

But perhaps what Ashton didn't realize was precisely by how much.



Wirelessly monitored jet engines will slash fuel costs by $30 billion over 15 years

"The technical innovations of the industrial IoT could find direct application in sectors accounting for more than $32.3 trillion in economic activity"

Doing the math

Peter C. Evans and Marco Annunziata have attempted to calculate the savings an 'industrial' IoT will yield. Evans and Annunziata, employees with U.S-based industrial conglomerate General Electric, produced a report[1] which calculated cost saving achieved by connecting industrial assets to the Internet. The authors focused on GE's business sectors - aviation, power, health care, rail, and oil & gas - and considered the impact of embedding wireless sensors into the array of machines powering these sectors, from the very simple to the highly complex.

Huge amounts of data from embedded wireless sensors would be sent across the Internet to powerful Cloud servers that use sophisticated algorithms to determine, for example, how to tune a machine to enhance performance, and what a machine's state of wear is in order to intelligently decide when to perform maintenance and replace parts.

Evans and Annunziata estimated the economic significance of connected machines by calculating the savings gained from just a one percent efficiency improvement. For example, if wireless sensors were fitted to the three main rotating parts of each of the world's 43,000 commercial jet engines the efficiency gains in engine maintenance, fuel consumption, crew allocation, and scheduling would be huge. A one percent cut in fuel consumption across the global commercial aircraft fleet would slash costs by $30 billion over a 15-year period.

Likewise, a one percent efficiency improvement in the global gas-fired power plant capacity could yield a $66 billion saving in fuel consumption over 15 years. The global health care industry could also benefit from the industrial IoT, through a reduction in process inefficiencies: a one percent gain globally could yield more than $63 billion in savings. Freight moved across the world rail networks, if improved by one percent could yield another gain of $27 billion in fuel savings. Finally, noted Evans and Annunziata, a one percent improvement in capital utilization for oil & gas exploration and development could total $90 billion in avoided or deferred capital expenditures.

What's more, the industrial sectors to which wireless sensors can be applied extend far beyond GE's focus. The technical innovations of the industrial IoT could find direct application in sectors accounting for more than $32.3 trillion in economic activity, say Evans and Annunziata. As the economy grows, by 2025, IoT innovations could be applicable to $82 trillion of output or approximately one half of the global economy.

To encourage these technical innovations, there needs to be sound commercial incentives for companies to invest in the industrial IoT. While the conventional Internet was originally financed as a U.S. Department of Defense project, then as an academic and scientific tool, only later being made freely available for leveraging by commercial companies, the industrial IoT is unlikely to develop in the same way. The power of one percent is just the kind of commercial incentive that's needed. ■

[1] "*Industrial Internet: Pushing the Boundaries of Minds and Machines*," Peter C. Evans and Marco Annunziata, General Electric, November 2012.

ANT and the Internet of Things

New IoT technology from ANT allows adopters to create overlapping secure mesh networks that operate independently, but co-exist cleanly. Michael Rounding explains

Because the Internet of Things (IoT) is an emerging technology - a hot topic in the press, on crowdfunding websites, and in maker campaigns among others - commercial companies are designing new products with IoT applications in mind. ANT Wireless is no exception and is fostering a culture of innovation in this new wireless technology space.

Connecting devices across the IoT for control, monitoring or just plain fun involves getting devices to talk across low power multinode mesh networks. ANT Wireless offers an entire family of multinode solutions built on the ANT protocol. From simple mobile personal area networks (PANs) to large area multinode coverage, there is an ANT solution for the multinode problem facing any product.

At Mobile World Congress (MWC) 2015, held in Barcelona during March, ANT Wireless announced the latest addition to this family. The yet-to-be-named technology is a product enabler for the IoT and allows adopters to create overlapping secure mesh networks that operate independently, but co-exist cleanly.

Autonomous networks

The new technology uses ANT to create self-forming, -healing, and -managing networks that operate autonomously – no special network controller, hub or central master node is needed. All mesh network members are battery powered and have equal roles in this architecture; there is no significant difference in power consumption from one to the next, and any node can become a bridge to the outside world. Member nodes can be accessed individually or all at once, allowing for a scaled control experience.

The architecture supports roaming nodes, which join the main mesh to participate only periodically or on demand. Smartphones, remotes, and intermittent sensors checking in, are examples of roaming nodes. Roaming nodes can travel across the network as needed, moving their connection between main member nodes as they come in and out of range. A distinct advantage surfaces when two roaming nodes cross paths: each member node supports connections to multiple roaming nodes at once, allowing for a clean and predictable user experience. The transient nature of roaming nodes means that they can have incredibly low power requirements.

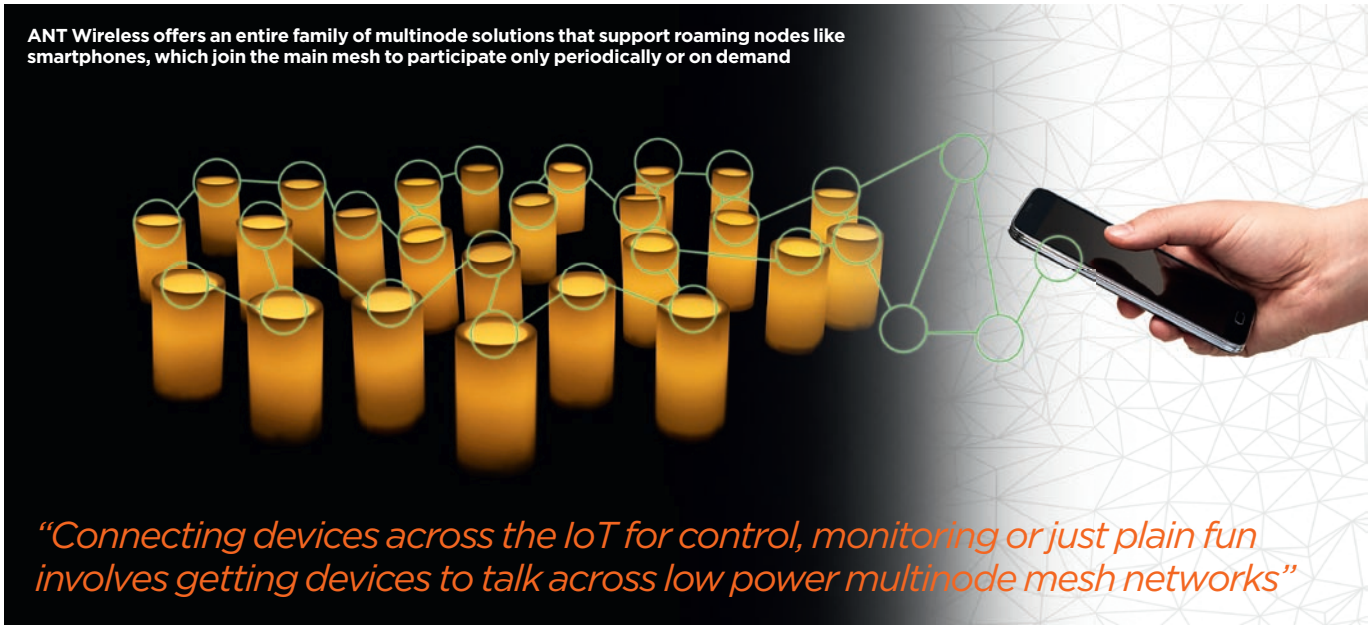
Other capabilities of ANT's new technology complete the toolset necessary for the creation of a great IoT solution. Member nodes can be updated over-the-air, on-the-fly, and can also be passively scanned to obtain in-the-moment network information. Tools like these not only aid in development but also can extend to supportability in end products. Imagine having a fully featured home-monitoring station that sets itself up by simply installing and running an app on a tablet!

