ultra low power wirelessQ

QUARTER 4 | **WINTER 2014**

COVER STORY

Rise of the Maker Movement

Bluetooth powers mobile commerce

Flash eases wireless development

Applying science to soccer training

NORDIC SEMICONDUCTOR

OPINION

J Darren O'Donnell

Maker Movement changes electronics market dynamics

Change is afoot in the semiconductor industry. This time it's not a new peak or trough in the sector's sales cycle, rather the rise of the "Maker Movement" - amateur engineers with a passion for design, assembly, and writing lines of code. It's a rise that has silicon vendors sitting up and taking notice.

There is nothing new about someone sitting in their shed armed with breadboard, soldering iron, 8-bit processor, and RS232 cable. But a maker is an entirely new species; and their influence runs deep.

Easy access to shared information and simple-to-develop hardware and software are fuelling the growth of the movement. The Internet has enabled like-minded individuals to share ideas, ask questions, and solve problems on community forums around the world. And the advent of technologies such as Arduino and Raspberry Pi (stripped-down computers that can be used as the foundation of smart electronic products), plus concepts such as open source design software make it easy to develop and share digital blueprints.

Makers even have their own formal gatherings, Maker Faires, where up to 35,000 visitors meet to show off their ideas and find out what new technologies are available to help them realize their dreams.

A decade ago, semiconductor vendors, Nordic Semiconductor included, were happy enough if a distributor supplied a handful of chips to a hobbyist, but these firms focused their main support efforts on professional engineers in large, established ODMs and OEMs. That's changed not only because makers now represent a large group of new and untapped customers, but also because mature companies, faced with increasing competition and tightening budgets, are limiting research and concentrating on conservative product lines that they know will sell. As a result it's possible that the next 'killer app' could just as likely come from a 17-year-old working from his bedroom in Jakarta as the development lab of a Silicon Valley computer company. And with the advent of crowdfunding to get production started and a connected global population with money in its pockets, it's possible for a fledgling company to sell thousands of products a month in short order. No semiconductor vendor wants to miss out on a cut of that action.

Nordic is working hard to make its technology accessible to the Maker Movement. For example, the nRF51 Series multiprotocol SoC features a unique software separation that makes it easy for a non-RF expert to write the code for their application without fear of corrupting the RF protocol software. The company has also launched a low-cost development kit for ultra low power (ULP) wireless applications that's hardware compatible with the Arduino Uno standard, making it possible to use third-party standard compatible shields with the kit. (*See page 8 this issue.*)

As Nordic and other chip vendors make it easier for makers to work with their products, a whole new source of innovation will flower. For a ULP wireless sector on the cusp of a revolution powered by emerging technologies like beacons and the Internet of Things (IoT) that source of innovation will result in some incredible products. Far-fetched? Not when you consider that the first industrial revolution grew out of workers doing piecework in their kitchens. (*To find out more about makers, see pages 16 and 17.*)

Yours Sincerely,

J. Darren O'Donnell
Director of Marketing & Sales - Americas

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John Leonard is Tactical Marketing Manager with Nordic Semiconductor. In this issue he explains why all Bluetooth Smart chips are not the same

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Sally Ward-Foxton is an electronics freelance journalist. Here she explores the rise of the Maker Movement and what that means for semiconductor companies

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Jack Shandle is a freelance writer specializing in semiconductors. On page 18 he explains how integrated Flash has revolutionized wireless Systems-on-Chip

The momentum of the Maker Movement is making semiconductor vendors sit up and take notice

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NEWS

The latest developments from Nordic Semiconductor

nRF51 Series SoCs get more RAM and smaller packages

Nordic has announced enhanced drop-in compatible variants of its nRF51 Series of Bluetooth Smart and ANT Sytems-on-Chip (SoCs). The devices feature 32kB RAM - for improved application performance - plus an ultra-compact wafer level chip scale package (WLCSP) option.

By doubling the RAM compared to the previous variant the nRF51 Series SoCs are able to run more complex, computationally intensive applications or run existing applications faster.

The increase in RAM also gives Nordic's R&D teams greater flexibility to develop new SoftDevices (self-contained RF software protocol stacks for nRF51 Series SoCs) with even greater performance and features.

The WLCSP options have a surface area as small as 11.8 mm^2 and are targeted at the wearables sector.

First launched in June 2012, the nRF51 Series is optimized for ultra low power (ULP) wireless connectivity and integrate a 2.4GHz multiprotocol radio, 32-bit ARM Cortex M0 processor, and up to 256kB of Flash memory alongside the RAM memory.

The nRF51 Series is notable for its software architecture that features a unique separation between protocol stack and user application code providing application developers maximum flexibility, ease-of-development, and code safety.

Nordic's nRF51 Series SoCs with 32kB RAM are now available in production volumes.

Nordic Semiconductor named 2015 CES Innovation Awards Honoree

Nordic's multiple award-winning nRF51822 Bluetooth Smart and 2.4GHz proprietary multiprotocol SoC with S110 SoftDevice v7.0 has been made an Honoree in the prestigious 2015 CES Innovation Awards. The awards recognize innovative design and engineering in the most cutting-edge tech products and services coming to market around the world.

Fellow CES 2015 Innovation Awards Honoree adidas' miCoach SMART BALL uses Nordic technology

Products entered in this prestigious program are judged by a preeminent panel of industrial designers, engineers, and members of the trade media to honor design and engineering in consumer electronics products.

The nRF51822 SoC is a Bluetooth Smart solution optimized for ULP wireless connectivity that features a unique separation between the Bluetooth Smart protocol software stack and user application code.

The S110 SoftDevice v7.0 is Nordic's latest Bluetooth Smart stack for the nRF51822 SoC. (A SoftDevice is Nordic's self-contained stack for nRF51 Series SoCs that incorporates an RF protocol and its associated management framework.) The S110 SoftDevice v7.0 brings a range of features including Over-The-Air Device Firmware Upgrade (OTA-DFU) and the ability to handle concurrent multiprotocol Bluetooth Smart and 2.4GHz RF proprietary communication allowing consumer electronics companies to offer a proprietary version of their product, without requiring any re-design effort, depending on the target market.

In brief

Nordic opens Finnish office

Nordic is opening a new R&D office in Oulu, Finland, taking advantage of the layoffs recently announced by several large technology companies based in the country. "As Nordic constantly targets to be leading in connectivity technologies, we are strengthening our R&D resources [in Norway and Poland] by adding highly qualified engineers from the IT hub that has been built in Northern Finland during the last years," says Nordic CEO, Svenn-Tore Larsen.

TSMC platform targets wearables

Long-term Nordic foundry partner, TSMC, has announced the "world's first" and most comprehensive ultra low power technology platform for the Internet of Things (IoT) and wearable sectors. The platform includes semiconductor fabrication processes that support RF and embedded Flash memory capabilities and system-level integration that will yield smaller form factors, power reduction benefits, and a comprehensive design ecosystem designed to accelerate time-to-market.

More phones than people by 2015

Worldwide cellphone subscriptions are forecast to exceed the population of the world for the first time in 2015 with 7.5 billion subscriptions compared to 7.4 billion people. According to a report by IC Insights, this reflects a 19-year CAGR growth rate of 16 percent between 1999 and 2018. The analysts do note, however, that because many people own multiple SIM cards the true penetration rate is currently 60 percent – or 4.4 billion unique cellphone users – of the 2014 world population of 7.3 billion.

In brief

45 trillion sensors in two decades

According to a statement by Fraunhofer EMFT, networked sensors capable of collecting data and exchanging information – dubbed the 'Internet of Everything' (IoE) by the group – are set to increase exponentially with forecasted demand reaching 45 trillion sensors in 20 years. Ultra-high volume applications relevant to the IoE (also called the 'Internet of Things' (IoT)) include the mobile and wearable market, digital health, smart home, automotive, 3D printed sensor systems, the network infrastructure for IoE and IoT sensors, and sensor data security.

Smartwatches hit 100m by 2019

More than 100 million smartwatches will be in use worldwide by 2019, with a host of premium brand launches over the next 12-to-18 months. According to UK analyst Juniper Research, the range of functionality available means that it is unlikely that a 'killer app' for smartwatches will evolve. Juniper says smartwatches will slowly gain more sales outlets as brands outside the technology sector, such as luxury watch makers, enter the smartwatch space, and the average selling price is likely to stay above $200 until at least 2020.

Wearables go from geek to chic

Wearable electronics are becoming sexy as new smartwatches from the likes of Apple and Samsung have set a new standard for technological 'bling', says analyst IHS. The developments in flexible displays has opened up new opportunities for wearable devices and will enable the design innovations now being seen in the smartwatch market. IHS predicts the next wave of wearable products will come from smartwatch computing but that the field of wearables will be diverse and include gaming, infotainment, and health monitoring.

Battle-race cars merge video and slot-car style racing

The Anki Drive 'battle-race' game from U.S artificial intelligence (AI) consumer robotics startup, Anki, is claimed to be part of a new category of racing car-based product positioned at the intersection of toy and video game. The product comprises a roll-out vinyl mat that uses optical infrared 'ink' that the cars use for automatic guidance.

In operation, a Nordic nRF8001 Connectivity Chip embedded into each car communicates via Bluetooth Smart wireless technology with an Anki Drive app that is used to control weapons and maneuvers (such as lane changes on each car during battle races). The app is also used to configure and upgrade weapons, difficulty level, and the abilities of cars in a 'virtual garage' using gaming points earned from disabling other cars.

Anki Drive costs $149 in starter kit form (two cars plus a 'Crossroads' mat that features an intersection where cars can collide) from all major U.S, Canadian and UK retailers (including the Apple Store, Amazon, Best Buy, GameStop, and Toys"R"Us). The game supports up to four cars that players configure and control using their iOS and Android smartphones and tablets to battle and race with other cars (either player- or AI-controlled) using virtual weapons.

