WQ
WIRELESS QUARTER

Issue 3, 2020

THE BUSINESS OF WELLNESS:
A QUIETLY BOOMING SECTOR BEYOND THE PANDEMIC

GUIDING LIGHTS:
A BRIGHT START FOR SMART CITIES

PRECISION POSITIONING:
BLUETOOTH LE AND UWB JOIN FORCES

Holding the Line

Using cellular IoT geofencing to fight global deforestation and conserve biodiversity

ACCURATE HIGH-VALUE ASSET TRACKING

CELLULAR IoT PROTECTS CYCLISTS AND BIKES

INSIDE A DUAL-CORE WIRELESS SoC

NORDIC SEMICONDUCTOR

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Welcome

Geir Langeland
Director of Sales & Marketing

Fighting the COVID-19 pandemic is still the global priority and it's a battle in which Nordic's customers are playing a critical role. But Nordic is also starting to look to a future where SARS-CoV-2, the virus behind the disease, is beaten and the world returns to normal – albeit a normal that's different from before.

Post pandemic, the world's most pressing problem will be the one with which it was grappling before priorities changed, that of global warming. The science points to a world where man-made emissions such as the carbon from burning fossil fuels has pushed up the world's mean temperature. This in turn, say the scientists, has caused an increase in the frequency of extreme weather events and rising sea levels among other major changes. Changes that will dwarf those brought on by coronavirus.

Deforestation of natural wildernesses such as the Amazon rainforest robs the world of major carbon stores. Brazil's National Institute of Space Research estimates nearly 20 percent of the region has been cleared compared to the forest's area in 1970. Some of this deforestation is officially sanctioned for agriculture and commercial logging, but much of it is illegal and damaging.

Just as it has done against the coronavirus, wireless tech and the IoT can help turn the tide of illegal deforestation and in this edition (*pg10*) we highlight one example. In a pilot project, Nordic's nRF9160 low power cellular SiP forms the heart and brain of a device that monitors the location of heavy machinery in the Amazon. While the equipment operates in legal forest zones no action is taken, but should the earthmovers and trucks wander, Nordic's technology immediately informs the authorities. It's a real-life demonstration of how to best manage the planet's natural resources and a pointer to a brighter future.

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News

The latest developments from Nordic Semiconductor

Smart Agriculture

Cellular IoT-powered farm storage tank tracks fuel levels


The CoreKinect TankTrack reader can be installed in under a minute

An agricultural storage tank that eliminates the common problem of farms running out of either fuel or fertilizer has been introduced by Arizona-based scalable hardware design and manufacturing specialist CoreKinect.

The CoreKinect TankTrack wireless gauge reader is based on Nordic's nRF9160 low power multimode NB-IoT/LTE-M SiP and is securely attached to any storage tank using four permanent magnets. CoreKinect claims the solution is so simple and easy to install that it can be done in under a minute. In part due to the nRF9160's low power consumption design, the battery powered monitor lasts for ten years and provides fill level, location, temperature and other critical information for a multitude of fuel types.

Tank level, GPS location and other readings are sent using the SiP's LTE-M connectivity to a Cloud display platform accessible from any smartphone, tablet or computer.

The company explains that the cost of avoiding even a single unnecessary fuel or fertilizer truck delivery would cover the entire purchase cost of its solution.

According to Ali Kozlica, Executive Chairman at CoreKinect, determining fuel and fertilizer levels has been a long-term challenge for farmers and "before the advent of cellular IoT technology a commercially viable way to remotely monitor levels in fuel storage tanks did not exist".

Kozlica explains that the lack of coverage and power requirements previously made such a solution cost prohibitive. "Now, with the Nordic nRF9160 SiP, all the major barriers are broken, and the rules have changed," he says.

"What's often missed about cellular IoT is that its range far exceeds traditional cellular voice and data signals used by smartphones," continues Kozlica. "We aim to install over 1.3 million TankTrack monitors over the coming years in the U.S."

Nordic and Qorvo collaboration extends to Ultra Wideband

Following Qorvo's acquisition of Ultra Wideband (UWB) pioneer Decawave, Nordic Semiconductor and Qorvo are expanding their partnership to include dual UWB and Bluetooth LE connectivity solutions.

"Nordic and Qorvo have built a solid partnership developing next generation cellular IoT solutions with combined expertise from both companies," says David Fullwood, Vice President of Sales for Mobile, Qorvo. "We expect our collaboration on Bluetooth LE and UWB will complement our partnership and accelerate the adoption of location-based technologies."

Nordic's nRF9160 cellular IoT SiP uses Qorvo's RF Front End (RFFE), advanced packaging and MicroShield technology.

Nordic and Decawave also collaborated previously and Nordic's nRF52832 SoC is integrated in Decawave's DWM1001C UWB and Bluetooth LE module.

Nordic and Qorvo anticipate their partnership and Qorvo's contributions to UWB will help to accelerate future product development.

Bluetooth LE and UWB are complementary technologies suited to a wide range of consumer and industrial IoT applications, particularly those demanding precision location measurement and proximity awareness. UWB can be used to provide micro-positioning accuracy in products including smartphones, the smart home, industrial asset tracking and automotive. (*See page 22.*)

"With UWB added to Qorvo's product range, our collaboration now covers three complementary technologies across a wide range of applications," says Geir Langeland, Director of Sales & Marketing with Nordic.

Smart Health

ECG monitor detects heart arrythmia

Healthcare manufacturer, MEZOO, has launched a wireless, wearable electrocardiogram (ECG) monitoring system, employing Nordic's nRF52832 SoC.

The HiCardi tag is stuck to the chest and enables continuous monitoring. It is suitable for bedside use or in place of an ECG Holter.

The wearable measures vital signs including one channel ECG, heart rate, body temperature, respiration rate and body posture, and detects arrhythmia in 'real time' at the device. The data is then wirelessly relayed by the Nordic SoC to the user's smartphone, where from the HiCardi app they can review their data.

The heart data can then be remotely viewed and analyzed from HiCardi's web platform by healthcare professionals.

Smart Home

Xiaomi ecosystem company launches Nordic Bluetooth LE smart lock

Shenzhen, China-based Lumi United Technology, a member of smartphone and electronics giant Xiaomi's ecosystem of companies, has released its Aqara Door Lock N200. The smart lock enables instant keyless door entry for multiple authorized users in domestic security applications.