ANT is an industry leader through its established protocol and silicon solutions for ULP practical wireless networking applications. The ANT software runs on 2.4-GHz wireless silicon such as Nordic Semiconductor's nRF51422 ANT chip and Dynastream's (ANT Wireless' parent) N548 module which is also built on the nRF51422.) Applicable in sport, wellness management, and home health monitoring, ANT+ (built on the base ANT protocol) defines device profiles that specify data formats, channel parameters, and network keys. There are over 100 million devices in the field using ANT+ to facilitate interoperability between sensor data. ■

Michael Rounding is Product Manager – ANT Wireless.

Visit www.thisisant.com/directory for a complete listing of ANT+ certified products, and www.thisisant.com for more information on multinode solutions.

ANT Wireless offers an entire family of multinode solutions that support roaming nodes like smartphones, which join the main mesh to participate only periodically or on demand



"Connecting devices across the IoT for control, monitoring or just plain fun involves getting devices to talk across low power multinode mesh networks"

Ultra low power wireless connectivity solutions

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

DATE: MARCH 2015

Product Line	Product Series RF: Radio Frequency "wireless"	ICs Integrated Circuits "chips"	Operating Band	Wireless Protocol	IC Type: SoC System-on-Chip	IC Type: Connectivity	IC Type: Transceiver	On-chip CPU	On-chip Memory OTP: One Time Programable	Oscillators	Peripherals: 2-Wire	Peripherals: ADC	Peripherals: AES	Peripherals: Analog Comparator	Peripherals: Battery Monitor	Peripherals: I2S	Peripherals: MDU	Peripherals: PWM	Peripherals: Real Time Clock	Peripherals: RNG	Peripherals: SPI	Peripherals: S/PDIF	Peripherals: Temperature Sensor	Peripherals: UART	Peripherals: USB	Applications: Appressories	Applications: PC Peripherals	Applications: Sports & Fitness	Applications: Gaming	Applications: Cellphone Accessories	Applications: Consumer Electronics	Applications: Automation	Applications: Healthcare	Applications: Toys	Applications: Wearables	Ref. Designs	Dev Tools	WLCSP Wafer-level chip-scale package option
2.4-GHz RF																																				
2.4 GHz	nRF24L	nRF24LE1	2.4GHz	Proprietary	●			8051	1kB + 256B RAM 16kB + 1.5kB Flash	16MHz / 32kHz Crystal 16MHz / 32kHz RC	●	●	●	●			●	●	●	●	●			●	●			●		●		●	●		●		PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit Prog. Kit	
		nRF24LE1 OTP	2.4GHz	Proprietary	●			8051	1kB + 256B RAM 16kB + 1kB OTP	16MHz / 32kHz Crystal 16MHz / 32kHz RC	●	●	●	●			●	●	●	●	●			●	●			●		●		●	●		●		PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit Prog. Kit	
		nRF24LU1+	2.4GHz	Proprietary	●			8051	2kB + 256B RAM 16/32kB Flash	16MHz Crystal			●				●				●			●	●			●		●		●	●		●		PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit Prog. Kit	
		nRF24LU1+ OTP	2.4GHz	Proprietary	●			8051	2kB + 256B RAM 16kB + 1kB OTP	16MHz Crystal			●				●				●			●	●			●		●		●	●		●		PC Desktop, Smart Remote, R/C Toy	nRFgo Dev Kit Prog. Kit	
		nRF24L01+	2.4GHz	Proprietary			●	–	–	16MHz Crystal											●							●		●			●			–	Eval Kit	
	nRF24 Audio Streamer	nRF2460 (mono)	2.4GHz	Proprietary		●		–	–	16MHz Crystal	●				●						●							●		●			●			Microphone	nRFgo Dev Kit	
		nRF24Z1 (stereo)	2.4GHz	Proprietary		●		–	–	16MHz Crystal	●				●						●	●						●		●			●			–	Eval Kit	
	nRF51	nRF51822	2.4GHz	Bluetooth v4.x & Proprietary	●			Cortex M0	32kB or 16kB RAM 128kB or 256kB Flash	16MHz / 32kHz Crystal 16MHz / 32kHz RC	●	●	●	●			●	●	●	●	●		●	●			●	●	●	●	●	●	●	●	●	●	PC Desktop, Smart Remote	Eval Kit, Dev Kit	●
Sub 1-GHz RF																																				
Sub 1-GHz	nRF900 Multiband	nRF9E5	433 / 868 915MHz	Proprietary	●			8051	4kB + 256B RAM	4 / 8 / 12 / 16 / 20MHz Crystal		●					●	●		●			●								●					–	Eval Kit	
		nRF905	433 / 868 915MHz	Proprietary			●	–	–	4 / 8 / 12 / 16 / 20MHz Crystal											●										●					–	Eval Kit	
Bluetooth Smart																																				
	nRF8000	nRF8001	2.4GHz	Bluetooth v4.x		●		–	–	16MHz / 32kHz Crystal 32kHz RC											●		●					●	●	●	●	●	●	●	●		PC Desktop, Smart Remote, Smartphone Demo Apps	nRFgo Dev Kit Prog. Kit	
		nRF8002	2.4GHz	Bluetooth v4.x	●			–	–	16MHz Crystal 32kHz RC					●																●					Key Tag, Smartphone Demo Apps	nRFgo Dev Kit Prog. Kit	
	nRF51	nRF51822	2.4GHz	Bluetooth v4.x & Proprietary	●			Cortex M0	32kB or 16kB RAM 128kB or 256kB Flash	16MHz / 32kHz Crystal 16MHz / 32kHz RC	●	●	●	●			●	●	●	●	●		●	●			●	●	●	●	●	●	●	●	●	●	PC Desktop, Smart Remote, Smartphone Demo Apps	Eval Kit, Dev Kit	●
		nRF51422	2.4GHz	Bluetooth v4.x & ANT	●			Cortex M0	32kB or 16kB RAM 128kB or 256kB Flash	16MHz / 32kHz Crystal 16MHz / 32kHz RC	●	●	●	●			●	●	●	●	●		●	●			●	●	●	●	●	●	●	●	●	●	Smartphone Demo Apps	Eval Kit, Dev Kit	●
ANT																																				
ANT+	nRF24AP2	nRF24AP2-1CH	2.4GHz	ANT		●		–	–	16MHz / 32kHz Crystal											●		●					●		●		●	●				Smartphone Demo Apps	ANT Dev Kit	
		nRF24AP2-8CH	2.4GHz	ANT		●		–	–	16MHz / 32kHz Crystal											●		●					●		●		●	●				Smartphone Demo Apps	ANT Dev Kit	
		nRF24AP2-USB	2.4GHz	ANT		●		–	–	16MHz Crystal																		●		●		●	●				ANT USB Dongle	ANT Dev Kit	
	nRF51	nRF51422	2.4GHz	Bluetooth v4.x & ANT	●			Cortex M0	32kB or 16kB RAM 128kB or 256kB Flash	16MHz / 32kHz Crystal 16MHz / 32kHz RC	●	●	●	●			●	●	●	●	●		●	●			●	●	●	●	●	●	●	●	●	●	Smartphone Demo Apps	Eval Kit, Dev Kit	●