Nordic technology wirelessly links Anki Drive cars with a smartphone app

Anki also recently released a 'race' mode to complement its initial 'battle' mode gaming format, so users can choose between racing to a finish line first or seeing who can disable opponent cars the most.

Intelligent hob optimizes cooking with wireless technology

The "IQcook" induction hob can communicate wirelessly with partner pot and pan lids that employ embedded sensors to allow cooking temperatures to be continuously monitored, optimized, and automated via preset cooking profiles, while removing the risk of food boiling over or burning.

In operation, the IQcook hob uses sensors embedded in the pot and pan lids (any type of cookware suitable for induction hobs can be used) enabling automation and optimization of any one of the five most common types of hob-based cooking process. These are: steam cooking, cooking with large amounts of water, slow cooking, deep frying, and grilling.

IQcook was developed by Slovenian high-end domestic home appliance company, Gorenje Group, and employs Nordic nRF24LE1 proprietary 2.4GHz Systems-on-Chip (SoCs) to provide the wireless connectivity between the hob and partner pot and pan lids.

Perfect cooking every time with Gorenje's IQcook system

"If you are cooking beef soup, for example, you would put water, meat, and other ingredients in the pot in the normal way, and then select the 'IQboil' program on the hob [which itself can be further adjusted between light, moderate, and heavy boil settings]," explains Elizabeta Biluš, Head of External Communications at Gorenje Group. "The wireless sensors in the hob and lid then immediately start communicating to achieve and maintain the optimal boil profile."

Biluš claims that the IQcook's steam feature also enables optimal nutrient-conserving cooking of vegetables in very small amounts of water (for example, 0.05 liters per 1kg of vegetables).

Remote control features voice Internet search with extended battery life

Developed by leading Japanese IT developer, SMK, the 'SSR-RF11B' Bluetooth Smart Voice Remote control, designed for consumer home entertainment OEMs, features a 'voice' Internet search capability and advanced navigation functions with motion sensors.

Voice search - using spoken commands to locate Internet content - has been popularized by search giant Google and the concept has migrated to smart TVs that provide Internet access but don't necessarily have the convenience of a regular PC keyboard or mouse.

SMK's new voice remote control employs Nordic nRF51822 Bluetooth Smart SoCs to extend the device's battery life and ensure much quicker responses when waking from 'sleep' mode while offering enough bandwidth to support advanced navigation aids such as motion sensors.

SMK's remote control for smart TVs supports over-the-air firmware updates

The SMK remote features the latest version of Nordic's S110 (v7.0) Bluetooth Smart 'SoftDevice' to support over-the-air device firmware updating (OTA-DFU) using the devices' own wireless link. This means owners of the SMK remote control will be able to update to the latest stack or application software quickly and easily.

SMK's remote is sampling now and expected to be launched in volume during the first half of 2015.

Nordic-powered beacons come out top in independent tests

Beacons based on Nordic Semiconductor's nRF51822 Bluetooth Smart and 2.4GHz proprietary multiprotocol System-on-Chip (SoC) have been rated "Most Stylish beacon" and most "High Performance beacon" out of 16 beacon makers using four different chipsets.

Between them, these chipsets share 95 percent of the market and of the beacons tested, six used Nordic's nRF51822 SoC.

Beacons use Bluetooth Smart wireless technology to advertise their position to Bluetooth Smart Ready smartphones.

A companion app can then provide contextual information such as product information or directions in shops, restaurants, malls, and airports.

The beacon test report, entitled "*The Hitchhikers Guide to iBeacon Hardware*" was compiled after comprehensive examination of the beacons by Toronto-based test laboratory Aislelabs.

Kontakt.io's beacon was praised for its range and low power consumption in independent tests

According to the company, each beacon product was "stress tested under many conditions examining every aspect of them".

Nordic customer Estimote's beacons were rated highly because "their flexible silicon cover, a selection of bright colors, and reusable adhesive [makes them] stand out as the most stylish among all beacons available in the market today".

Kontakt.io, another Nordic customer, was recognized for its product's "accurate and extensive range transmission and significant power optimization" and took the high-performance award. Kontakt.io and Estimote were also rated first and second respectively for battery life out of all the beacons in the test (*for more on beacons see page 10 issue*).

Wearables to consume $9 bn of chips

The semiconductor content of wearables will reach $9 billion in 2019 with nearly half of this coming from shipments of devices to the healthcare sector, and a further quarter coming from sales of smart glasses, according to analyst The Information Network. The firm predicts that the remainder of the semiconductor content for wearables will be split in decreasing amounts between smartwatches, wearable cameras, sports and activity trackers, smart clothing, and 3D motion trackers (particularly for use in the remote monitoring of the elderly to detect falls). Key wireless technologies are predicted to be Bluetooth, Wi-Fi, and NFC.

Workers embrace wearables

In brief

A survey conducted by Harris Poll (for The Workforce Institute at Kronos Inc.) found that 73 percent of adults polled in Australia, China, France, Germany, India, Mexico, U.K., and the U.S. see at least one potential benefit to the use of wearables in the workplace. This includes increased efficiency, productivity, and safety. The survey also points out that only 13 percent of U.S. adults currently use wearable devices in their personal lives compared to 73 percent in China, the highest-ranked region. Globally the top-three wearable devices that those polled said would be useful at work were: smart headphones, smart watches, and arm or wrist computers.

Slot-cars race like they're real with up to 24 overtaking vehicles on any number of lanes

An Australian slot-car specialist, Scorpius Wireless, has developed what it claims is the world's most technologically advanced slot-car racing platform using Nordic 2.4GHz proprietary transceivers.

Called 'Scorpius', the platform supports a long list of features designed to imitate the realism of real motor racing. These include the ability to race up to 24 cars on any number of lanes, lane changing and overtaking, pitstops, virtual fuel tanks, adjustable brakes, automatic flag and timed penalties (for example for pit lane speeding), PC-controlled race management, driverless 'ghost' cars that can autonomously analyze track traffic ahead and change lanes, lap counting, and over-the-air firmware and software upgrades.

Each Scorpius slot-car is controlled by a wireless 2.4GHz controller with embedded nRF24L01+ that communicates with an nRF24L01+ based decoder under the hood of each car and/or an nRF24L01+ based USB wireless PC dongle that is used to manage and set-up races and reconfigure car and track firmware 'over-the-air'.

Each controller features an LCD 'virtual dashboard' screen, 'frictionless' trigger (with adjustable spring tension), ten preset throttle maps, and even displays each driver's name.

Scorpius says that one of the biggest technological challenges it faced while developing its platform was electrical noise and RF interference.

"We had to address issues relating to operating in a noisy electrical environment, including arcing that occurs in the motor brushes and the power pickup braids that deliver power to the car from the track [and which we found] caused chip resets," comments John Huberts, an engineer with Scorpius.

"In addition, running up to 24 cars controlled by uniquely-paired throttle controllers plus a potentially similar number of lane changers as well as one or more PC dongles, all communicating at up to 100 times a second, was a major potential 2.4GHz co-existence headache."

Scorpius got around the latter issue by using the "ShockBurst" capability of the Nordic transceivers that enabled very short, fast transmissions that minimize on-air time and the likelihood of data packet collisions. The Nordic chips also employ an advanced frequency hopping capability when interference is encountered in the 2.4GHz band.

Scorpius also says it has been able to achieve a 300-hour battery life equivalent with around 25 hours per week usage from its nRF24L01+ based wireless controllers.

Scorpius wireless controllers deliver long battery life and support racing of up to 24 cars

Distribution agreement supports China expansion plans

Nordic Semiconductor has signed an agreement with leading Chinese distributor Honestar Technologies. The deal will aid Nordic's expansion strategy in China and support the dramatic growth of Bluetooth Smart in the country.

Honestar Technologies is a component distributor and electronics solution provider headquartered in Shenzhen, with subsidiaries in Hong Kong, Beijing, Shanghai, Chengdu, Qingdao, Xiamen, and eleven other key locations in China. The company employs around 350 staff, of which one third are R&D engineers.

"Bluetooth Smart is a particular focus for Honestar Technologies," says Alex Lin, the company's CEO. "Because Nordic Semiconductor has played an important role in the development of the Bluetooth Smart specification and offers award-winning Bluetooth Smart solutions we were keen to formalize our partnership with the company."

Nordic's Gary Ho (left) shakes on a new distribution deal with Alex Lin, CEO of Honestar Technologies

Lin predicts strong growth for Bluetooth Smart in China, particularly in emerging technologies. The company's widespread reach across the country will enable it to promote Bluetooth Smart to customers developing applications in the smart home, beacon, and IoT sectors.

"With Honestar Technologies now acting as our distributor, Nordic has a partner with a wealth of expertise in the domestic Chinese market to promote local sales of Bluetooth Smart together with Nordic's ANT+ and 2.4GHz proprietary solutions," says Gary Ho, Nordic's Regional Sales Manager in China.

ULP WIRELESS TRENDS

The latest developments in technology

Bluesmart suitcase uses Bluetooth wireless technology and smartphones to drag luggage into the 21st century

Smart carry-on suitcase auto locks, tracks, and weighs itself

Developed by U.S. startup of the same name, the Bluesmart suitcase is said to be brimming with patent-pending technology that supports a raft of brand new features.

The luggage includes a digital lock controlled from a smartphone via Bluetooth wireless technology and an auto-lock which activates when the suitcase is separated from the user. A built-in digital scale allows the Bluesmart to weigh itself and a distance alert informs users via SMS if they are about to leave their suitcase behind. Also included are location tracking with GPS to help find a lost case, trip stats and data, and a portable device battery charger that's claimed to allow users to charge their devices up to six times while traveling.