Once installed, the lock can be paired to the user's smartphone or tablet and set up and operated from either the Xiaomi Mi Home app or the Apple Home app. A Nordic nRF52840 SoC provides the Bluetooth LE connectivity between the smartphone and door lock.

From the app users can configure the lock settings and remote alarms, and add, delete or update user information.

The user can also remotely monitor the status of the lock, review a history of when the lock has been opened, and receive push notifications in the event the lock is tampered with, or if the door has not been properly locked.

The Nordic SoC incorporates an Arm TrustZone CryptoCell-310 cryptographic module and an AES 128-bit hardware accelerator, supporting a wide range of asymmetric, symmetric and hashing cryptographic services for secure applications, and underpinning the security of the Aqara Door Lock N200 unlocking process. In addition, the smart lock supports NFC, fingerprint, password and temporary password, and emergency key unlocking.

Xiaomi Mijia and Apple HomeKit compatibility allows the user to connect the smart lock to other Xiaomi and Apple devices, as well as third party smart home devices, and then perform linked events. For example, turning off the lights and activating the security camera as soon as the door is locked.

"Bluetooth LE was the preferred wireless protocol for the Aqara Door Lock N200 because it provides fast, stable configuration for users without the need for Wi-Fi connectivity," says Dachuan Zhou, Senior Product Manager with Lumi United.

"We selected the nRF52840 SoC because of its ability to run Bluetooth LE and its Apple HomeKit compatibility," continues Zhou. "The software architecture is also an advantage because it allowed us to significantly reduce the size of the device's firmware."

The Aqara Door Lock N200 is compatible with Xiaomi Mijia and Apple HomeKit and can perform linked events when unlocked such as turning on the lights

Smart Health

pH monitor aids oral health strategies

U.S.-based health tech company Lura Health is developing an oral pH monitoring system that enables continuous monitoring of saliva pH (acidity) levels. The information can be used to create oral health strategies.

A Nordic nRF52810 SoC-powered M1000 tooth sensor sits on the patient's tooth and features a pH sensor and compensatory temperature sensor. The pH data is sent over the Bluetooth LE link to the patient's smartphone at 15 minute intervals.

From a smartphone app, the user can view their current oral pH data and trends, as well as receive recommendations for products that can assist in managing oral health such as mouthwash.

Sport & Fitness

Gym management platform analyzes equipment and zone use

A wireless gym management sensor platform that allows facility operators to monitor and record what equipment is being used and how, has been launched by technology startup D-Fetch.

The Gymplanner gym management platform comprises D-Fetch's MultiTracker device which integrates accelerometer, temperature, humidity, air pressure and magnetic contact sensors to track a range of data. The information can be used by operators of health and fitness clubs to determine which equipment in the facility is being under- or over-utilized and plan gym layouts accordingly.

The solution is powered by a Nordic nRF52832 SoC. The platform also features a Nordic nRF52810 SoC-powered motion detection sensor which performs as a discrete device for monitoring occupancy.

In addition, Nordic's nRF51822 SoC is deployed in networked access points as well as a proprietary centralized gateway to provide Bluetooth LE connectivity across the system.

Once mounted, the compact battery-driven sensors are able to accurately measure the usage of specific gym equipment and zones. For example, the accelerometer can measure equipment use and usage patterns to estimate loading for particular pieces of equipment. The information can then be used to determine where equipment bottlenecks and congestion occur, or where space and equipment could be better employed. The system can also be used to schedule preventative maintenance.

Industrial IoT

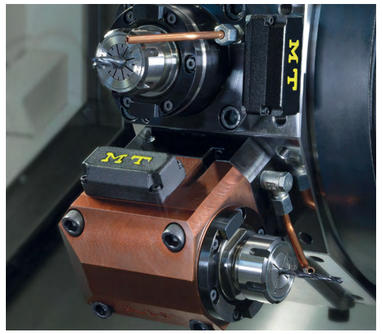
'World first' cellular IoT predictive maintenance product for toolheads

German IoT design house, InnBlue, has partnered with Italian static and driven toolholder manufacturer, M.T., to develop the world's first predictive maintenance and continuous usage-based warranty monitoring solution. The product monitors high speed driven toolheads by using Nordic's nRF9160 low power LTE-M/NB-IoT SiP.

A small, retrofittable battery-powered metal box with an external antenna, developed by InnBlue, is attached to an M.T. toolholder. Internal sensors collect data on toolhead spin speed, temperature, vibration and collisions. The toolhead location is also recorded using GPS. All data is processed using the nRF9160's edge computing capability and key changes are then wirelessly sent to the Cloud.

"If any abnormalities are detected the customer is alerted via a Cloud dashboard," says Oleh Lozynskyy, the Founder of InnBlue. "For example, an alarm is raised if the toolhead reaches an unusual temperature, or if we sense abnormal vibrations that would typically indicate something is going wrong with a critical internal component.

"We also use the accelerometer to detect ... collisions that will almost certainly have damaged the toolhead and potentially anything it is used on, even if the tool isn't broken."



By using cellular IoT, InnBlue says the need for a gateway is eliminated. Encrypted data is sent periodically to summarize how a toolhead has been used, and automatically in the event of an alarm.

"By spotting problems early they can be fixed more cost effectively instead of developing into expensive failures," says Lozynskyy. "If a warranty claim is made it can quickly be determined if it was caused by the toolhead being used out of recommended guidelines or a genuine warranty or parts failure. And it keeps driven toolheads operating optimally."

By the Numbers

$88.5 million in revenue

Nordic Semiconductor has reported Q2 2020 revenue of $88.5 million and a gross profit of $45.9 million, a 27 percent increase in profit over the same quarter in 2019. The company continued to see strong demand in several verticals including healthcare, consumer electronics and home office equipment. Cellular IoT, which is in the early stages of commercialization, generated revenues of $1.2 million. The company also ended the second quarter with a record order backlog of $201.9 million, which offers support for continued revenue growth in H2.

7 million missed hospital appointments

Data suggests a significant portion of the 6.9 million hospital appointments missed in the U.K. each year are as a result of navigation problems in sprawling hospitals. With each appointment costing an average of £108 ($140), that's nearly a billion dollars in lost productivity. Bluetooth LE beacon-based wayfinding systems are helping solve the problem, allowing for seamless connectivity with smartphones and letting patients and visitors view the hospital map on their device and navigate to their destination in the hospital in real time. Associated smartphone apps can also share helpful details such as contact information and hours of operation, descriptions and weblinks.