www.nordicsemi.com

IPv6 coffee, Bluetooth Smart first steps, PCB tips and more

Nordic's Developer Zone is buzzing with discussion about chips, software, design tips, and more from the ULP wireless world. ULP Wireless Q highlights what's trending

Since its launch in June 2013, Nordic's Developer Zone has fielded over 6000 questions and picked up a huge following of engineers, hackers, students and just about anyone who's interested in the company's products and how best to use them in ULP wireless applications. If you haven't yet had time to check out the site, we've selected some of the most popular threads to whet the appetite. But this is just a tiny sample of what's trending on the "devzone"; to keep right up to date, head over to devzone.nordicsemi.com now.

Best of the Blogs

IPv6-brewed coffee over Bluetooth Smart – *Glenn Ruben Bakke*

We wanted to demonstrate the exciting possibilities that IPv6 over Bluetooth Smart enables and we wanted to show that by doing something practical. What better way than brewing coffee over IPv6? – not only demonstrating a connected appliance that can be controlled and monitored from the Internet, but also getting a nice cup of coffee at the end of it.

The coffee machine, being IP enabled, has its own IPv6 address which means it is directly addressable from the Internet. Also, native support IP protocols allow the coffee machine and the cloud application to use the same protocol without any need of proxy or translations. The application protocol used in this demo is MQTT, a TCP based protocol.

In this demo you can request a brew through the web interface. You can also see if the coffee machine is brewing or idle, the number of cups brewed etc. – all examples of monitoring a remote appliance.

For more from Glen, go to https://devzone.nordicsemi.com/blogs/658/ipv6-brewed-coffee-over-bluetooth-smart/

Ordering coffee over a web interface is now possible with Nordic's IPv6 over Bluetooth Smart

General PCB design guidelines for nRF51 – *Kristin* (Nordic Employee)

In RF, things work differently than in 'regular' electronics, due to high frequencies (and short wavelengths). One of the resulting effects is that the phase of a signal will vary along the transmissions lines, as opposed to low frequencies where the wavelengths are much larger than transmission lines, and this effect can be disregarded. If the system (chip and antenna) is not matched, there will be reflections of the signal in the transmission line, resulting in loss. The system can be matched using a 50 Ohm reference point; matching the chip and the antenna to 50 Ohm.

The RF part of the schematic and layout should be a copy of our reference design. It means that not only the component values, but also the geometry, relative placement of the components with respect to each other, and the lengths of the transmission lines should be the same as in our reference design. The reference design for both nRF51822 QFN and WLCSP package can be downloaded from the nRF51822 webpage.

For more from Kristin, go to https://devzone.nordicsemi.com/blogs/655/general-pcb-design-guidelines-for-nrf51/

Baby steps with Bluetooth Smart – *David Edwin* (Nordic Employee)

Are you looking to make your first steps with Bluetooth Smart? Are you looking for hands-on help to get started with Bluetooth Smart? Playing could be the best form of learning and it's time to play.

The Bluetooth SIG has created the Bluetooth Smart starter kit that allows you to quickly get started on BTLE (Bluetooth low energy).

The kit includes the source code (for the Arduino and the phone i.e. iOS, Android, Blackberry, and Windows 8.1) and also has the list of hardware to purchase to start using the kit. The required hardware includes a Redbearlab BTLE shield and an Arduino or compatible board.

This is a great way to get started on BTLE, and gets you ready to play. You can play only after you know the rules and the starter kit helps to understand the rules of BTLE so you can quickly start playing.

For more from David, go to https://devzone.nordicsemi.com/blogs/489/baby-steps-with-bluetooth-smart/

Top-trending questions

'Guest' asked: **"How can I calculate the maximum throughput for an application running on the nRF51822 and the S110, when connecting to different kinds of Central devices?"**

Ole Morten from Nordic answered: There are primarily 3

NORDIC DEVELOPER ZONE
ask questions, share info, and be inspired!

factors that determine maximum throughput with BLE: operation type, connection interval, and number of packets transmitted per connection event.

For high-throughput applications, you should make sure to use either Write Commands (Write without response) or Notification. In each such Write Command or Notification, you can have 20 Byte data. Given a number of packets per interval, n, and a connection interval, T, the maximum throughput can be calculated from n x 20 Byte x 1/T.
For Ole's full answer go to https://devzone.nordicsemi.com/question/3440/how-do-i-calculate-throughput-for-a-ble-link/

'Guest' asked: **"When working with Bluetooth low energy, one sees a lot of different names for roles, which is confusing. What is actually the difference between them all, master, slave, central, peripheral, client, server and so on?"**
Ole Morten from Nordic answered: No wonder you are confused, but there are two different kind of roles in BLE that it's useful to separate.

NORDIC DEVELOPER ZONE

ask questions, share info, and be inspired!

First, there is the concept of Central/Peripheral, which has to do with establishing a link. A Peripheral can advertise, to let other devices know that it's there, but it is only a Central that can actually send a connection request to establish a connection. When a link has been established, the Central is sometimes called a Master, while the Peripheral could be called a Slave.

The Core Specification also defines the roles of an Observer and a Broadcaster. These are basically just non-connecting variants of the Central and Peripheral, in other words devices that just listen for advertisement packages (and possibly send scan responses) or just sends such packages, without ever entering a connection.
For Ole's full answer go to https://devzone.nordicsemi.com/question/232/what-is-a-client-and-server-in-ble/

'Guest' asked: **"What's the difference between nRF51822 Evaluation and Development Kits?"**
Ole Morten from Nordic answered: The difference is primarily that the Development Kit is made to be used with the nRFgo Starter Kit, while the Evaluation Kit is a standalone kit.

With the Development Kit, you get two different modules that fit on the nRFgo Starter Kit, one with a PCB antenna and one with an SMA connector. The motherboard from the nRFgo Starter Kit is then used to provide power and I/O access.