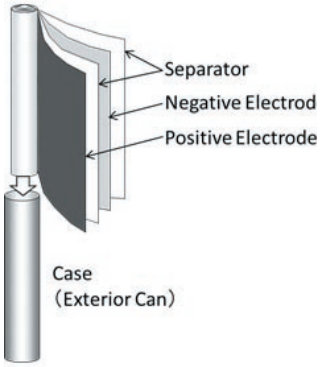
The Bluesmart has raised over a million dollars on crowdfunding website Indiegogo.

World's smallest rechargeable battery targets wearables

Due to ship from February next year, Panasonic has launched what it claims is the industry's smallest lithium-ion rechargeable battery specifically targeted at the most compact wearable devices such as rings, glasses, and pens, as well as being suitable for Near-Field Comms (NFC) applications.

The pin-shaped 0.6g Panasonic CG-320 is said to be occupy around one-twentieth the volume of a regular AAA-sized battery and measures just 3.5 (diameter) by 20mm (length), while offering a 13mAh (nominal) capacity from a 3.75V (4.2V max for charging) supply.

The company says a high-strength stainless steel can is used for the exterior to prevent swelling and the battery delivers excellent reliability. The company says the battery leverages its technological know-how from the manufacture of small coin cell-shaped batteries.



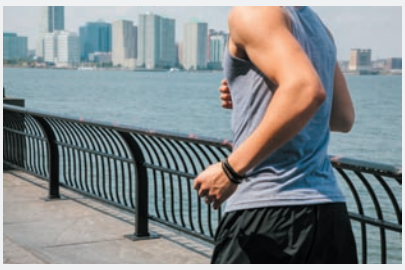
The smaller and lighter the battery, the smaller and lighter the wearable

Latest Jawbone activity band tracks heart rate and temperature

The Jawbone UP3 tracker comes packaged in a slim, low-profile design and is designed to monitor a wide range of biometric signals to give users even greater insights into their overall activity levels, behaviors, and habits.

The band includes an advanced bioimpedance sensor to measure resting heart rate (which Jawbone defines as your heart rate upon waking up before doing anything else, including consuming caffeine), a skin and ambient temperature sensor, and an advanced sleep tracker that can track detailed sleep stages including REM, light, and deep sleep states.

Jawbone says the UP3 even includes a smart algorithm that can automatically distinguish between various types of workout activity including running, cross-training, tennis, and many more. And the company adds that a free, over-the-air firmware update due shortly will allow even more health data to be captured.



Jawbone's tracker is sleek enough to be worn everywhere

nRF51 Design Kit supports Bluetooth Smart, ANT, and 2.4-GHz designs

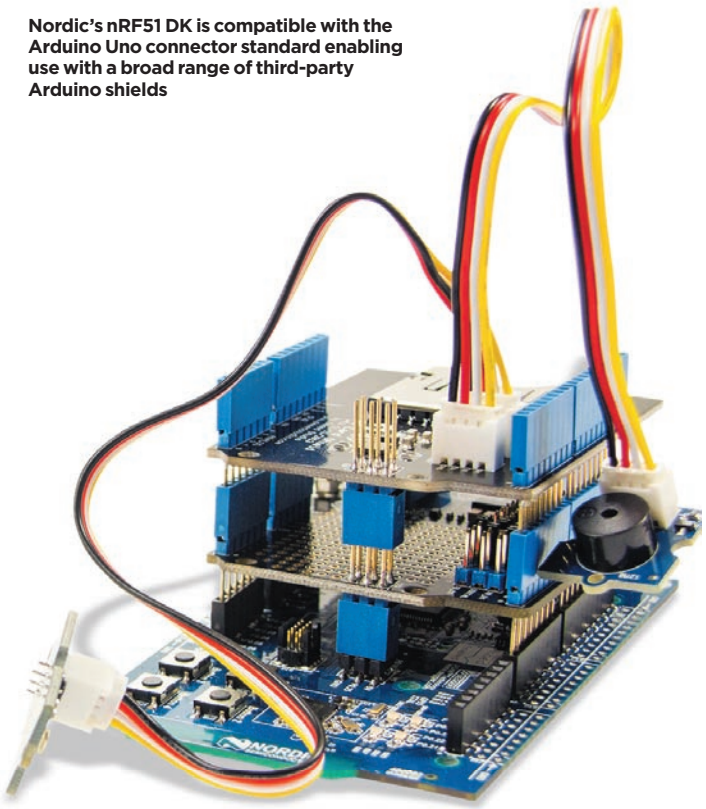
Amateur and professional engineers alike now need to purchase only one kit for ULP wireless product development irrespective of their choice of wireless technology

The so-called 'Maker Movement' is on the rise. The movement is a groundswell of millions of people who are taking big risks to start their own small businesses dedicated to creating and selling self-made products. Modern technology has made it easier than ever for a single individual to create and sell items that are customizable and unique without having to turn to middlemen like manufacturers.

With the launch of its nRF51 DK, a low-cost development kit (DK) for fast, easy, and flexible development of Bluetooth Smart, ANT+, and 2.4-GHz proprietary applications Nordic is doing its bit to bring ultra low power (ULP) wireless technology to makers.

But that's not to say that professional engineers won't benefit from the nRF51 DK too. Whatever the user's level of engineering knowledge, the DK makes it much easier to add a ULP wireless connection to a new product.

Nordic's nRF51 DK is compatible with the Arduino Uno connector standard enabling use with a broad range of third-party Arduino shields



Lowering barriers

"The nRF51 DK significantly lowers the skill- and cost-barriers for keen amateurs in the 'maker' sector and professional engineers alike looking to develop Bluetooth Smart, ANT or 2.4-GHz proprietary wireless products," explains Geir Langeland, Nordic's Director of Sales & Marketing.

"Bluetooth Smart is booming while ANT and 2.4-GHz proprietary also show healthy growth in their respective niches so it's not always clear cut which technology to choose when development begins," says Langeland.

"Because it can easily handle all three key ULP wireless technologies, the nRF51 DK allows the user maximum flexibility when selecting a ULP wireless technology."

"The nRF51 DK significantly lowers the skill- and cost-barriers for keen amateurs in the 'maker' sector and professional engineers alike looking to develop ULP wireless products"

The nRF51 DK is based on Nordic's nRF51 Series System-on-Chip (SoC) which can support a range of SoftDevices for Bluetooth Smart, ANT, 2.4-GHz proprietary, and even combinations of these protocols on a single device.

The nRF51 DK measures 63 by 101mm and features a coin-cell battery holder allowing application field testing. The DK can also be used as a programmer for other target boards that use the nRF51 Series SoC.

Uno-connector compatible

The nRF51 DK is compatible with the Arduino Uno connector standard enabling use with a broad range of third-party Arduino shields.

Arduino is an open-source electronics platform based around an eight-bit microcontroller. Arduino is popular with the amateur engineering and maker communities because it makes things simple when adding sensing and control to "hobby" products.

The nRF51 DK allows access to all device peripherals, interfaces, plus I/Os and features four user-programmable buttons and LEDS plus voltage and current pins to measure device power consumption.

Bluetooth Smart analysis

Complementing the nRF51 DK is the launch of the nRF51 Dongle, a highly versatile USB dongle to aid test, analysis, and development of applications using any of the three ULP wireless technologies.

The nRF51 Dongle can be used for standard software development on the nRF51 Series SoCs. The device is especially useful when used in conjunction with Nordic's nRF Sniffer and Master Control Panel.

nRF Sniffer is a utility available as a download from Nordic and when used in conjunction with the nRF51 DK can capture Bluetooth Smart packets over the air. The information can then be viewed and analyzed using Wireshark, a free, open-source protocol analysis tool.

The DK, dongle, and these two utilities - available as downloads from Nordic - provide developers with the ability to analyze the Bluetooth Smart communication of their application.

The nRF51 DK can also be used when developing ARM mbed applications.

The product replaces all previous nRF51 Series DKs and evaluation kits (EK) and is available from Nordic now priced $69. The nRF51 Dongle is also available now at $49. ■

Software influences Bluetooth choice

John Leonard explains why all Bluetooth Smart chips are not the same

John Leonard is Tactical Marketing Manager, Nordic Semiconductor

A key strength of Bluetooth Smart is its interoperability. But interoperability shouldn't be mistaken for uniformity. Just as, for example, the performance of 32-bit microcontrollers from different vendors varies, there are good Bluetooth Smart chips and not so good ones. Inspection of data sheets reveals differences in operational characteristics or development features, but that is only half the story; Equally important is software quality, flexibility, and optimization.

Previously, I explained how this software typically comprises the RF protocol (for example Bluetooth Smart) and the OEM application software. (*See* ULP WQ, *Autumn 2014, pg 9.*) Here, I'll look at how the RF protocol can influence the choice of a Bluetooth Smart solution.

Nordic's software and hardware teams work together to ensure the RF protocol is highly optimized for operation with the ARM processor at the heart of Nordic's nRF51 Series SoCs

Highly optimized software

Bluetooth Smart chip vendors sell solutions comprising hardware and the RF protocol. Some manufacturers develop everything in-house while others source their software from a third party. The latter method can introduce some challenges for the OEM. First, the software vendor designs its product for a range of hardware meaning that it won't be optimized for a particular device (the vendor could also make later changes to its software that make it even less compatible with the hardware). Second, a competitor of a particular Bluetooth Smart chip vendor could buy the software maker and terminate supply – causing the OEM a serious production hiatus. Even if the Bluetooth Smart chip vendor sources alternative software it may not be compatible with the current iteration of hardware necessitating a redesign and further delays for the OEM.

Nordic develops its own Bluetooth Smart RF protocols (called "SoftDevices"). The software team works intimately with the hardware group to ensure the protocol is highly optimized for the ARM processor at the heart of Nordic's nRF51 Series SoCs. Any proposed changes to hardware or code are communicated to the other team to ensure that they won't compromise chip performance.