In Brief

KEEPING TRACK OF MISSING KEYS

Chinese wearable electronics firm, Beijing Zizai Technology, has released a range of wireless trackers that help users prevent the loss of personal items. The Nut 3 key finder can be attached to a key fob or other personal items and once paired with a smartphone using Nordic-powered wireless connectivity, the user can ring the device, set alerts if the tag and the smartphone become separated by a certain distance, as well as record the location where the device was disconnected.

NB-IoT PILOT PROJECT FOR UK WATER

U.K. water utility, Yorkshire Water, is in the final stages of an NB-IoT and AI pilot to connect almost 4000 acoustic, flow, pressure and water quality monitors to manage leaks and interruptions in the water network in the north of England. Billed as the U.K.'s largest smart water network pilot, the project is expected to deliver significant improvements in data quality and battery life, enabling the utility to identify and prevent leaks and network incidents more accurately. The platform will use AI to cluster data sets, and remove false positives, and to accurately inform asset and operational decision making.

CELLULAR IoT MODULE SHIPMENTS ON THE RISE

According to analyst, Berg Insight, global cellular IoT module shipments increased by 22 percent in 2019 to a new record level of 265 million. The research said LTE-M and NB-IoT would contribute substantially to growth in the coming five years. It added that cars equipped with 5G IoT modules, video surveillance, as well as other multimedia applications would drive growth over existing wired communications solutions.

INDUSTRIAL IoT ON THE CHARGE

IoT connections driven by early industrial deployments and pandemic-driven telemedicine applications are projected to reach 83 billion by 2024, a 130 percent growth rate, as IoT platform revenues jump an estimated 20 percent this year to $66 billion, according to estimates by analyst Juniper Research. Despite security and data privacy challenges, the market tracker predicts IoT deployments will be largely unaffected by the economic downturn created by COVID-19.

Logistics & Transport

Bluetooth LE fuel level sensor helps fleet managers track usage

Escort, a Russia-based technology company, has released the Escort TD-BLE fuel level sensor, a platform designed for the transport telematics market. The device is claimed to be the world's first wireless capacitive fuel level sensor integrating Bluetooth LE technology.

Once installed into a vehicle the device is configured and commissioned via a smartphone app, and then enables fleet managers to remotely monitor the amount of fuel being used by that vehicle.

The device employs a Nordic nRF52832 SoC to wirelessly send the collected fuel level information via Bluetooth LE connectivity to a Bluetooth- and GPS-enabled tracking device.

Alternatively, the fuel level sensor can be connected to trackers that don't offer Bluetooth LE connectivity via the company's proprietary BLE-BASE wireless adapter.

The fuel level sensor relays data to the BLE-BASE—which also integrates a Nordic SoC—that in turn can send the data to a tracker via an RS485 interface.

Once the data is transmitted from the fuel level sensor to the tracker, the data can then be transferred to the Cloud—typically via the GSM channel, or in rare cases via satellite—where the detailed information and insights can be viewed through a web-based dashboard. This information allows fleet managers, for example, to closely monitor the fuel consumption of individual vehicles, track a whole fleet more efficiently, reduce operating costs by optimizing routes, and assess breaches of protocol by drivers.

Escort TD-BLE uses a lithium-thionyl chloride 2600mAh battery to provide approximately seven years of continuous operation before replacement, thanks in part to the ultra low power characteristics of the Nordic SoC.

Smart Health

Lung transplant patients benefit from remote monitoring

To provide another layer of support for lung transplant recipients, the Keck Medicine of University of Southern California's (USC) lung transplant team launched a two year observational pilot study to monitor patients post discharge using Bluetooth LE-enabled devices and computer tablets.

Lung transplantation has become a viable option to extend lives and improve quality of life. However, once lung transplant recipients leave hospital, they may experience complications. These include problems such as infection or organ rejection and can result in unplanned hospital readmissions and other poor outcomes.

One of the many challenges patients face is managing their health from home and adhering to medication schedules.

The devices measured blood pressure, heart rate, weight, blood glucose, oxygen saturation and pulmonary function. The researchers discovered that monitored patients had 44 percent fewer hospital readmissions and spent 54 percent fewer days in the hospital when readmitted.

"This study is significant because it is the first to use Bluetooth technology to comprehensively monitor transplant patients," says Felicia Schenkel, MSN, lung transplant manager and lead author of the study.

Twenty-eight lung transplant patients received the two year remote tracking and 28 matched control patients did not. With the exception of remote monitoring, all patients received the same level of post-surgical care.

Monitored patients used computer tablets to report symptoms, track appointments and medication compliance, conduct videoconferences with staff and access educational videos along with other materials.

According to Schenkel, the at-home tracking worked for two reasons. "With constant monitoring, we were able to react to data sooner and take intervening steps before a patient's condition worsened," she explained.

Bluetooth LE robot camera takes a ride on beetle backs

Researchers at the University of Washington (UW) have developed a tiny wireless steerable camera that can also ride aboard an insect. The camera, which streams video to a smartphone at 1 to 5 frames per second, sits on a mechanical arm that can pivot 60 degrees.

This allows a viewer to capture a high-resolution, panoramic shot or track a moving object while expending a minimal amount of energy. To demonstrate the versatility of this system, which weighs about 250 mg, the team mounted it on top of live beetles and insect-sized robots.

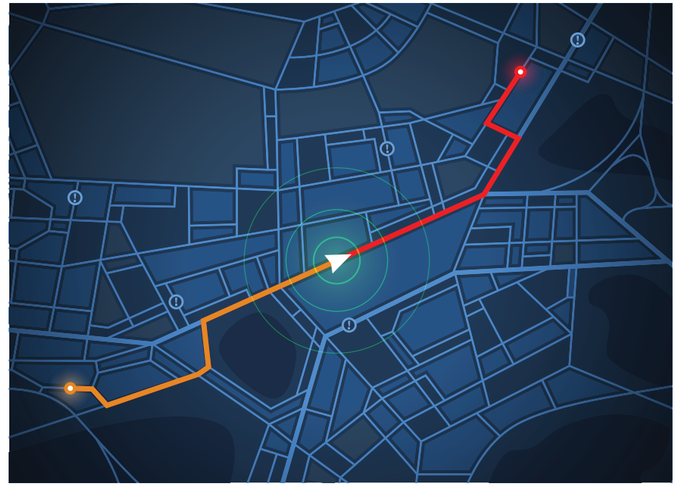
The researchers used a tiny, ultra-low power black and white camera that can sweep across a field of view with the help of a mechanical arm. The camera and arm are controlled via Bluetooth LE from a smartphone from a distance up to 120 meters away.