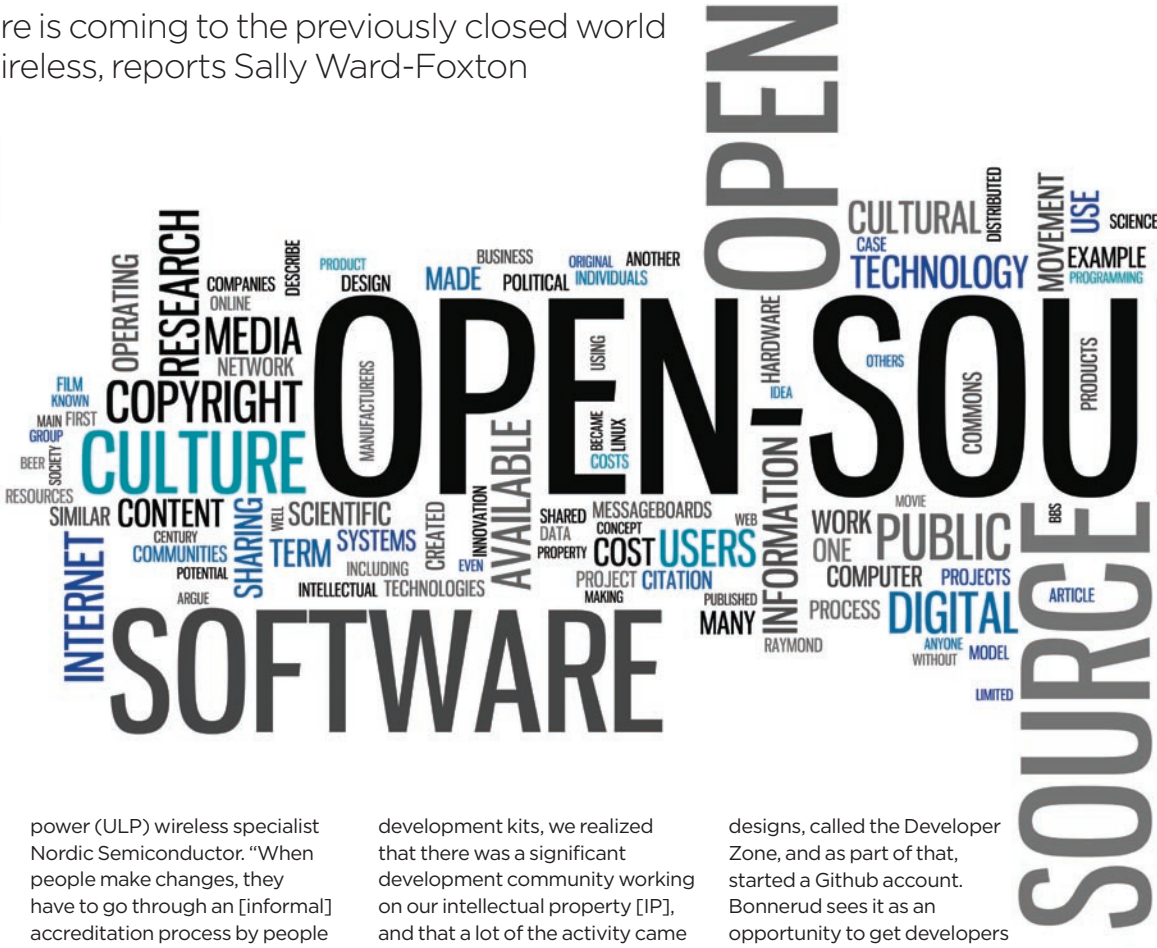
The Development Kit also includes an nRF51 Development USB dongle, which is a small dongle with a Segger programmer chip and an nRF51822 chip. This is used, for example, as the dongle for the Master Control Panel.

With the Evaluation Kit on the other hand, you get this same dongle and just one other board, the Evaluation Kit itself. The Evaluation Kit board is a stand-alone board that includes an on-board Segger programmer and has two buttons/LEDs. The Segger chip also provides a virtual serial port that can be used to talk to the nRF51822 from the PC. Most importantly, the Evaluation Kit does not come with a separate programmer that can be used to program custom boards.
For Ole's full answer go to https://devzone.nordicsemi.com/question/609/whats-the-difference-between-nrf51822-evaluation-and-development-kits/

Opening the doors

Open source software is coming to the previously closed world of ultra low power wireless, reports Sally Ward-Foxton

Sally Ward-Foxton is a freelance journalist specializing in electronics



Open source, or the concept of users of software collaborating to improve it, has gone from strength to strength in recent years. And the concept seems to work. Since the inception of the open source operating system Linux in the early 1990s, it has come to be regarded as one of the most stable operating systems out there, and is used in web servers across the world as well as many mainframes and supercomputers. A better example of the open source model would be hard to find; the Linux kernel is also the basis for Google's Android operating system.

Today, a proliferation of versions of Linux for different applications exists, and a vast community collaborates to fix bugs, add new features, and test the different versions. Following Linux's example, the base of open source software available has grown at a rapid pace and today community development sites like Github.com offer a wide range of software for all kinds of applications. The site makes it easy for developers to build things together by providing a mechanism for sharing code libraries and evaluating code that has been produced by members.

But with so many developers of different skill levels working on any one project, how is quality maintained and what happens if the work someone produces isn't up to the right standard?

"What you tend to find is that it self-polices. People give credit or criticism to any new copies of the original code," says John Leonard, Tactical Marketing Manager with 2.4 GHz ultra low power (ULP) wireless specialist Nordic Semiconductor. "When people make changes, they have to go through an [informal] accreditation process by people who are members of that Github account. So you don't just spawn thousands of really lousy copies; they sit in limbo for a bit until people agree the changes have improved things, and then [the software] becomes a new fork of that library."

New to wireless

Despite the success of the open source movement in many applications and markets, it's a new idea for the traditionally conservative ULP wireless sector.

"Traditionally we had the 'industry-standard' formal control on allowing access to our software and development kits," explains Thomas Embla Bonnerud, Director of Product Management at Nordic. "But once we started to ship a significant number of Bluetooth Smart development kits, we realized that there was a significant development community working on our intellectual property [IP], and that a lot of the activity came from non-traditional customers like innovative start-ups.

"We came to a point where there were enough developers working on our stuff that they started to share code, despite our 'closed door' license agreement," he says. "The community had already built an entire OSX toolchain for our IP and shared it. We made the decision that this was not something we wanted to stop, rather something we wanted to encourage and drive further."

Today, Nordic has removed a lot of the barriers to getting hold of its technical documentation and software. Some software can even be downloaded without a non-disclosure agreement (NDA) and even without registration. The company opened a forum for developers to offer support to those working on Nordic-based designs, called the Developer Zone, and as part of that, started a Github account. Bonnerud sees it as an opportunity to get developers to contribute – if they find a bug, for example, they fix it and share it. Some of the first code libraries to be shared include software for microcontrollers used in combination with Nordic's nRF8001 Bluetooth Smart connectivity chips. Today, developers have modified this code to run on microcontrollers from Atmel, Microchip, TI and other chips and shared it for fellow engineers to use too.