The performance of the Bluetooth Smart chip is highly dependent on the protocol's operation and efficiency. For example, Nordic's S130 SoftDevice is able to handle more "connection events" in a set time than competitors' software. This results in greater bandwidth and lower power consumption. The analogy I draw is with two otherwise identical internal combustion engines in different states of tune; both work in the same way but one will have more power than the other.

It can be tricky to link the OEM application code to the RF protocol so that things run smoothly. Often the application code can cause the protocol to run less optimally than the chip vendor intended, compromising performance. In the worst case the application code can corrupt the protocol software and the developer has to start over.

Nordic is unique in offering a software architecture that separates the application code from the RF protocol. The designer can develop the application code safe in the knowledge that the protocol can't be compromised. Nordic's development tools link application code and protocol ensuring both elements of software remain highly optimized.

Some vendors use a ROM-based architecture which means the RF protocol is "built-in" during the chip fabrication process. This makes software enhancements - either at the OEM's factory or as over-the-air updates when the device is in the field - impossible. An OEM could be stuck with thousands of outdated chips. Worse yet, it could affect product sales if the consumer opts for a competitive product because it uses more up-to-date software.

Nordic's nRF51 Series employs a Flash-based architecture ensuring an OEM can hold "blank" chips and then download the latest SoftDevice from Nordic's website for chip programming during end-product manufacture. ■

To find out more about the advantages of Flash architecture, turn to the article on page 18 of this issue.

Beacons power mobile commerce revolution

Mobile commerce is morphing into location-based retailing as Bluetooth Smart beacons proliferate. ULP Wireless Q reports

Mobile commerce made its debut back in 1997 when two soft drink vending machines were installed in Helsinki, Finland. According to online encyclopaedia *Wikipedia*, the units were the first in the world to accept payment via short message service (SMS). Shortly after, Merita Bank of Finland launched a mobile phone-based banking service also using SMS.

At the time Finland was the center of the mobile universe courtesy of Nokia. Today, Nokia no longer makes handsets, having sold its interests in the technology in 2013 to Microsoft, yet smartphones continue to influence the development of mobile commerce.

That development is rapid. The British Retail Consortium's annual payments survey for 2014, for example, shows the use of cash by U.K. consumers has fallen by 14 percent over the past five years, to just £27.64 ($42.89) of every £100 ($155) spent at retailers, Debit cards have replaced some of those transactions, but contactless payments via smartphones also played a big part.

The British trend is mirrored across the globe, with more than 130 million people worldwide making mobile contactless payments this year. The number is forecast to hit 300 million by 2017, according to analyst Juniper Research.

Retailers are looking to enhance mobile commerce by using a smartphone's inbuilt wireless connectivity to determine its position. Offers specific to a user's location could be used to encourage purchases. A fast food outlet, for example, could send details of a discount meal deal to smartphone owners passing by.

Major League Baseball is adopting iBeacon-powered location-based commerce in 20 stadiums

There are several techniques for fixing a smartphone's position. For example, Global Positioning System (GPS) signals can be used; but the technique suffers from some notable drawbacks. First, resolution is only around a few tens of meters, compromising a precise fix, and second, GPS doesn't work indoors, which is of no use to retailers in covered premises such as malls or airport terminals.

Wi-Fi hotspots can overcome the lack of indoor signals. Triangulation between Wi-Fi routers can locate a smartphone with some accuracy. The drawback is that the Wi-Fi router doesn't broadcast its location so systems have to refer to databases of the approximate location of hotspots held by companies such as Apple and Google. If the hotspot is relocated the database can take a while to catch up compromising location precision.

Lighting the beacons

Beacons - compact wireless devices that are inexpensive enough to be distributed in their hundreds in shops, restaurants, malls and airports - address the drawbacks of GPS and Wi-Fi position determination. Beacons transmit a short-range signal advertising their position which can be picked up by compatible smartphones. Because the mobile can only detect a specific beacon when in close proximity (a few meters) its location is effectively fixed.

The beacon does no more than advertise its location. If consumers have then "opted in" to the beacon owner's location-based commerce scheme - by downloading an app and ensuring the Bluetooth Smart Ready capability of their smartphone is enabled - the handset then takes over by displaying the relevant information based on the user's proximity to a particular beacon. For example, if the user is in the pasta aisle in the supermarket, the smartphone could flash up a 25-percent discount on bolognese sauce and show where the jars are located.

Leading firms such as PayPal (PayPal Beacon) and Apple

(iBeacon) have already put the technology into action.

PayPal Beacon is a device that businesses can purchase to connect to a customer's PayPal app (once the customer has opted in to the service). Consumers are automatically checked into the system when they walk within range of the beacon. When the customer makes a purchase the merchant activiates the payment process, including sending the consumer an electronic receipt.

For its part, Apple has trialled an iBeacon system at a U.S. baseball stadium, The Citi Field. As smartphone owners approached the stadium, beacons detected their presence and a companion app flashed up a ticket barcode on the handset's display for scanning at the turnstile. The success of the demo has prompted Major League Baseball to install iBeacon technology in 20 stadiums.

The advantages of Bluetooth Smart-powered beacons are allowing the technology to gain commercial traction. Bluetooth Smart Ready devices such as

Kontakt.io's location-based commerce system is boosting trade in the Brixton area of south-west London

smartphones can communicate seamlessly with Bluetooth Smart beacons. (*See* ULP Wireless Q, *Summer 2014, pg 16.*)

According to Steve Cheney, a Senior VP with beacon maker Estimote, such beacons will enable smartphones to "sense" their environment. "The smartphone is a powerful computer but it's 'blind' to the world, people, and objects around it," explains Cheney. "Beacons give smartphones the ability to recognize their immediate surroundings and so enable apps that can be built on top of the physical world."

Powered by Nordic

Two of the companies in the vanguard of Bluetooth Smart beacon commercialisation have adopted Nordic Semiconductor technology to power their products.

Both Estimote and Kontakt.io started up in Poland and both use Nordic's nRF51822 Bluetooth Smart solution to provide the wireless connectivity between their beacons and smartphones.

Estimote says its software development kit (SDK) is in use by over 25,000 developers worldwide, and adds that it has already signed up major industry partners including Cisco to work with its new "nearables" Stickers hardware. Stickers are targeted at location-based commerce among other applications.

Among other major projects, Kontakt.io has implemented a location-based commerce system for an alternative currency called the "Brixton Pound" that can be spent in the Brixton area of London - boosting local trade.

An independent survey[1] of the top 16 beacon manufacturers by retail technology company Aislelabs rated Estimote's product as "Most Stylish beacon" and Kontakt.io's device as most "High Performance beacon". (*See this issue page 5.*)

1. "The Hitchhikers Guide to iBeacon Hardware: A Comprehensive Report by Aislelabs."

Ultra low power wireless connectivity solutions

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

DATE: DECEMBER 2014

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: Accessories	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

Fitness and health devices drive wearables expansion

Bluetooth Smart and ANT+ powered wellbeing gadgets currently dominate the wearables sector. ULP Wireless Q reports

While other wearables are in the stores, fitness and health devices are setting the sales pace. Analysts claim that shipments of fitness and health devices with integrated wireless connectivity will grow to an estimated 75.7 million units in 2018, up from 23.0 million units in 2011.

Compact, wireless fitness sensors measure parameters such as speed, distance, and heart rate, while health sensors monitor things like blood pressure, blood glucose, and whether an elderly person has fallen. Both types send their data to a smartphone or tablet computer for analysis and forwarding to the Cloud.

The key driver for growth of fitness devices is the desire to track, analyze, and share personal data as a motivational tool to maintain or increase wellbeing. Factors stimulating the health devices market include an aging demographic in developed countries concerned about preserving health and the rising use of remote healthcare systems (or "telehealth").

According to market researchers The Information Network, fitness and health devices comprise 50 percent of the wearables market by value. Smartglasses account for around a further 25 percent with the remainder of the market comprising, in order of decreasing content value, smart watches, wearable cameras, smart clothing, and 3D motion trackers.

The introduction of innovative fitness and health wearables shows no signs of slowing. Among them is U.S.-based FitLinxx's AmpStrip, a wireless fitness sensor the user sticks to their torso

Semiconductor bonanza

Analyst RnR Market Research estimated the value of the global wearable technology market at $4 billion in 2012, and expects it to reach $8 billion by 2018. The total addressable market for wearable technology is estimated to be more than $14 billion.

Sales of wearable devices are set to generate a windfall for silicon vendors by fuelling a market worth $9 billion by 2019, according to The Information Network.

The wireless connectivity chips at the heart of fitness and health devices are set for double-digit growth in 2014 and beyond, notes analyst IHS Technology. The company says that shipments this year for wireless semiconductors in fitness and health products will reach a projected 61.2 million units, up 11 percent from 55.0 million in 2013. And the market shows little signs of slowing, with shipments in 2018 climbing to over 95 million units.

The company says Bluetooth Smart is the most successful wireless technology for fitness and health applications because of its compatibility with Bluetooth Smart Ready-smartphones and -tablet computers powered by Apple iOS, Google Android, Microsoft Windows 8, and the BlackBerry operating system.

IHS says ANT+ also enjoys a significant market share especially in products designed for serious fitness enthusiasts and in cycling electronics. ANT+ technology is natively-supported in Sony and Samsung mobile products.

The introduction of innovative new fitness and health wearables shows no signs of slowing. And increasingly compact electronics is allowing manufacturers to make the devices even more discrete. U.S.-based FitLinxx, for example, is commercializing AmpStrip, a wireless sensor that the user sticks to their torso.

The sensor tracks heart rate, calories burned, respiration, body temperature, and posture - even when the user is asleep - and lasts between three and seven days before the adhesive portion needs to be replaced.

The rechargeable battery in the device lasts more than seven days and charges in two or three hours. The device uses Bluetooth Smart to link to an iOS or Android smartphone supporting a companion app.

nRF51 Series success

Nordic Semiconductor is enjoying success in the wearables sector with its nRF51 Series Systems-on-Chip (SoCs). The company offers Bluetooth Smart, ANT+ or multiprotocol Bluetooth Smart/ANT+ solutions in a single chip.