"[To save power] we added a small accelerometer to our system to be able to detect when the beetle moves" says co-lead author Vikram Iyer, a UW doctoral student in computer engineering. "Then it only captures images during that time."

News Extra

Door-to-door high value asset tracking nearing mass deployment

Compact and battery-friendly ShipSafe combines Wi-Fi, GPS and cellular IoT to track valuable assets indoors or outside with ten-meter precision



The pandemic has spurred a massive increase in online shopping and, in turn, the delivery services that move the goods from warehouse to the customers' homes. And in a post COVID-19 world the momentum will be unstoppable. The transition to home delivery has also seen a proliferation of apps enabling the customer to gain a rudimentary insight in to how delivery is progressing and when the goods might arrive.

But what if the delivery is urgent, highly valuable and delicate? Items such as ventilators, biomedical equipment, high-end industrial equipment or even human organs for transplant can't be held up or damaged because they're needed in a hurry. For such deliveries precise and timely tracking is a must. It's a problem which New York-based Crosby Technologies set out to answer and the company's solution, ShipSafe, is about to hit the market.

ShipSafe offers ten-meter positional accuracy and relies on Nordic's nRF9160 low power cellular IoT SiP's powerful application processor and LTE-M connectivity to support high-value asset tracking applications. Better yet, because the nRF9160 was intentionally designed to minimize power consumption, ShipSafe offers up to two years of battery life from a rechargeable 3200 mAh lithium-ion polymer (LiPo) battery.

The compact and lightweight asset tracker includes a built-in accelerometer to detect potentially damaging impact during shipment and an LED which can be remotely triggered to aid visual location of a package. ShipSafe also has a built-in temperature and humidity sensor to monitor transit conditions.

Saving battery life smartly

The key to ShipSafe's remarkable battery life is the innovative way Crosby has combined Wi-Fi location with GPS and cellular IoT technologies. Using GPS for full-time position tracking is a major power drain (and is no use indoors where the satellite signals are shielded). Instead ShipSafe uses the signals from nearby Wi-Fi routers to determine its position. There are some five billion of these routers in the U.S. and databases record the position of each. ShipSafe triangulates the signal from several routers and by consulting a database is able to determine its own position to within ten meters. On the occasions where the Wi-Fi coverage is patchy, the asset tracker reverts to a GPS signal to determine its location.

> The combination of features like the processor and memory, speed of operation and low power consumption makes the nRF9160 a winning product

But using Wi-Fi positioning alone is not enough to extend battery life to years. To save even more power, ShipSafe remains in a very low power sleep state only reporting its position when triggered by the user. This allows the asset tracker to make full use of the nRF9160 SiP's support of enhanced discontinuous reception (eDRX) (and in particular eDRX at very low currents) to dramatically extend the time that it can spend in the sleep state from the few seconds typical of conventional cellular modems to up to 40 minutes. At the end of this period, ShipSafe will wake up still synchronized with LTE-M's "paging windows" – the period when data can be transmitted and/or received from the network - aiding fast response.

The extended sleep cycle doesn't compromise the application; when a user contacts ShipSafe (via a smartphone app and the cellular network), the nRF9160 wakes rapidly and sets to work. The user experience is virtually seamless. "Compared with a competing cellular product we used previously, the nRF9160 draws an order of magnitude less power because of the speed at which it performs location data transactions. The SiP is far and away the fastest solution we've tested," says Jerry Pietroforte, Chairman of Crosby Technologies.

The nRF9160's 64 MHz Arm Cortex-M33 processor backed by 1 MB Flash and 256 KB RAM provides sufficient computational power to not only run the LTE-M cellular connectivity but also all other ShipSafe functionality.

ShipSafe's software and platform is provided by M2MD Technologies, an Atlanta-based software firm. "The Nordic SDK is extensive and it's easy to build on the feature set that's included with it," says Chuck Link, CTO and President of M2MD. "That accelerated our development program because we were able to take the SDK's asset tracking features and then just customize the software."

"The nRF9160 has truly been a game-changer for us," adds Pietroforte. "The combination of features like the processor and memory, speed of operation and low power consumption makes the nRF9160 a winning product."

Tech Check

The nRF9160's 10 by 16 by 1 mm form factor enables ShipSafe to incorporate the SiP, a Wi-Fi chipset, sensors, LED, peripheral components, battery, and Wi-Fi and cellular antennas into a device measuring just 120 by 75 by 16 mm and weighing only 145 gm

Bluetooth LE becomes the new market standard

The low power version of Bluetooth short range wireless continues to drive significant growth across key sectors

For more than two decades, Bluetooth has consistently adapted to meet the increasing demands of wireless developers. Today the technology supports countless applications across a broad range of industries on the journey towards a connected world. In the process, Bluetooth technology has boomed – a trend set to continue well into the future.

Bluetooth enabled device shipments "will continue to increase with no sign of slowing down," according to the *Bluetooth Market Update 2020*, a Bluetooth SIG report supported by updated forecasts from industry analyst ABI Research along with insights from several other analyst firms. In 2015, three billion Bluetooth enabled devices were shipped, with the annual total rising to 4.2 billion shipments in 2019. The report predicts a CAGR of eight percent until 2024 when the annual total will hit 6.2 billion.

While classic Bluetooth proved a good solution for consumer applications, Bluetooth LE has emerged as the preferred wireless protocol because its capabilities have evolved to approach those of the original protocol but with much lower power consumption. Bluetooth LE tech is expanding at a rapid rate and remains the fastest growing form of Bluetooth radio with a CAGR of 26 percent. Today, almost all new mobiles, tablets and portable computers support both Bluetooth radio versions (classic and LE), but it's Bluetooth LE alone that's responsible for driving the majority of the growth in Bluetooth connectivity.