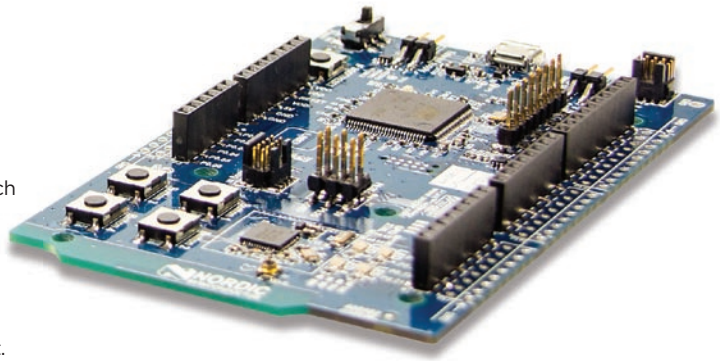
"We know that the majority of investment that our customers make in our chips is actually software, and a lot of the innovative software developers grew up with open source, so they know that model, they trust it, they like it," Bonnerud says. "They co-operate across companies to such a degree that you might be surprised to see

how much code they actually share, even between start-up companies that are competing with each other."

Cautious Approach

Despite open source gaining such momentum over many years, some major wireless System-on-Chip (SoC) manufacturers keep even basic information about their products, like data sheets, a closely-guarded secret.

Bonnerud's view is that their culture and mindset naturally prevents these larger companies from making the step to a more open approach, whereas younger, more dynamic companies such as Nordic are able to make strategic decisions like this a lot more easily because it takes the agreement of only a few key personnel.



A significant development community is working on Nordic's intellectual property through the company's software development kits

Aside from company cultures though, there are other factors at play. The tens of thousands of developers working on applications based on Nordic's devices and kits is in direct contrast with the big players, who tend to be focused on a smaller number of key accounts. A large number of developers is needed to make up an effective community so the momentum Nordic has built for its technology, combined with momentum from the uptake of Bluetooth Smart in Internet of Things (IoT) applications, really lends itself to the open-source approach.

"I do think you will see others follow [Nordic's approach]," Bonnerud continues. "What we are talking about is very normal in other industries; if you look at Microsoft, a lot of its Cloud technology is actually open-source technology. It is an established concept in many different fields."

Of course, with any strategic decision like this, there are pros and cons to be carefully considered. The value of opening up some of Nordic's code to the community must be balanced against any potential risks. For example, what happens if some unscrupulous company takes Nordic's code and without breaching any license, ports it to a device that directly competes with Nordic's own product?

"If they really want to copy our code, they are going to do that anyway," Bonnerud says. "What we'd be doing [by keeping the closed license] is creating problems for our users and trying to protect against something we can't really protect against anyway."

Nonetheless, some careful management is required on Nordic's part. The company must make sure it engages actively enough with the community so that it remains the key maintainer for all of its open source software development kits (SDKs). The idea is to test future versions of the SDKs that involve community contributions so that Nordic can guarantee the quality and approve them for production use. If this doesn't happen proactively, the community may 'fork' the SDK; this means an improved version may exist that doesn't have Nordic's stamp of approval, leading to confusion. Commitment to following through and serving the community in the right way is therefore required.

Ultimately, Nordic's view is that the pros of working with the open source community outweigh the cons, since making developers' lives easier is a good way to get them on side.

"In the traditional semiconductor world, you sell [your product] to the customer's purchasing officer and he or she 'forces' their developers to use your IC, because it fits the purchaser's parameters [such as cost and availability]," says Bonnerud. "But these days you see that more and more developers are the key component selection decision makers and they will have a tendency to pick the things they like to work on. Lowering the [technical] barrier, making things easily available, open sourcing, these are the kind of things that today's developers really care about." ■

At a glance

- **A large community is collaborating on ultra low power wireless applications**
- **Nordic has made some of its code libraries and SDKs available to the open-source community**
- **Software developers are increasingly becoming key decision makers on components in their companies**

How IPv6 will widen the scope of the Internet of Things

Within five years, up to 30 billion devices, each requiring its own IP address, will be connected to the Internet. Caroline Hayes explores the implications

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

The Internet of Things (IoT) offers a myriad of opportunities, possibly only restricted by the inventiveness of the OEM. For example, smart cities will rely on the IoT to advise where traffic congestion is lightest, to re-route vehicles, or where and when utilities are required, and the most cost-efficient times to use them.

Wireless sensors at the edge of the IoT will monitor factory equipment and conditions for optimum performance. In the home, these sensors will communicate with lighting and heating systems, via the Internet, to initiate operation when needed. Even domestic appliances will be able to communicate to advise of when a service is due, sending an alert to the owner's smartphone to book a service. Other opportunities are in health care and fitness, for example sending data to the Internet to track blood glucose levels, heart rate or other vital signs. And IoT beacons will provide contextual information and inform a shopper which stores are close by, and which are holding a sale at the moment.

But if the IoT is to reach this potential, the wireless sensors on its fringes will need to be unobtrusive, reliable, and low maintenance. Bluetooth Smart is an ideal technology for IoT sensor applications because it is purpose designed for frequent transmission of sensor data while consuming very little power – extending battery life and lowering maintenance overheads. (*See box "A tale of two technologies" on page 19.*)

Smart cities will rely on the IoT to run more efficiently

Bluetooth Smart technology's ultra low power operation allows months, or even years, of uninterrupted operation from small batteries, and the technology benefits from an established, open standard, underwriting interoperability. Bluetooth Smart saves power by sending packets of data quickly (raw data transfer speed is 1Mbps) and then returning quickly to a sleep state. It is also a secure technology with full AES-128 encryption using the CCM (counter with cipher block chaining message authentication code, or CBC-MAC) authenticated encryption algorithm for confidentiality and authentication. (This is important, as data sent over the air must be secure – you don't want your neighbor knowing your blood pressure readings, for example!)

Bluetooth Smart also benefits from a large ecosystem of Bluetooth Smart Ready devices, such as smartphones. There were 1.3 billion Bluetooth Smart devices in 2013, a figure expected to grow to 3.3 billion by 2016. These devices can be leveraged to relay information from Bluetooth Smart sensors to the Internet; no competing technology can boast this level of support.

However, while using the resources of a smartphone, tablet, PC or dedicated Bluetooth-to-Internet hub to connect a sensor to the Internet is a good way to experiment with the IoT, it's impractical in the long term because it would be far too expensive to use such devices to route traffic from the billions of sensors that could eventually make up the network.

The Bluetooth Special Interest Group (SIG) has addressed this challenge, with Bluetooth Version 4.2 (v4.2).

Optimized for IoT

This latest version of Bluetooth technology (released in December 2014) enhances the technology for IoT use with capabilities such as the ability to detect, access, and control any Bluetooth Smart device over the Internet, using standard Hypertext Transfer Protocol (HTTP). This allows a mobile application or web browser to review the status of Bluetooth Smart devices remotely, using an Internet connection.