Sports equipment manufacturer adidas, for example, selected Nordic's nRF51822 SoC for its latest fitness wearable, the FIT SMART. The SoC provides the Bluetooth Smart wireless communications between the fitness monitor and the adidas miCoach app running on Bluetooth Smart Ready smartphones.

The ultra low power operating characteristics of the nRF51822 enable the FIT SMART to run for up to five days on a single charge from its internal lithium-ion battery.

Unlocking the intricacies of mountain bike suspension adjustment

German hydraulics specialist MAGURA uses ANT+ wireless technology to automate mountain bike fork adjustments to suit the terrain. ULP Wireless Q reports

Like most things associated with fun on two wheels, mountain bike suspension has seen its fair share of rapid technological development in recent years. One key development has been the advent of the suspension lock; riders are able to prevent the front and rear units operating when climbing in order that muscle power is used to gain height rather than to repeatedly compress springs.

The original technology used a lock mounted on top of the front forks. The main drawback was the need for the rider to reach down to operate the lock and then remember to unlock before hitting the bumps on the downhill section. Later the lock operating switch was moved to the handlebars making access a lot easier. And a further modification saved forgetful riders' spines by releasing the lock as soon as the forks hit the first big bump on the ride down.

Now MAGURA, a German hydraulics specialist, has taken things a big step further by incorporating ANT+ Suspension Device Profile (a profile builds on the base ANT protocol to optimize the software for a particular application) into their MAGURA eLECT mountain bike suspension unit. eLECT is a lightweight, easy-to-handle system that controls manual or fully automatic suspension lock-out for both front and back units.

Developed by ANT+ ultra low power (ULP) interoperable wireless technology supplier ANT Wireless, the Suspension Device Profile transfers key data from the ANT+ enabled fork and rear shock to a handlebar remote, bike computer, smartphone or smartwatch. Riders can choose to manually lock or unlock their suspension to suit their riding style and trail conditions by sending commands back from the remote.

In the automatic mode, eLECT's accelerometers determine if the bike is on a downslope, incline or level ground and adjust the suspension as required

"eLECT is the first electronic suspension system that thinks for the rider"

Alternatively, locking and unlocking can be activated automatically eliminating the need for the rider to stop or take their hands from the handlebar. The profile also allows for precise control over suspension stiffness or damping enabling varying settings for different terrains.

An intelligent system

In the automatic mode, accelerometers determine if the bike is on a downslope, incline or level ground and adjust settings or lock the suspension as required. The system is intelligent; for example if the rider takes off over a jump with locked forks, the sensors register the sudden altitude loss and open the lock within 200 milliseconds.

eLECT's USB-rechargeable battery provides approximately 40 hours of life in automatic mode and 60 hours in manual. "This is a special upgrade for an existing product," explains Götz Braun, Head of Marketing for MAGURA. "It's the first electronic suspension system that thinks for the rider and is an upgrade that makes a ride unforgettable.

"We choose ANT+ because it means no untidy cables and less weight," adds Braun. "And because ANT+ technology is adopted widely, riders who still prefer to operate the suspension via a manual button press can control the eLECT suspension system using a device they probably already own as the remote control."

"Having a record of settings takes the guess work out of post-ride analysis and lets people repeat or improve settings for the next ride," says Sebastian Barnowski, Senior Team Lead at ANT Wireless.

Barnowski explains that ANT+ equalizes the value of each fork so, for example, a damping value of 0.6 on one fork will be represented as the same value on a second fork. This means that if the rider buys a new fork, they can use the data from their previous unit to determine their new starting point, shortening set-up time.

ANT is a ULP RF software protocol that's considered a *de facto* standard for much of the sports sector. By implementing ANT+ profiles, manufacturers can make their products interoperable. (ANT RF software runs on 2.4-GHz wireless chips such as Nordic Semiconductor's nRF51422 ANT System-on-Chip (SoC) and Dynastream's N548 module also based on Nordic's nRF51422.) ■

For more information about ANT go to www.thisisant.com.

Democratizing technology: Rise of the Maker Movement

A combination of cheap development tools, crowdfunding websites, and support from tech vendors is helping the maker community thrive, writes Sally Ward-Foxton

Sally Ward-Foxton is a freelance journalist specializing in electronics

U.S. President Barack Obama speaks with members of the maker community about their inventions at the White House Maker Faire

Over the summer, the White House - home of the President of the U.S. - hosted a Maker Faire: a gathering of like-minded tech enthusiasts, hobbyists, engineers, and students. These events give people a chance to show off what they have made, and learn about new technologies. Projects on display included a life-size semi-intelligent robotic giraffe, a piano with bananas for keys, and a machine for 3D-printing pancakes in any design.

"Today's DIY is tomorrow's 'Made in America'," U.S. President Barack Obama told the assembled makers and dignitaries. "Your projects are examples of a revolution that's taking place in American manufacturing ... a revolution that can help us create new jobs and industries for decades to come."

Maker Faires have become wildly successful and now take place all over the world, signalling the rise of the Maker Movement. Crucially, they are giving mainstream attention and credibility to the millions of people who love making things and who just could be tomorrow's tech entrepreneurs.

It's not just the White House getting involved; big companies in the technology space are beginning to take notice. Engineers from some of the largest companies in the world now attend Maker Faires and Hackathons. At the AT&T 'Code for Car and Home' Hackathon, which took place recently, participants were supplied with hardware kits and challenged to build their ideas for the connected car or automated home into a workable system in just two days. The event was supported by companies like Cisco, Microsoft, and BMW, with cash prizes for the best ideas totalling $100,000.

Taking it seriously

Historically, electronics hobbyists and makers wanting to develop an idea into a small business faced massive barriers to entry. The cost of production in Europe or America was prohibitive, while the Far East was a total unknown. Finance for amateur projects was almost unheard of. Often dismissed as 'Fred in a shed', a hobbyist found it difficult to get even a basic level of support from potential suppliers.

The situation started to change in the mid-2000s, by which time the Internet had made access to information and communication across continents more straightforward. Today, the two key enabling technologies for innovation at the grassroots level are the 3D printer, which allows plastic objects to be manufactured on demand, and crowdfunding websites, which give start-ups access to funding and to potential customers easily. (*See* ULP WQ *Autumn 2014 pg17.*)

"All of a sudden you can have an idea, design it, manufacture it, put it in something someone would buy, and then with crowdfunding, get some

investment and get it to market," says John Leonard, Tactical Marketing Manager at Nordic Semiconductor.

3D printing, the on-demand printing of plastic objects such as electronics casings, has revolutionized the manufacturing sector. The success of the RepRap project – which produced a 3D printer capable of replicating itself – has given the hobbyist

community easy access to basic 3D printer technology. For more advanced, commercial designs, budding entrepreneurs can head to one of the many burgeoning 'maker spaces', essentially shared offices for start-ups which typically share access to electronics test equipment and 3D printers, removing another barrier to entry for these companies.

Crowdfunding websites such as Kickstarter have also been instrumental in forming the next generation of tech start-ups. Entrepreneurs upload details of their project and the general public can pledge financial support, usually in return for being the first to receive the final product after manufacture. Wireless projects that have received funding include Airfy, a home automation beacon which allows a smartphone to detect a person's presence and automatically control lighting, heating, and home appliances, which raised $30,000. Another company, Atomwear, has made an open source modular development platform for Bluetooth Smart wearable devices, designed specifically for the maker community. At the time of writing, it had raised $11,500.

Support from silicon

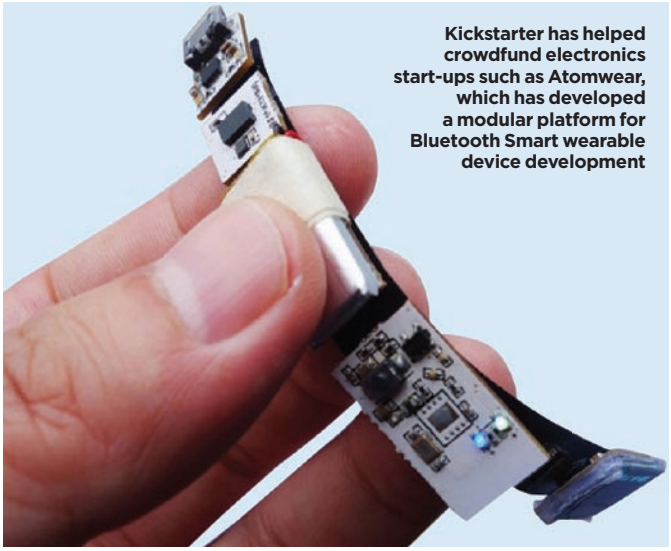
Hardware advances are also boosting the maker community's creativity by making electronics more approachable for non-professionals. Leonard cites the Raspberry Pi and Arduino initiatives as examples of how electronics is becoming less challenging and adds that the advanced technology in today's silicon chips makes them easier to build into complete systems anyway.

At a glance

- **Technology advances such as inexpensive development tools, combined with the growth of crowdfunding, are removing the barriers to entry for tech entrepreneurs**
- **The maker community is widely seen as an important seed ground for tech start-ups and is gaining credibility**
- **Silicon vendors recognize the importance of the maker movement and are encouraging interaction via new forums, kits, and open source libraries**

"Chips are getting more and more powerful and you get more for a lot less money," says Leonard.

"Previously, a microcontroller development kit was a few hundred dollars and it would take some temperature readings and flash an LED. It was interesting to those who enjoy technology, but it's not going to make a product. The explosion of systems-on-chip put connectivity, digital signal processing, and display drivers all on one chip, and costs came down too. Now people can get kits they can do really powerful stuff with."