Live market prospects

Bluetooth technology is a driving force behind the emergence and future prospects of markets including connected devices, smart industry, smart building, smart home and smart city.

Every day, millions of connected devices including tools, toys, toothbrushes and more turn raw data into meaningful information and insights for users thanks to the power of Bluetooth. Annual Bluetooth connected device shipments have risen from 180 million in 2015 to 540 million in 2019. This includes an anticipated 119 million smartwatch shipments, 130 million Bluetooth-enabled personal tags and inventory trackers, and 83 million shipments of Bluetooth connected endpoints that fall outside traditional device category definitions (up from 27 million in 2019), demonstrating that almost any device can become smart through a Bluetooth connection.

Nordic's Bluetooth LE wireless solutions support numerous customers in the connected devices sector. For example, Upright Technologies' UPRIGHT GO 2 is a Bluetooth LE personal posture trainer that attaches to a user's back and provides body alignment feedback to a smartphone companion app via the Nordic SoC-enabled Bluetooth LE connectivity. Global oral hygiene giant, Colgate, also employs a Nordic SoC in its Colgate Electronic Toothbrush, which is paired using Bluetooth LE to the free Colgate Connect app allowing the user to track how well they brush across mouth zones.

Annual Bluetooth smart industry device shipments are expected to reach 335 million in 2024, up from 88 million in 2019 and just 51 million the year prior. This anticipated growth is due in part to the improved location accuracy and robustness of Bluetooth technology, which supports commercial and industrial IoT solutions aimed at increasing workplace safety and security, reducing costs and enhancing operational efficiency. The latest Bluetooth innovations in range, speed and advertising channels provide data for more informed decision making and support predictive maintenance across a variety of industrial and commercial environments. For example, smart industry solutions such as the ABB Ability Smart Sensor, Lynxemi's Temperature and Vibration Sensor, and National Instruments' MON-10411 Wireless Vibration Sensor all employ Nordic Bluetooth LE connectivity allowing plant maintenance personnel to remotely monitor the diagnostic health data of critical assets in the field for preventative maintenance purposes.

By 2024 there are expected to be 451 million annual Bluetooth smart building device shipments. Location services including in-building wayfinding, asset management and space utilization solutions form the majority of this market. Bluetooth mesh networking is also powering a surge in connected lighting and asset tracking tags are allowing facilities to geofence harsh environments and critical assets to protect personnel and equipment. The number of annual shipments of Bluetooth asset tags in manufacturing is forecasted to grow from 66 million in 2020 to 217 million by 2024. One example, BlueCats' BC2500 industrial asset tracking solution, employs Nordic's nRF52840 SoC to relay asset location data to the Cloud via a gateway using Bluetooth LE, enabling geospatial tracking of business critical assets such as vehicles, containers and heavy equipment across large controlled sites.

Need to Know

In 1998, the not-for-profit Bluetooth Special Interest Group (SIG) was formed to oversee Bluetooth technology—a simple, flexible and secure wireless communication solution—and serve industry leading member companies around the globe. By the turn of the century, the first mobile phone with Bluetooth capacity had entered the market. In 2020, the total number of annual Bluetooth device shipments is set to hit 4.6 billion

> "Today, almost all mobile devices support both Bluetooth classic and LE radios, but it's Bluetooth LE alone that's responsible for driving the majority of the growth

Around the house

Annual shipments of Bluetooth smart home devices—comprising home automation, lighting control and connected home devices—are expected to double from 910 million in 2019 to 1.82 billion in 2024. The connected home will lead the way with one billion shipments of Bluetooth devices such as OEM remote controls, speakers, TVs, and other home audio and entertainment devices.

On an even grander scale, Bluetooth technology is also connecting tomorrow's smart cities to enhance the quality of life for citizens and expand the possibilities for organizations. The forecast is for five times growth in annual shipments of Bluetooth smart city devices (48 million in 2019 to 234 million in 2024), highlighted by a $10.2 billion market for global beacon technology as location services are deployed in airports, hospitals, stadiums, tourism centers and shopping malls.

By the Numbers

7.5 billion
devices containing Bluetooth LE will be shipped in the next five years

1.4 billion
connected device annual shipments in 2024

1.8 billion
connected lighting devices by 2028

Bluetooth device shipments in the smart building market jumped from 48 million in 2018 to

95 million in 2019

Svein-Egil Nielsen
CTO: Nordic Semiconductor

What happens at home stays at home

Consumers won't tolerate smart home tech that spies on them

One of the biggest debates at CES earlier this year was why consumers don't want to risk personal information captured by smart home devices leaving the building.

Embarrassing security breaches go some way to answering that question. For example, in mid-2019, *Forbes* magazine reported that two billion records in an online database had been exposed in a single smart home-device security breach and included "everything from user passcodes to account reset codes and even a smart camera recorded conversation".

Elsewhere a shadow of doubt was cast over the popular Amazon Ring smart doorbells. *Wired* magazine described "a lot of creepy and concerning news" about how these smart doorbells were "bringing surveillance to suburbia and sparking data-sharing relationships between Amazon and law enforcement". The tech magazine added: "the situation with Ring is far from unique. At the beginning of the year, for example, hackers launched similar attacks against Nest cameras, complete with incidents where hackers were creepily talking to children through the devices."

Episodes like these demonstrate how a hacked smart home device puts people's privacy and safety at risk in the one place they should feel most safe and secure.

Keep it in the family

The only way to prevent hacking today is to disconnect a device from the Internet. Devices like smart speakers need to connect to the Internet sometimes, for example, to look up information when asked a question. But private data like voice and video should never be exposed to prying eyes.

The industry is coming to realize that success in the smart home won't come from trying to share information about consumers that they don't want known. Consumers have seen what can happen and they don't want to take the risk.

It's a risk that's only set to escalate as voice and other biometric data becomes ever more valuable in the future. In many cases that data could become a unique digital key used to identify the consumer in all kinds of transactions. There is a precedent in how to protect this information; the thumbprint or face ID used to open a modern smartphone is only ever saved locally on a highly secure and encrypted part of the phone and is never sent to the Cloud.

Next generation smart devices will not send user data outside the home. In the future all data processing will happen at the edge of the home network using the powerful embedded processors supported by lots of memory and Cloud connection will be kept to a minimum.