The latest Bluetooth Core Specification also provides for Bluetooth Smart devices to be able to connect and communicate with standard web servers, using a Generic Attribute Profile (GATT) service, called the HTTP Proxy Service – or HPS.

But perhaps the most important enhancement of Bluetooth v4.2 is its support for Internet Protocol version 6 (IPv6). Using the Internet Protocol Support Profile (IPSP) the Bluetooth Smart device can be allocated an IPv6 address and use the protocol to communicate with other IPv6 sensors or other devices directly.

IoT-connected wireless sensors will improve the efficiency of escalator maintenance, cutting costs

At a glance

- IPv6 will provide 340 undecillion IP addresses, plenty enough for every 'thing' to have its own IP address
- Bluetooth v4.2 supports IPv6, taking Bluetooth Smart from a smartphone-centric structure to end-to-end communications
- Development tools allow developers to experiment with IPv6 over Bluetooth Smart as part of a heterogeneous network

"I believe that the [existing] Internet will not adapt to the IoT, but that the IoT will be an extension of the Internet as we know it today"

"IPv6 over Bluetooth Smart" capability eliminates the need for an expensive router (however, because Bluetooth Smart is a short-range technology, sensors might require the use of an inexpensive 'headless' router to relay packets to the Internet).

Currently, the majority of devices, smartphones, computers, games consoles and other devices use IPv4 to communicate over the Internet. Unfortunately, the 4.3 billion IP addresses generated by IPv4's 32-bit address scheme are fast being exhausted. (In February 2011, the last block of 16 million IPv4 addresses was allocated to regional registers.)

IPv6 uses a 128-bit address scheme which generates 3.4 x 10^{38} (or 340 undecillion) addresses. The address format is hexadecimal and separated by colons (for example, "2015:9ce8:0011:ae3g:5f6a:6742:b21c:0eg6"), whereas IPv4 is decimal, formatted as four numbers, from 0 to 250, and separated by a full stop (for example, "192.168.0.3"). The longer addresses simplify address allocation and make routing more efficient.

Another progression is that the IPv6 specification uses multicasting to transmit a packet to multiple destinations in a single, send operation. This feature is optional in IPv4.

Untethered access

For Thomas Embla Bonnerud, Director Product Management at Nordic Semiconductor, IPv6 presents an exciting opportunity. "It means you can connect a device to the Internet and talk to a Cloud service or a web service all the time – not just when a smartphone is active," he says. "IPv6 for Bluetooth Smart can use a headless router bringing end-to-end communications between the 'thing' and the Cloud service." This extends the reach of Bluetooth to what Bonnerud describes as the bigger IoT around us all. "Now we can take Bluetooth Smart from being smartphone-centric to a wider range of applications," he enthuses, contrasting it with one view of the IoT comprising Bluetooth Smart devices and proprietary mesh solutions.

"I believe that the [existing] Internet will not adapt to the IoT, but that the IoT will be an extension of the Internet as we know it today," says Bonnerud. For this to happen, he insists that there is no place for proprietary technology: "There has to be open standards based on IP."

The key technical challenge is to integrate a complete IP software stack into the wireless System-on-Chip (SoC) powering the connected thing. Such a stack must comprise IP, Constrained Application Protocol (CoAp) and Message Queue Telemetry Transport (MQTT), in addition to the SoC's Bluetooth Smart stack and application code. Only with a compatible, capable SoC and optimized software will vendors be able to run end-to-end IP and eliminate the expensive router or gateway. "It is the software that will allow for adaptability," says Bonnerud.

Nordic Semiconductor has addressed this challenge with the released of a Software Development Kit (SDK) for IoT applications using IPv6 over Bluetooth Smart. The SDK is based on the company's nRF51 Series SoCs and is Arduino and Raspberry Pi-compatible (allowing these inexpensive computing devices to be used as headless routers). The SDK allows developers to experiment with nRF51 Series Bluetooth Smart devices talking directly to other Bluetooth Smart sensors as part of a heterogeneous IP network.

For Bonnerud, the introduction of an SDK that allows developers to play with IPv6 over Bluetooth Smart is an important step: "The main driver for the IoT is the interaction between the Cloud and the device," he says, citing the contemporary example of wearables, where a Cloud service makes, for example, a fitness tracker smarter, by analyzing statistics and intelligently presenting trends.

This interaction promises even bigger opportunities. One of Bonnerud's favorite examples is escalator monitoring whereby IoT sensors constantly report temperature and vibration allowing a Cloud server to trigger maintenance based on the actual state of the moving stairway rather than a calendar flagging periodic overhauls.

"IPv6 over Bluetooth Smart will move the Internet from a human-centric network to a 'thing' dominated one," concludes Bonnerud. "And once that happens, we'll be very pleased we've got the freedom of an inexhaustible addressing scheme."

A tale of two technologies

From the release of Bluetooth Core Specification version 4.0 ("Bluetooth v4.0") the technology split into two interoperable variants: Bluetooth Smart and Bluetooth Smart Ready. Bluetooth Smart (previously known as Bluetooth low energy) is an ultra low power form designed for wireless devices with limited power resources (such as IoT sensors). Bluetooth Smart Ready is the successor of the familiar technology used in cellphones, smartphones, and PCs, and offers higher bandwidth at the expense of power consumption. Bluetooth Smart chips can communicate with Bluetooth Smart Ready chips but not previous versions of the technology; Bluetooth Smart Ready can communicate with all Bluetooth chips, including legacy devices.

Book excerpt: 'Getting Started with Bluetooth Low Energy'

The second excerpt from a new book on the fundamentals of Bluetooth Low Energy / Bluetooth Smart wireless technology looks at the technology's throughput and range

The modulation rate of the Bluetooth Low Energy (BLE) radio is set by the specification at a constant 1Mbps. This sets the theoretical upper limit for the throughput that BLE can provide, but in actual terms, this limit is typically lowered significantly by a variety of factors, including but not restricted to bidirectional traffic, protocol overhead, CPU and radio limitations, and artificial software restrictions.

To illustrate some of these practical restrictions, consider the following basic preconditions we'll use for a calculation: A central (master) device has initiated and established a connection with a peripheral (slave) accessory; while in an active connection, the specification defines the connection interval to be the interval between two consecutive connection events (a data exchange before going back to an idle state to save power), and this connection interval can be set to a value between 7.5 ms and 4 s.

For this example, we'll use the nRF51822, a widely available SoC (system on chip) BLE IC manufactured by Nordic Semiconductor. Nordic's radio hardware and BLE stack impose the following data throughput limitations: The nRF51822 can transmit up to six data packets per connection interval (limited by the IC); each outgoing data packet can contain up to 20 bytes of user data (set by the specification unless higher packet sizes are negotiated).