Kickstarter has helped crowdfund electronics start-ups such as Atomwear, which has developed a modular platform for Bluetooth Smart wearable device development

"With the movement from Bluetooth to Bluetooth Smart, one of the goals was to make it easier for everyone,"

John Leonard, Nordic Semiconductor

At the same time, advances in hardware and software flexibility and user-friendliness which benefit professional developers have the side-effect of making it easier for students and hobbyists to get started too.

"For example, with the movement from Bluetooth to Bluetooth Smart, one of the goals was to make it easier for everyone," Leonard says. "Before, the functionality of whatever Bluetooth was doing was 'baked-in' to the stack. Things like RF comms, audio profiles, object exchange ... all baked in. If someone wanted to make a heart rate monitor, they had to wait for the Bluetooth SIG to bake it in."

The latest version of Bluetooth separated the application from the RF protocol itself, introducing the concept of profiles, essentially definitions of application types which specify general behaviors that Bluetooth devices use to allow them to communicate. There are around 20 profiles for Bluetooth Smart, but importantly, it's now possible to create your own profiles for any kind of application, no matter how niche.

As silicon vendors begin to recognise the value created by engaging with the maker community, makers can also expect more support from companies which traditionally prioritized bigger customers. As an example, Nordic has set up an online forum called the Developer Zone where anyone using Nordic parts can ask questions, get answers, and discuss technical problems with others, whether they are a student, hobbyist or developer at a tier-1 company. Development kits, reference designs, and even open source application code libraries are all available to support the maker community in developing new applications with Nordic parts.

The rise of the maker community has undoubtedly been helped by the development of 3D printing and the popularity of crowdfunding. Now that the maker movement has been embraced by the electronics and software industries, a new level of support is really enabling the community to thrive.

Flash memory boosts wireless system flexibility

A Flash-based chip architecture makes it easier for wireless product designers to meet the expectations of today's consumers. Jack Shandle reports

Jack Shandle is a freelance writer specializing in semiconductors

Keeping costs down is always a high priority for design engineers. But meeting this objective is not as simple as buying the least expensive part.

The range of considerations for making truly cost-effective component specification decisions is quite broad and while containing the bill of materials (BOM) is important other influences include production costs, field support, protecting intellectual property, and safeguarding a company's brand.

Designers looking to add an ultra low power (ULP) wireless link to thier product are fortunate in that they can choose from a range of wireless solutions from several vendors.

The high-end products are typically based around Systems-on-Chip (SoCs) integrating transceivers, processors. and memory. A key differentiation between devices from different manufacturers is the use of Read-Only Memory (ROM) or Flash memory in their chips.

ROM is attractive because it is less expensive and consumes lower operating current than Flash. But these advantages can easily be outweighed by both the production and operational flexibillty of Flash.

Non-volatile memory types

Electrically Programmable ROM (EPROM) and Electrically Erasable and Programmable ROM (EEPROM) preceded Flash into the market but each has at least one disadvantage that has relegated it to niche applications.

EPROM can be electrically programmed (one byte at a time) but must be exposed to ultraviolet (UV) light for about 20 minutes to erase all the bits in the memory array. EEPROM can be erased electrically and is programmable (one byte at a time). However, it uses more transistors to form a memory cell resulting in higher cost and lower density than EPROM.

Like ROM, EPROM and EEPROM, Flash is classified as non-volatile because it retains its data when power is lost.

Flash is a form of EEPROM that gets its name from its ability to electrically erase large sections of memory - blocks, sectors or pages - at the same time. Programming is still done one byte at a time. Like EPROM, Flash uses a single transistor to store a bit of information so it can achieve high memory densities. Some fabrication technologies even have the ability to store two bits per transistor.

There are two types of Flash technology – NAND Flash and NOR Flash. NOR has quick random access to any location in the memory array and is therefore typically used for code storage and execution. NAND Flash has a longer read access to the memory array and therefore is used mostly for data storage.

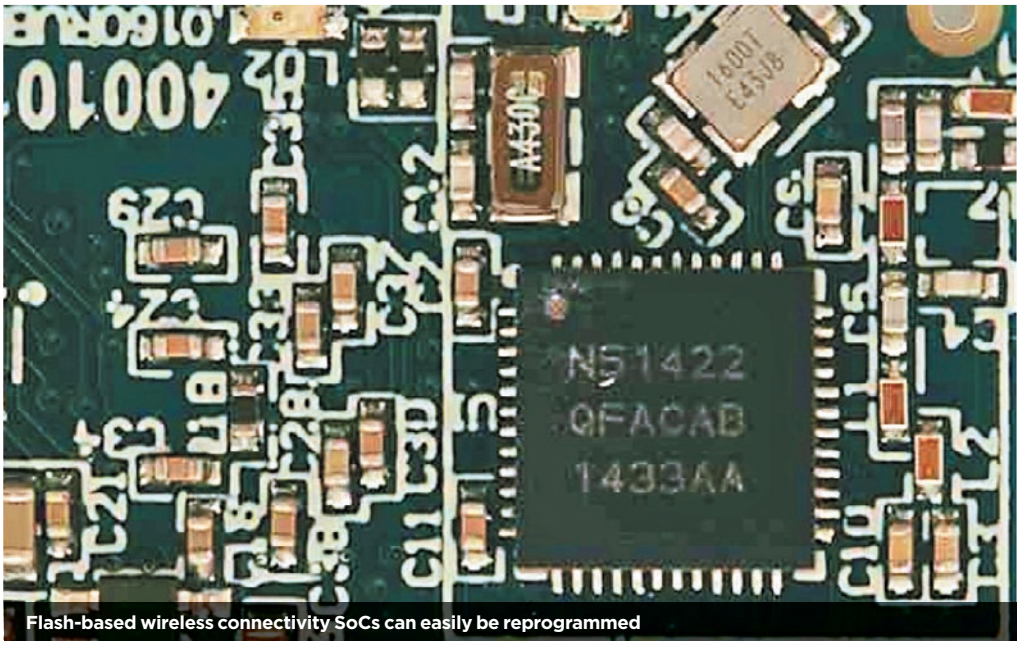
Early forms of Flash were limited in the number of times they could be overwirtten, but modern technology can be refreshed around a million times.

Partly because of these advantages, Flash has becopme by far the most popular non-voltaile memory in mobile consumer electronics. But its popularity was also boosted because the technology eliminated the primary problem with ROM, which is that it cannot be erased or reprogrammed.

Flash is not, however, the perfect non-volatile memory technology. It is considerably more expensive to manufacture than ROM because the wafer fabrication process takes at least ten additional mask steps. Second, compared to ROM, in which the memory bit is indelibly created during wafer fabrication, Flash adds time to the factory production process because it has to be electrically programmed.

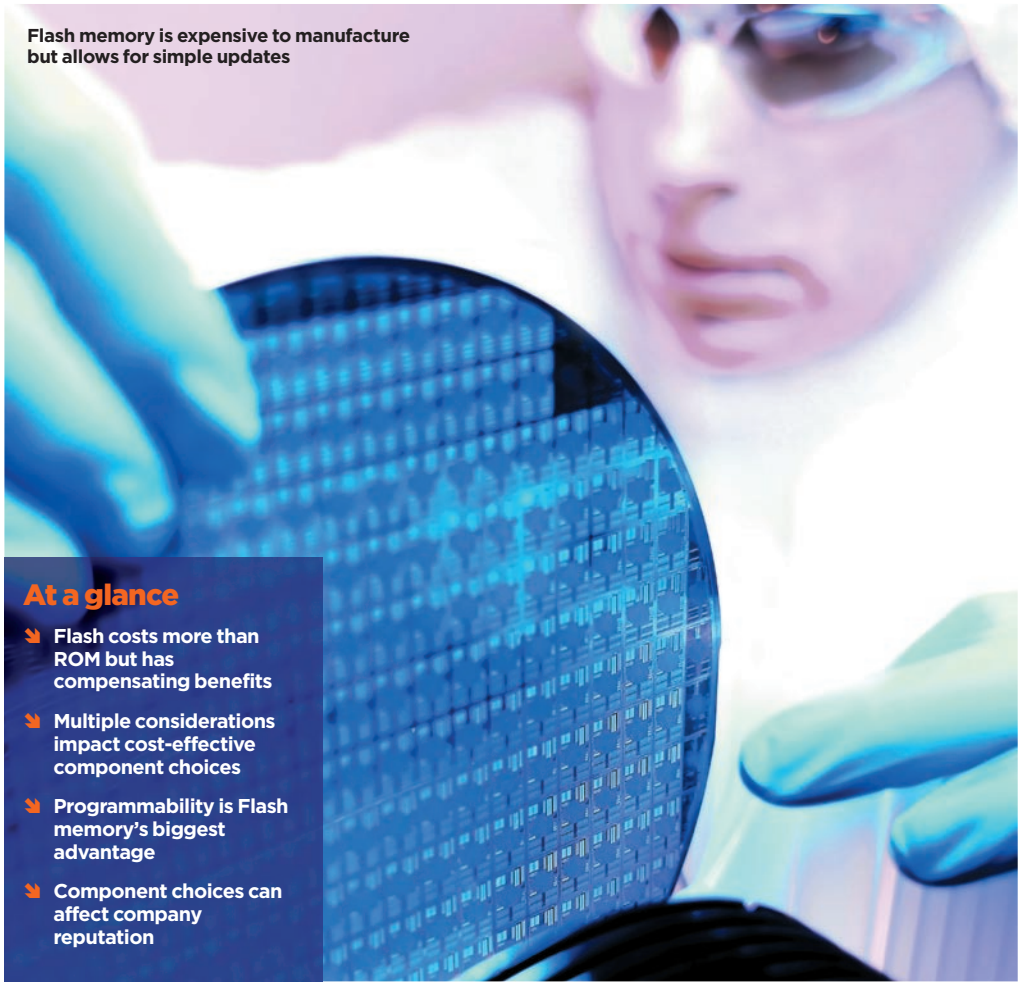
Increasing sophistication

The chips inside today's electronics products are more capable, sophisticated, and complex than yesterday's



Flash-based wireless connectivity SoCs can easily be reprogrammed

"Bluetooth Smart and ANT are the two leading protocols for ULP wireless systems and both support over-the-air (OTA) programming"



Flash memory is expensive to manufacture but allows for simple updates

At a glance

- Flash costs more than ROM but has compensating benefits
- Multiple considerations impact cost-effective component choices
- Programmability is Flash memory's biggest advantage
- Component choices can affect company reputation

components. And this increasing hardware complexity demands more from software. As a result of these demands, software evolves via routine updates.