Holding the Line

Innovative, wireless tech solutions can help reduce global deforestation and conserve biodiversity

In Short

As global demands for food, materials and energy increase, the world's forests are increasingly subject to threats like illegal logging

Protected land zones in rainforests are critical for biodiversity conservation but restrictions in these areas are difficult to enforce

The Nordic-backed 'Code of Conscience' initiative aims to help NGOs, governments and communities monitor and restrict heavy vehicles in protected areas

Other innovative wireless conservation technologies, including remote monitoring systems, are helping to reduce deforestation

Around a third of the Earth's land surface is covered by forest. Across the globe, forests provide food and habitats for wildlife and indigenous populations, protect vulnerable ecosystems, stabilize weather patterns and play an ever more vital role in reducing the impact of climate change. In a 2018 joint statement, the United Nations' environment, development and agriculture chiefs asserted "forests are a major, requisite front of action in the global fight against catastrophic climate change — thanks to their unparalleled capacity to absorb and store carbon."

Unfortunately, these same forests are experiencing a consistently alarming decline. Increasing global demands for food, materials and energy are leading to damaging levels of deforestation and forest degradation. The harsh reality is that human-driven threats including farming, livestock grazing, mining, drilling, logging and urbanization, as well as natural events like drought and wildfires, combine to decimate forests and harm terrestrial biodiversity. According to a landmark report by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), approximately 2.9 km^2 of native forest cover was lost from 1990 to 2015 due to clearing and wood harvesting, 50 percent of agricultural expansion occurs at the expense of forests and ten to 15 percent of global timber supplies are provided by illegal forestry. The report notes there was a seven percent reduction of intact forests from 2000 to 2013 alone in developed and developing countries.

The problem is becoming chronic; between 1990 and 2016, the world lost 1.3 million km^2 of forest—an area larger than the size of South Africa—according to the World Bank's 'World Development Indicators' database. In 2018 alone, global tropical tree cover shrank by 120,000 km^2 – the fourth-highest annual decline since records began in 2001, according to data provided by Global Forest Watch (GFW), an initiative of the World Resources Institute. The GFW open source web application monitors tree cover losses from Brazil to Ghana in real time using satellite imagery and remote sensing technology. Meanwhile, the World Wildlife Fund (WWF) claims on average, the world loses 75,700 km^2 of forests annually — the equivalent of 27 soccer pitches every minute.

Attempts to arrest deforestation rest in major part on protected land areas, particularly within tropical rainforests. These are proving critical for biodiversity conservation as well as the continued existence of culturally rich local communities. But borders, regulations and restrictions don't entirely guarantee the health and safety of a forest.

For example, despite the presence of conservation programs and dedicated efforts on the ground, about 20 percent of the world's largest intact forest, the Amazon, has been lost in the last five decades, according to WWF. Satellite data released by the Brazilian Space Agency's deforestation monitoring system shows deforestation of the Brazilian Amazon (which makes up 64 percent of the 6.9 million km^2 Amazon basin) has accelerated drastically following a spike of invasions to exploit natural resources amid the COVID-19 pandemic. Our forests need help.

CODE OF CONSCIENCE

Thankfully, innovations in environmental conservation-related technology may offer some light at the end of the canopy. One promising initiative aims to help NGOs, governments and communities around the world monitor and restrict the use of heavy-duty vehicles—the kind that are used to rip through the forest in both legal and banned logging operations—in protected areas. Launched in September 2019 by a collective of designers, engineers and content creators led by global agency AKQA, Code of Conscience is a proof-of-concept (PoC) to protect against illegal deforestation. Open source software uses publicly available, regularly updated, cached and compressed mapping data, in conjunction with existing GPS tracking technology installed in construction vehicles, to autonomously restrict crews from entering protected zones (as determined by the UN World Database on Protected Areas). The open source software provides the GPS-based geofence capabilities which interlock with the fuel pump systems of the machinery, enabling automatic shutdown if the equipment moves into a restricted area.

Integrated cellular connectivity enables notifications and audits of the machinery's position during normal operation and also provides a method of updating map data. A small, low-cost chip has also been developed to equip older, non-GPS vehicle models with the same code. With a vision for all new machines to leave the factory with Code of Conscience technology pre-installed, the collaborative sent the CEOs of the world's top-ten construction equipment manufacturers an invitation to participate in the initiative along with the Code of Conscience chip embedded in a wooden sculpture of an endangered animal.

"We made the Code of Conscience open source because we wanted to be transparent about how simple this initiative is from a technology standpoint," says Tim Devine, Executive Creative Director at AKQA (Australia and New Zealand). "The sociopolitical challenges of implementing this at scale are the most urgent to solve. Many of the regions where the Code of Conscience will be useful have complex sociopolitical conditions with extreme environmental variation."

The collaborative began by working with NGOs, governments and local communities to pilot a project in the Amazon—using Nordic Semiconductor's Nordic Thingy:91 multisensor cellular IoT prototyping platform—to demonstrate its PoC design for tracking forestry and agriculture vehicles, both on land and water. Looking ahead, the goal is to establish more key partnerships to help accelerate the Code's transition from PoC to adoption.

"Telematics exists in hundreds of millions of vehicles worldwide, many of which are heavy vehicles used in forestry and agriculture. If there was the will, we might be able to [use it to monitor those vehicles], potentially saving millions of hectares of protected forests," says Devine.

It's a sentiment shared by Matthew Adams, Lead Engineer at Tekt Industries, the Australia-based technology company responsible for developing the original hardware

By the Numbers

THE GLOBAL IMPACT OF DEFORESTATION

It is estimated that over

15 billion

trees are cut down each year

Source: Tree density projections from a 2015 'Nature' journal study

75%

of the land-based environment has been severely altered by human actions

Source: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)

Up to

90%

of logging in tropical rainforests is illegal

Source: UNESCO

Forest loss contributes to around

15%

of all harmful greenhouse gas emissions

Source: World Wildlife Fund (WWF)

for Code of Conscience based on Thingy:91. "Citizens are beginning to look at intentionality in the design of products, and companies manufacturing these machines have the opportunity and the power to shape the future of our planet through the responsible design of their machinery," says Adams. "Long-term we hope to see greater accountability and transparency for all machinery which works around protected sites worldwide."