Assuming the shortest connection interval (the frequency at which the master and the slave exchange packets) of 7.5 ms, this provides a maximum of 133 connection events (a single packet exchange between the two peers) per second and 120 bytes per connection event (6 packets * 20 user bytes per packet). Continuously transmitting at the maximum data rate of the nRF51822 would suggest the following real-world calculation:

133 connection events per second * 120 bytes = 15960 bytes/s or ~0.125Mbit/s (~125kbit/s)

That's already significantly lower than the theoretical maximum of BLE, but the peer device you are pushing data to (typically a smart device such as a smartphone or a tablet) can add further limitations.

Your smartphone or tablet might also be busy talking to other devices, and vendor-implemented BLE stacks inevitably have their own limitations, which means the central device might not actually be able to handle data at the maximum data rate either. And because of multiple other factors, the actual connection interval might be spread out further or more irregularly than you had originally planned.

So, in practice, a typical best-case scenario should probably assume a potential maximum data throughput in the neighborhood of 5-10 kbytes per second, depending on the limitations of both peers. (*See box "Racing to Idle".*) This should give you an idea of what you can and can't do with Bluetooth Low Energy in terms of pushing data out to your phone or tablet and explain why other technologies such as Wi-Fi and classic Bluetooth still have their place in the world.

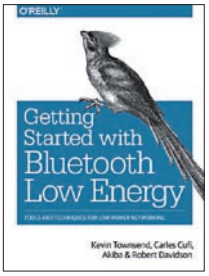
Operating range

The actual range of any wireless device depends on a wide variety of factors (operating environment, antenna design, enclosure, device orientation, etc.) but Bluetooth Low Energy is unsurprisingly focused on very short-range communication.

Transmit power (typically measured in dBm) is usually configurable over a certain range (usually between -30 and 0 dBm), but the higher the transmit power (better range), the more demands are placed on the battery, reducing the usable lifetime of the battery cell(s).

It's possible to create and configure a BLE device that can reliably transmit data 30 meters or more line-of-sight, but a typical operating range is probably closer to 2 to 5 meters, with a conscious effort to reduce the range and save battery life without the transmission distance becoming a nuisance to the end user. ■

*This is the second in a series of extracts from "*Getting Started with Bluetooth Low Energy*" by Kevin Townsend, Carles Cufí, Akiba, and Robert Davidson and is reproduced with permission of the book's publishers O'Reilly (www.oreilly.com). Copies of the book are available from http://shop.oreilly.com/product/0636920033011.do, as well as from Amazon. Co-author Carles Cufí is a Senior Software Engineer with Nordic Semiconductor.*



Racing to Idle

In a world where things usually get faster with time, 10 kbytes per second might seem slow and counterproductive, but it does highlight the primary design goal of Bluetooth Low Energy: low energy! Even transmitting at these relatively modest data rates, 10 kbytes per second will quickly drain any small coin cell battery, and the Bluetooth SIG made a clear, conscious effort not to design yet another generic wireless protocol and slap the label "low power" on it. Instead, they wanted to design the lowest power protocol possible, optimizing in every way possible to achieve that goal. The easiest way to avoid consuming precious battery power is to turn the radio off as often as possible and for as long as possible, and that is achieved by using short burst of packets (during a connection event) at a certain frequency (determined by the connection interval). In between those, the radio is simply powered off.

This means low amounts of data transmitted in short bursts, with connection intervals spread as far apart as possible to save battery life. The user-selectable 7.5 ms–4 s connection interval offers a sufficiently wide window to allow product designers to make the right tradeoff between responsiveness (a short connection interval) and battery life (a longer connection interval), without straying too far from the narrow design goals behind BLE.

Magellan Echo Smart Watch

A few years ago smartphones looked to be driving the digital watch market into terminal decline. Fast forward to 2013, and with 3.1 million smartwatch units sold and a market size of $700 million, according to analyst Smartwatch Group, the watch is making a comeback, and smart sportswatches like the Magellan Echo are leading the charge

Recent research from the University of Birmingham in the U.K. found that a person's internal 'body clock' can affect sporting performance by as much as 26 percent, depending on the time of day an activity is undertaken and whether they consider themselves an early riser or a 'night owl'. According to the research, early risers reach their athletic peak around lunchtime, while night owls are best around eight in the evening.

The Pulsar NL C01 is generally acknowledged as being the world's first 'smartwatch'. Released by Seiko in 1982 the NL C01 sold for $3995 or $10,295 adjusted for inflation in 2015. Early adopters didn't get a lot for their money, the watch's only smart function was the ability to store 24 digits in its user-programmable memory. A year later Seiko released the Data 2000 watch which came with an external keyboard for data entry and the capability to store 2000 characters. In contrast, the Magellan Echo sports smartphone connectivity, runs for months from a coin cell battery, displays real time data from sports apps on a high resolution display, and can receive firmware updates over the air, all for $149.99.

The Magellan Echo uses Nordic Semiconductor's μBlue™ nRF8001 chip to provide Bluetooth Smart connectivity. The chip's ultra-low power (ULP) operating characteristics help the Magellan Echo to be powered by a single CR2032 coin cell battery. This supports a traditional lightweight (44 gram) sportswatch form-factor while leveraging Bluetooth Smart wireless technology to connect to the latest smartphone sports apps and GPS functionality.

The Magellan Echo smart sports watch is designed for both professional and weekend athletes, allowing them to control compatible smartphone apps from their wrist as well as remotely controlling common smartphone functions such as music replay. The smartwatch can function as an everyday watch while also offering specialized app support for golf, skiing, hiking, running, and other outdoor activities, creating a personalized data set so the user can analyze their performance over time.

Magellan Echo Smart Watch

This sports watch can stream smartphone sports app data for up to 11 months

Meeting the challenge of the IoT

John Leonard discusses the future of the Internet of Things with EETimes China

John Leonard is Tactical Marketing Manager with Nordic Semiconductor

EETimes China: What opportunities does the Internet of Things (IoT) present to semiconductor companies?

John Leonard: The opportunities for semiconductor companies are numerous and occur all the way up the value chain. For example, the IoT will provide a much better way of interfacing the physical world with the digital one by using wireless sensors to measure, record, and transmit information about their local environment. Technologies such as Bluetooth Smart will power many of these wireless sensors. But this is just one example of an IoT opportunity, others include Wi-Fi hubs to connect sensors that aren't equipped with Internet Protocol (IP) software to the Internet and Cloud-based servers to process data from sensors and use the information to generate value.

EETC: What challenges does the IoT bring?

JL: The key activity right now is at either end of the chain. One end is formed by the back-end integration that needs to ensure services can communicate seamlessly and that applications can access these services. At the other end of the IoT, the challenge is to handle the huge volume of information passing from and to compact wireless sensors. A notable enhancement to the latest version (v4.2) of Bluetooth technology, for example, facilitates IP-connected operation (leading to wireless sensors which can directly communicate across the Internet). Such functionality will become increasingly important as the number of sensors proliferates into sectors such as wearables, toys, health-care products, and domestic appliances.