For example, smartphone vendors constantly add new features, deploy bug fixes, and make security patches. For iOS and Android devices software updates are accomplished with a hefty amount of built-in Flash memory integrated into the processor, communications SoC, and dedicated Flash chips.

But what about systems that don't run a full-featured OS? In this product tier - which includes wearables and sensor-node products - the communications protocol and the applications software may require less frequent upgrades but they are nonetheless important.

Bluetooth Smart and Dynastream's ANT are the two leading protocols for ULP wireless systems and both support over-the-air (OTA) programming. OTA programming is only possible for chips with Flash memory.

Determining how much onboard Flash is needed is an key design decision not just for the initial software but also for updates. Updating is safer it there is sufficient Flash to store both old and new versions until the new is verified. (*See* ULP WQ *Summer 2014 pg 9.*) When protocol and application code are separate, the amount of "backup" Flash needed is reduced. Partitioning also eliminates the risk of corrupting application code when updating the protocol and vice-versa.

A third product tier embraces systems that have relatively few lines of code that don't change because the system's task is simple or mature. These products are a good fit for ROM.

Programmability matters

When a ULP wireless connectivity product goes into production, one critical step is programming the SoC with the protocol and application code. A lot can go wrong on a production line and it is not uncommon for the wrong version of the code to be programmed. Or, there may be a bug in the protocol. Other times, a manufacturing-line event such as a power failure or spike can corrupt the code. Although there is a time-and-money cost, Flash-based SoCs can easily be correctly reprogrammed if a manufacturer experiences any of these problems.

However, in the worse case, a product with the wrong code version or invalid or corrupted code could make it into the hands of consumers with potential damage to the company's reputation.

Nonetheless, without the ability to correct the problem quickly with OTA software updates to refresh the content of the product's Flash memory, the damage could be much greater.

While ROM memory is "programmed" at the chip manufacturing stage - avoiding some of the manufacturing line issues detailed above - errors such as incorrect versions or bugs in the protocol stack can still occur. Moreover, when the inevitable software upgrade is needed, a product manufacturer could be left with thousands of chips in its warehouse programmed with an old version of the software and no way to change it.

"If you're manufacturing 100,000 systems in a particular production run and 1,000 are improperly programmed before you identify the problem, resolving it will more than write off any savings made in purchasing a less expensive [ROM] part," says John Leonard, Tactical Marketing Manager for ANT and Bluetooth Smart chip vendor Nordic Semiconductor.

A final consideration for designers choosing between ROM and Flash for their next wireless SoC is the protection of intellectual property (IP). A seldom mentioned advantage of Flash memory is that the code it holds cannot be uncovered by the means frequently used by IP pirates, says Leonard. In an SoC that uses ROM, the reverse engineer's first step is to meticulously grind the chip down to the ROM mask layer. By examining which fuses are blown, each bit of the code can be read. This technique cannot be used for Flash memory because memory states are charge related.

Thanks to its programmability, the value of Flash memory has been well established for years in the communications, computer, and consumer markets. Similarly, the low-per-unit costs associated with ROM have made it an important memory product. Sometimes the relative merits of each technology are blurred by marketing initiatives and by the pressure to bring a system-level product to market at a particular price point. When the larger picture is considered, however, it becomes clear that – with the exception of a few applications – wireless designs are best served by the inclusion of an appropriate amount of Flash memory.

Book excerpt: 'Getting Started with Bluetooth Low Energy'

A new publication for mobile application developers and embedded engineers explains the fundamentals of Bluetooth Low Energy / Bluetooth Smart wireless technology

The Bluetooth specification covers both classic Bluetooth (the well-known wireless standard that has been commonplace in many consumer devices for a number of years now) and Bluetooth Low Energy (BLE - the new, highly optimized wireless standard introduced in 4.0). Those two wireless communication standards are not directly compatible and Bluetooth devices qualified on any specification version prior to 4.0 cannot communicate in any way with a BLE device. The on-air protocol, the upper protocol layers, and the applications are different and incompatible between the two technologies.

The Bluetooth Specification (4.0 and above) defines two wireless technologies: BR/EDR (classic Bluetooth), the wireless standard that has evolved with the Bluetooth Specification since 1.0; and BLE, the low-power wireless standard introduced with version 4.0 of the specification.

There are two device types to be used with these configurations: Single-mode (BLE / Bluetooth Smart) device; a device that implements BLE, which can communicate with single-mode and dual- mode devices, but not with devices supporting BR/EDR only. And dual-mode (BR/EDR/LE, Bluetooth Smart Ready) device; a device that implements both BR/EDR and BLE, which can communicate with any Bluetooth device.

Figure 1 shows the configuration possibilities between available Bluetooth versions and device types, along with the protocol stacks that allow these devices to communicate with each other.

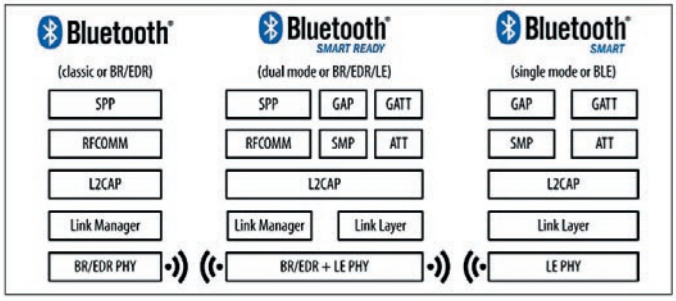


Figure 1: Configurations between Bluetooth versions and device types

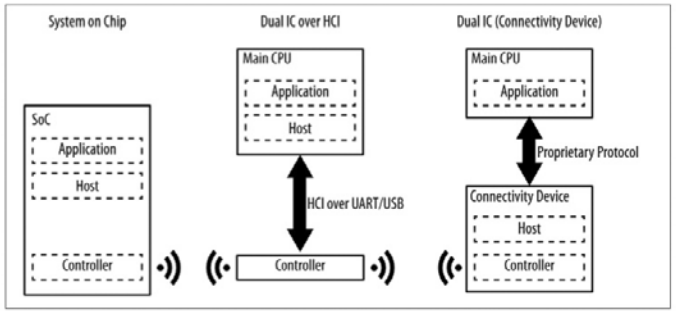


Figure 2: Hardware configurations

Building blocks

There are three main building blocks of every Bluetooth device: *Application* - the user application interfacing with the Bluetooth protocol stack to cover a particular use case. *Host* - the upper layers of the Bluetooth protocol stack. *Controller* - the lower layers of the Bluetooth protocol stack, including the radio.

Additionally, the specification provides a standard communications protocol between the host and the controller - the Host Controller Interface (HCI) - to allow interoperability between hosts and controllers produced by different companies.

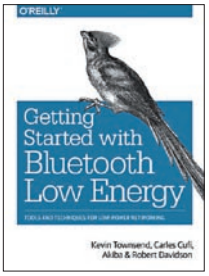
These layers can be implemented in a single integrated circuit (IC) or chip, or they can be split in several ICs connected through a communication layer (UART, USB, SPI, or other).

These are the three most common configurations found in commercially available products today: *SoC* (System-on-Chip) - a single IC runs the application, the host, and the controller. *Dual IC over HCI* - one IC runs the application and the host and communicates using HCI with a second IC running the controller. The advantage of this approach is that, since HCI is defined by the Bluetooth specification, any host can be combined with any controller, regardless of the manufacturer. *Dual IC with connectivity device* - one IC runs the application and communicates using a proprietary protocol with a second IC running both the host and the controller. Since the specification does not include such a protocol, the application must be adapted to the specific protocol of the chosen vendor.

Figure 2 shows the various hardware configurations with the layers of the Bluetooth protocol stack.