The Thingy:91 proved an ideal 'out-of-the-box' solution forming the foundations for a future custom device, according to Adams. "Given the remote installation and potential support issues with the hardware, the Thingy:91 was a natural choice as a proven low-risk technology which could easily be taken up by OEM partners and effortlessly integrated into their machinery," he says.

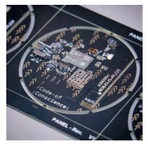
SHOWING INITIATIVE

Wireless tech is also being embraced by innovators as a potential solution to other global forest environmental conservation challenges.

For example, inspired by the UN Global Goals initiative, the not-for-profit Micro:bit Educational Foundation invited children and teens to design sustainable development solutions using the Nordic-powered micro:bit, a tiny yet powerful pocket computer with wireless capability. (*See WQ Issue 4, 2019, pg8.*)

Young coders around the world responded to the "do your:bit" BBC micro:bit challenge by creating an impressive variety of tech-based sustainability solutions, including a number designed to help protect life on land.

The North America winner, Lynn, created a unique device for highlighting the dangers of deforestation to local communities by detecting loud sounds in forests. Using a Raspberry Pi ultra-compact computer with a connected camera and a microphone that communicates with the micro:bit, the system wirelessly relays an audio signal then automatically takes a photo and posts it to a public Twitter account. A local park ranger can then review the picture to determine the source of the noise—which could be the crack of lighting or something more sinister, for example, the buzz of a chainsaw—and respond accordingly.



Tech Check

The Code of Conscience PoC uses the Nordic Thingy:91 to support an initiative to restrict heavy vehicles from entering protected land areas. Built around the nRF9160 SiP, the Nordic Thingy:91 is a prototyping platform for cellular IoT using LTE-M, NB-IoT and GPS. It is ideal for creating PoC demos and prototypes. Cellular connectivity alongside GPS makes the product suitable for sophisticated asset tracking solutions

The Middle East winner, Zayd, created the Z Palm Tree, a complex device enabling a tree to 'communicate' its needs. The system uses multiple sensors including a vibration sensor to detect the tree being felled, a flame sensor to detect the tree being burned down, a moisture sensor in the ground to detect water level and a temperature sensor to measure the air temperature. All the collected sensor data is sent to a bespoke smartphone app using either Bluetooth LE or Wi-Fi connectivity, providing the user with updates on the tree's status and warning of any impending or immediate dangers.

At the 2019 Zoo Hackathon event in Bogota, Colombia, teams proposed a number of technical solutions for controlling the production chain to combat illegal logging and deforestation. The solutions needed to be inexpensive, scalable, interoperable with the Colombian Ministry of the Environment and Sustainable Development's information system and exclusively based on open source development services. The winning team presented a solution to track logging from extraction to manufacturer using an IoT device installed in trucks. The device detects anomalies, for example a deviation from an established route, and sends suspicious activity alerts to authorities.

REMOTE FOREST MONITORING

A number of other environmental innovators see the ability to remotely monitor activity in forests as the key to reducing global deforestation and conserving biodiversity. Brazilian startup Treevia has developed SmartForest, a wireless sensor-based monitoring system that enables the remote tracking of forest growth rates in real time. Once fixed around trees, the sensors capture changes in tree diameter at regular intervals. The collected data is relayed via a wireless network to the company's customized web-based system. The information is then combined with satellite images and analyzed by machine-learning algorithms to detect early signs of infection or pest attacks on plantations and provide researchers and technicians with reliable estimates on how well the forest is developing.

San Francisco-based not-for-profit, Rainforest Connection (RFCx), has developed a solar-powered, wireless acoustic monitoring system using modified recycled smartphones fitted with an extra microphone to continuously monitor the sounds of the forest. Using the standard local cellular network, all the audio is relayed from the canopy-mounted 'Guardian' devices to Cloud-based servers. Google's TensorFlow machine learning framework then uses AI techniques to continually monitor and detect the telltale indicators of illegal deforestation activity, such as the specific sounds made by heavy machinery. Text alerts can be automatically sent to local authorities for further investigation, while the comprehensive ecosystem data also assists with negotiations for greater protection in these areas. Various partners on the ground are using the RFCx system in projects to protect rainforests across Brazil, Peru, Ecuador, Costa Rica, Romania, Cameroon, South Africa and Sumatra.

Meanwhile a joint venture between the International Institute for Applied Systems Analysis (IIASA) and business intelligence tools company, SAS, has launched an initiative to combat deforestation by engaging crowdsourced 'citizen scientists' to examine satellite images of the Amazon rainforest for signs of human impact, such as roads and forest clearances. At the same time, the system uses the human input as a method of training the AI to detect human activity in future. As the volunteers carry out the work using a Cloud platform, an AI engine is continually learning how to accurately perform the same task at a much faster rate.

Whether it's customized cellular IoT devices installed on construction vehicles to prevent illegal logging activity, machine learning systems tracking data on forest growth, smartphone-based acoustic monitoring devices reporting sounds of destruction or earth-imaging satellites mapping changes to land use for review by volunteers, technology is now at the forefront of the fight against deforestation and the battle for biodiversity. Wireless and non-wireless surveillance solutions may not be able to save the forests on their own, but remote access to actionable information and real-time alerts could effectively support the individuals, organizations and communities prepared to make a difference.

> "Long-term we hope to see greater accountability and transparency for all machinery which works around protected sites worldwide

Mixed results for corporate biodiversity targets

Many everyday consumer goods directly or indirectly contribute to the issue of deforestation. For example, tropical rainforests are often illegally logged or cleared to grow plantations of commodity crops such as palm oil, which is found in around half of all packaged products. Palm oil is cheap and versatile, making it a popular choice for manufacturers and retailers everywhere. These days, buyers and users are strongly encouraged to purchase only products containing Certified Sustainable Palm Oil. When a company continues to purchase unsustainable commodity crops like palm oil sourced through deforestation, it is effectively funding forest destruction and biodiversity loss.

The good news is that corporate attitudes to these challenges are changing to reflect consumer sentiment. A 2018 study led by Oxford University's Department of Zoology revealed that 49 of the top 100 companies from the 2016 Fortune 500 acknowledged biodiversity in their reports, with 31 making clear commitments to the cause. However, only five of these could be considered "specific, measurable and time bound", according to the study. Moreover, only nine companies provided quantitative indicators to verify the extent of their biodiversity activities, while no companies reported quantitative biodiversity outcomes.