The IoT will bring many opportunities to semiconductor companies

EETC: What product solutions does Nordic provide for the IoT sector?

JL: Nordic's nRF51 Series Systems-on-Chip (SoCs) are an ideal solution for the endpoints of the IoT. Not only do the devices support Bluetooth Smart, but also ANT+ (RF protocol software from Dynastream Innovations, a long time Nordic Semiconductor design partner) and Nordic's own proprietary 2.4-GHz protocol. Nordic's nRF51 Series SoCs combine a powerful 32-bit ARM Cortex-M0, multiprotocol 2.4-GHz radio, and flash memory on a single chip. The ARM processor is easily able to handle any application software as well as looking after the wireless protocol.

Nordic chips bring together IoT connectivity with the computational power to run applications on a single device. The company's chips are specifically designed to be extremely power efficient and the nRF51 Series' unique software architecture makes it easy to develop applications quickly with minimum risk because the application code and protocol software are cleanly separated. Among other benefits, this arrangement makes it easier for engineers to re-use application code from previous product iterations rather than starting development from scratch each time.

EETC: What's the largest bottleneck in rolling out the IoT?

JL: Wide-ranging discussions about how the IoT will operate have been going on for a long time and will likely carry on for many years. There is no single issue that is preventing progress, just decisions to be taken about how the IoT as a whole will work. At this stage, IPv6 traffic is pretty much a given as the preferred protocol for transportation of data across the IoT in the same way that IPv4 has been used for HTTP traffic. At the endpoints of wireless networks, data will flow using several types of physical layers (PHY) such as Bluetooth Smart, Wi-Fi or 802.15.4. Much of today's work is focused on making sure IPv6 runs smoothly over these different technologies.

EETC: What is Nordic's roadmap for IoT products?

JL: Nordic has always focused on connecting "things-to-things" – long before the IoT was a hot topic. For example, in 2003, Nordic was the first company to use ULP wireless technology to connect things-to-things (for example, a Sunnto sportswatch to a heart rate monitor) and things-to-a-PC (the same watch to a desktop computer via a USB dongle). A year later, it was the first company to make a lowly pedometer smart by connecting it to the Internet (via a PC). Then in 2010, the company pioneered the use of Bluetooth Smart to connect appcessories to smartphones, and now, in 2014, it is leading the way in developing chips that will connect products directly to the Cloud, underpinning the growth of the IoT.

An example of this strategy is the recent launch of Nordic's most advanced feature-rich Bluetooth Smart protocol stack to date - the S130 SoftDevice, a Bluetooth 4.1-compliant protocol stack - that allows the development of Nordic nRF51 Series SoC-based peripheral wireless sensors that don't always need a smartphone present to operate. ■

EETimes China

This article was first published in *EETimes China* in December 2014

PEOPLE & PLACES

Ebbe Rømcke

Formulating optimized work processes leads to job satisfaction

Hi, I'm Ebbe Rømcke and I'm the Quality Director for Nordic Semiconductor.

I joined Nordic initially in 1990 where I worked for three years as a Digital Designer in Trondheim before leaving the company to join Normarc (now Indra Navia), where I again worked as a Digital Designer on the company's air traffic control Instrument Landing Systems (ILS) platform.

I rejoined Nordic in 1997 when the company opened its first offices in Oslo, again as a Digital Designer, and was later promoted to Project Manager, Group Manager, and finally Quality Director in 2002.

My main role is to ensure Nordic delivers what it agrees to deliver to customers, at the time it agrees to deliver it by liaising closely with all departments involved including internal sales & marketing, development, production, administration, and external distributors, contract manufacturers, and customers.

One of the things I really like about my job is that I am genuinely interested in formulating and maintaining optimized work processes and communications and I get a real kick out of solving genuine problems with customers in such a way that we end up with a strengthened relationship on the back of it.

Ebbe Rømcke recently completed a marathon bike ride from Trondheim to Oslo

And although we always strive for perfection, this includes implementing lessons learnt from any (near) failure scenarios and adapting to new challenges. From a quality perspective, this includes having more customers, more demanding customers, more complex products, larger production volumes, new technologies, more staff, more disciplines within the company, and more international office locations.

Outside of work I enjoy keeping fit by road cycling: I prioritize training for several hours, no matter the weather conditions, whenever I have the chance.

Last year I completed a 540 km tour from Trondheim to Oslo with my local cycling club. This was really challenging and at times pushed me to my mental and physical limits, although staying positive for my team mates and making fun of my own physical pains did help keep me going.

I also enjoy spending time with my wife, dog, and our four (now mostly young adult) children. It's been a real joy seeing four quite different personalities grow up to be independent human beings, making their own choices and forming their own lives. The problem is that my male dog Rico seems to think this applies to him too – which is a real problem given his fondness for the female dogs in our neighborhood! ■

Personal Profile

NAME:
Ebbe Rømcke

JOB TITLE:
Quality Director

JOINED NORDIC:
1990 & 1997 (rejoined)

BASED:
Oslo, Norway

INTERESTS INCLUDE:
Family; Cycling; Sailing; Woodturning

"I get a real kick out of solving genuine problems with customers in such a way that we end up with a strengthened relationship on the back of it"

JOIN A WORLD-CLASS TEAM

Nordic Semiconductor is a proud sponsor of the world's best chess player, Magnus Carlsen.

We are always looking for the best engineers and offer a working environment where you will be integral to the development of ideas and decisions. It is an environment where you can make a difference and contribute to the success of the company.

We are now hiring more engineers for our R&D centers in Oslo & Trondheim:

- *RF/ANALOG IC DESIGN ENGINEER*
- *MCU SYSTEM ENGINEER*
- *SENIOR SYSTEM ARCHITECT*
- *DIGITAL IC DESIGNER*
- *JUNIOR DIGITAL IC DESIGNER*
- *EXPERIENCED DIGITAL IC DESIGNER OR VERIFICATION EXPERT*
- *FW/SW VERIFICATION ENGINEERS*
- *HW VERIFICATION ENGINEER*

To apply or to learn more about our positions go to:
www.nordicsemi.com/eng/About-us/Career

NORDIC SEMICONDUCTOR

ABOUT NORDIC SEMICONDUCTOR The future of electronics is wireless and wearable due to a consumer demand for ever greater levels of freedom and flexibility. Nordic Semiconductor is playing a key role in realizing that future by specializing in ultra-low power short-range wireless communication supporting Bluetooth® Smart, ANT+ and 2.4GHz. The company's award-winning devices are employed by some of the world's leading brands in a variety of applications like wireless keyboard and mouse, game controllers, sports, toys, beacons, medical and smart home.

Nordic was established in 1983 and is a Norwegian company (listed on the Oslo Stock Exchange) with more than 360 employees. 260 employees are working in R&D in Trondheim and Oslo, Norway, Oulu and Turku, Finland and Krakow, Poland. The company's engineers are central in the development of the Bluetooth Smart technology standard, which is now being adopted by all major tech companies worldwide.