Simple sensors tend to use SoC configurations to keep the cost and printed circuit board (PCB) complexity low, whereas smartphones and tablets usually opt for the Dual IC over HCI configuration because they usually already have a powerful CPU available to run the protocol stack. The Dual IC with connectivity device configuration is used in other scenarios, one of which could be a watch with a specialized microcontroller to which BLE connectivity is added without overhauling the whole design. ■

*This is the first in a series of extracts from "*Getting Started with Bluetooth Low Energy*" by Kevin Townsend, Carles Cufí, Akiba, and Robert Davidson. The extract 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.*



adidas miCoach Smart Ball

Whether you call it "football" or "soccer", the roundball game is big business. According to Forbes magazine the top 10 richest clubs all hail from Europe with English club Manchester United at number one with a value of $3.44 billion and annual revenues of $675 million. But then, the outgoings are big too, with United laying out $93.4 million for Argentine Angel Di Maria among $234 million of spending on players this year. At a more modest $299.95, the adidas miCoach Smart Ball won't necessarily teach the user to strike the ball quite like United's new midfield maestro, but it will improve their kicking technique

Since if was first played under rules codified in England by The Football Association on 19 December 1863, the game of "Association Football" has expanded to become the world's most popular sport, played by 250 million players in over 200 countries. The five top European leagues - the Bundesliga (Germany), Premier League (England), La Liga (Spain), Serie A (Italy), and Ligue 1 (France) - attract the world's best players and each of the leagues has a total wage cost in excess of US$1.185 billion. Cost are partly offset by global TV deals. The Premier League, for example, generates in excess of $7.82 billion from selling global broadcast rights

The adidas miCoach Smart Ball uses a Nordic Semiconductor *µ*Blue™ nRF8001 Connectivity chip. The chip's ultra-low power (ULP) design helps the Smart Ball's rechargeable battery support around 2,000 kicks per week. The nRF8001 features sub-12.5mA peak currents and connected mode average currents as low as sub-12*µ*A (for 1s connection intervals). Depending on the duty cycle of the application, battery life in coin cell battery-powered wireless devices can extend to years. The chip is supplied in a compact 5 by 5-mm, 32-pin QFN package

Goalkeepers such as Chile's Claudio Bravo (pictured) require supreme fitness and athletic ability. In free kick situations on the edge of the 16.5m (18-yard) penalty box, the 1.85m tall player is required to react and dive in less than 440 milliseconds to save a ball struck at up to 135-km/hr heading for the top corner of the 7.32 by 2.44m (8 by 2.66-yard) goal. A free kick struck by Brazilian Roberto Carlos, for example, travelled 35m at speeds up to 130-km/hr to beat 'keeper Fabien Barthez in a game between France and Brazil in 1997

A six-axis MEMS accelerometer sensor package suspended in the middle of the Smart Ball continuously measures post-kick flight characteristics and streams data via Bluetooth Smart to a smartphone or tablet. A proprietary app then analyzes the data from which key ball parameters - such as how hard the ball has been struck, launch angle, spin rate, spin axis, and velocity - can be derived. The app allows visualization of flight trajectories and an option to take a video of a kick and replay it frame by frame. This collective information - which was previously impossible to gather - helps players improve their game, either alone, with friends, or under the supervision of a team coach

adidas miCoach Smart Ball

Motion sensor-packed, intelligent ball brings scientific analysis to soccer training

Key technologies converge to drive wearable electronics

The current boom in wearables owes much to the surge in smartphone use and the handsets' interoperability with ultra low power wireless sensors

By Svenn-Tore Larsen, CEO of Nordic Semiconductor

In 2006, Nike, the U.S.-based sportswear company, launched one of the first mass-market speed & distance sensors which, when attached to a sports shoe, recorded how far and fast the user ran.

Back then, wearable electronics were targeted at fitness gadget early adopters and used niche technology. But today, wearable devices have become the latest hot toys for the mass market. Analyst Markets&Markets, for example, estimates that the "global wearable technology ecosystem's" value will reach US$14 billion by 2018, growing at a compound annual growth rate (CAGR) of more than 18 percent from 2013 to 2018.

"Wearable electronics" covers a range of devices from computers such as Google Glass, through smart watches, fitness bracelets and heart rate monitors, to lowly pedometers. Some of these products feature color displays and functionality such as GPS receivers and therefore require the resources of rechargeable Li-ion batteries. But a growing proportion of wearable devices, particularly compact sensors, are designed to be light and unobtrusive, which limits space for a battery - yet are expected to operate for months or even years without cell swaps.

The tiny power-efficient chips that provide sufficient computational muscle yet can run off small batteries for long periods are one of the key technologies behind the wearable electronics revolution. Engineers didn't set out to design these chips specifically for wearable electronics, rather they came up with them in order to make the most out of the relatively puny batteries used in the first generations of portable computers and cell phones. Squeezing just a few hours of operation out of these early rechargeable cells demanded some novel silicon design.

The latest wearable devices, such as these 3-D pedometers from HMM Diagnostics GmbH, are designed to be light and unobtrusive.

COURTESY: HMM DIAGNOSTICS GMBH

Improving efficiency

One way that engineers improved the efficiency of silicon was by integrating more functions onto a single chip. For example, instead of using separate memory and microprocessor chips and then linking them together using the tracks on a printed circuit board (PCB), the devices were "embedded" onto the same slice of silicon. Embedded microprocessor and memory devices consume far less power than equivalent discrete chips on a PCB. An added bonus is that embedded devices take up much less space – an important advantage considering the Lilliputian internal dimensions of many mobile devices. It should come as no surprise to learn that embedded electronics technology was rapidly embraced by cellphone industry; for example, embedded processors based on intellectual property (IP) from U.K.-based ARM power the majority of the world's mobiles.

To keep power consumption down, Nordic Semiconductor employs similar high levels of integration in its latest generation of wireless chips. These devices embed an ARM processor, 2.4-GHz silicon radio and Flash memory onto a tiny slice of silicon measuring just 3.5 by 3.8 millimeters - making them a good choice for wearable applications.

Since the first generation of portable devices, batteries have steadily improved. However, along with that improvement has come an expectation from consumers that each new generation of handhelds offers more functions but with longer battery life – ensuring the engineer's battle to design chips that conserve power continues unabated.

A second technology essential to (and stimulating) the rise of wearable electronics is the proliferation of portable, Internet-enabled computers (otherwise known as a smartphones and tablet computers). In the next several years, sales of these devices are forecast to surge, with analyst Statista Research, for example, estimating there will be a cumulative total of 6.1 billion mobile devices globally by 2020.

Two factors have put mobile devices at the centre (literally and figuratively) of the wearable electronics revolution. First, mobiles will form the "hubs" that provide the processing power to collect and make sense of data coming from a personal network of wearable devices, then analyze, present and share that information. And second, the current generation of tech-savvy consumers have grown up with the smartphone and expect it to link seamlessly with other gadgets they buy so it can be used to control them.

The final technology that's driving the wearable electronics sector is wireless connectivity. Without this connectivity, body-worn devices would be forced to operate in isolation, greatly limiting their potential. The wireless link enables either a connection to a Wi-Fi bridge and from there to the Internet, or, increasingly, to the smartphones carried in virtually every consumer's pocket. In the latter case, the link allows the wearable electronics product to leverage the smartphone's powerful microprocessor, large color touchscreen and downloaded app software. ■

GSA Forum

This article was first published in *GSA Forum* in June 2014.

To see the article in full go to: http://www.gsaglobal.org/forum/2014/2/articles_8.asp (A free subscription is required to view the article)

PEOPLE & PLACES

Juha Heikkilä

R&D head of Nordic's new Finnish office relishes his role

Hi, I'm Juha Heikkilä and I'm the Head of Nordic Semiconductor's new R&D operations in Finland, based at Oulu in Northern Finland, and Turku on the Southwest coast.

I have enjoyed working in the semiconductor and wireless technology business for my entire professional life and before joining Nordic in November I was VP of Wireless Technology at Broadcom Communications.

Because Nordic's R&D operations in Finland were formed at high speed to take advantage of the recently announced layoffs in Oulu by several large technology companies, my main focus at the moment is on fully establishing Nordic's operations here as quickly and smoothly possible.

This includes identifying the core competencies and skills that will be required - with the focus being on developing wireless chip solutions for products to be used in the Internet of Things (IoT) market which is very wide and covers areas like IT networking and security, retail, transport, healthcare, CE, and home, energy and buildings automation.

Juha Heikkilä keeps in shape by taking part in skiing races

Personal Profile

NAME:
Juha Heikkilä

JOB TITLE:
Head of Nordic Semiconductor Finland

JOINED NORDIC:
November 2014

BASED:
Oulu, Finland

INTERESTS INCLUDE:
Hunting; Fishing; Skiing; Marathon Running

One of the things I really like about my job is the buzz of working for a small, fast expanding company and the opportunity to work with a team of such talented, enthusiastic and welcoming people - both on the business and management side, as well as the technology and R&D side.

Even though I have only been at Nordic for a short-time, I am really impressed by how a still relatively small company has managed to build a portfolio of class-leading, surprisingly low-cost, ultra low power wireless solutions that are the envy of the its competitors around the world.

Outside of work I like outdoor activities, which vary between seasons. Autumn is for hunting of both small (bird) and big (moose) game for which I have trained dogs. In summer, fishing takes my focus and includes an annual fishing trip to Finnmark which is my favorite fishing area, in search of trout, my favorite fish. Springtime brings a lot of white, powdery snow perfect for snowboarding and long-distance cross-country skiing which helps me maintain my fitness for my other outdoor passion: marathon running. ■

"Because Nordic's R&D operations in Finland were formed at high speed to take advantage of the recently announced layoffs in Oulu by several large technology companies, my main focus is on fully establishing Nordic's operations here as quickly and smoothly as possible."

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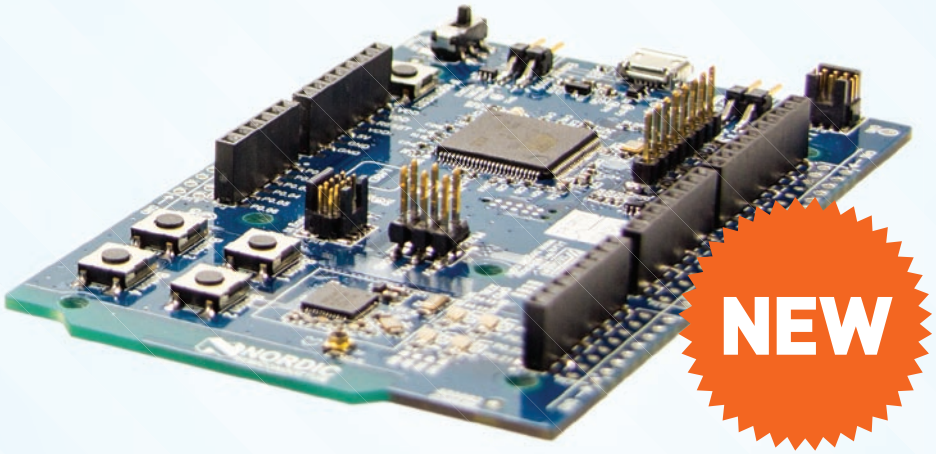

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