Elsewhere, ambitious biodiversity and sustainability goal-setting has not always proved a reliable indicator of success. Industry trade group, the Consumer Goods Forum (CGF), recently suggested that hundreds of member companies that made 2020 zero net deforestation pledges had underestimated the scope of the task and would fail to meet their own deadlines. For example, Nestlé and Procter & Gamble—the world's two largest consumer goods companies—announced in September 2019 that they will fall short of self-imposed targets for their products to use no ingredients that contribute to deforestation by the end of this year.

Some corporations in the technology space are at least demonstrating a willingness to adjust their approaches. A September 2019 report by IoT specialist, Libelium, explored the IoT's contribution to the United Nations' Sustainable Development Goals and explained how the company's technology is supporting the achievement of these targets. Last year, multinational manufacturer, Siemens, declared: "Environmental efficiency is just as important as productivity, flexibility and time-to-market." It is now, for example, using IoT and technology to help a chocolate maker reduce primary energy consumption by 20 percent.

The Business of Wellness

As the world grapples with the health implications of COVID-19, the wellness technology industry is quietly booming

As the world adjusts to the new normal in the midst of the COVID-19 pandemic, the importance of our health and of those who help us maintain it has never been in sharper focus. More than the absence of disease or infirmity, health is in equal measures physical, mental and social wellbeing, and for most, all three have been tested in 2020.

But while staying healthy is naturally top of everyone's priorities, the business of wellness is often viewed with more suspicion. Whether it conjures up images of organic probiotic juices, relaxing inside a yurt on a mindfulness retreat in Sardinia or the fragrant waft of some pseudo-scientific essential oil, consumers are often skeptical when faced with products and services that promise the fuzzy concept of wellness.

It shouldn't be so because wellness is the process of achieving health by practicing good habits chiefly through exercise, nutrition, sleep and social contact. And like healthcare, wellness is also big business. According to analyst Research and Markets the global healthcare market reached a value of $8.4 trillion in 2018 and is expected to continue to grow as populations age and lifestyles become more sedentary. Not to be outdone, in 2018 the global wellness economy was worth an estimated $4.5 trillion, more than half the size of health expenditure, and it too is growing. The long-term aim is to transfer the outlay on healthcare products and services to those of wellness. Spending money to stay healthy, rather than to just get healthy, promises greater return on investment.

According to non-profit organization, the Global Wellness Institute (GWI), consumer opinion is also shifting. "Once upon a time, our contact with wellness was occasional … but this is changing fast," says Katherine Johnston, Senior Research Fellow at GWI. "Wellness, for more people, is evolving from rarely to daily, from episodic to essential, from a luxury to a dominant lifestyle value. And that profound shift is driving powerful growth."

In Short

The wellness industry has become big business worth an estimated $4.5 trillion in 2018 as people aim to stay healthy rather than get healthy

Exercise, nutrition, sleep and social connection are key to wellness, and wireless technology and wearables are helping power it

Consumers have embraced wearables that they expect will not only keep them healthy, but also live longer, lose weight and save money

BEHIND THE BOOM

Many factors are driving growth in the wellness industry, but according to the GWI, four in particular stand out. Firstly, consumers are increasingly focused on nutrition, and are prepared to pay extra for "free-from" and organic food. At the same time 'wellness tourism' is generally on the rise (although it has taken more of a backseat during the pandemic as international travel remains off limits). As of 2017, the GWI claims the sector was worth $639 billion, with 830 million wellness trips made that year. And when the pandemic abates, wellness seekers will surely get back on the road.

Then there are the trends powered by technology. A byproduct of the rise of consumer monolith Amazon—not least during the pandemic when consumers prefer their 'wellness' delivered to their door—has been the e-commerce giant's ability to position itself as the preferred channel for nutritional supplements and skincare products. The average consumer is spending $1300 a year on supplements, sports nutrition and skincare, and Amazon has established itself as the number one provider.

Wearable devices have also proliferated in the wellness industry ushering in the personalization of wellness rather than a one-size-fits-all approach with its inherent limitations. After all, your grandmother and a Tour De France cyclist have rather different metrics when it comes to determining their fitness for their stage in life. According to a 2019 survey by business news website, *The Manifest*, 56 percent of the population of the U.S.—about 183 million people—now own a connected wearable, and demand, as well as the sophistication of these devices, has increased dramatically. The days of mechanical pedometers and even digital step counters are history, people now want solutions that not only monitor their activity levels, but also their fitness, heart rate and its variability, blood oxygen saturation, muscle oxygen, sleep as well as emotional and mental health. The demands put on wearables and their makers by consumers is unprecedented. A 2018 Pricewaterhouse Coopers (PwC) report claims health-conscious consumers expect their wearable devices to help them live longer (70 percent), maintain a healthy weight (63 percent) and reduce their health insurance premium (62 percent). That's quite an ask but does explain why the wearables market is expected to grow to $27 billion by 2022.

> Technological development, the IoT and the rise of wireless solutions. Each gives innovators unlimited possibilities to create products that could change people's lives for the better

WELLNESS WEARABLES

Smart healthcare solutions have grabbed all the headlines in 2020 as we reinvent the delivery of health services in a socially distanced world.

While an array of Bluetooth LE- and other wireless-based technologies have eased the burden on overstretched health services and enabled good hygiene practice, contact tracing, social distancing, and home and remote patient monitoring (*see* WQ *Issue 2, 2020, pg8*), technology that allows individuals to practice wellness can, in theory, go one better. Wireless tech that helps prevent you getting sick rather than helping you recover after you've been ill, allows healthcare services to focus their attention on treatment for non-preventable conditions.

If two of the key trends powering the wellness industry are clean eating and wearable technology, then it is hardly surprising that solutions have already been developed that successfully marry the two. Late last year, London, U.K.-based DnaNudge launched a wearable device that uses a combination of the user's DNA and wireless technology to help people make healthier food choices. After a one-time-use cheek swab test that analyzes and maps the user's genetic profile to key traits, the results are loaded onto a capsule that can be worn as 'digital DNA' on the wrist, fitted inside the Nordic Semiconductor-powered DnaBand wearable. The user can then scan the barcodes of approximately half a million food products and instantly have the device determine if the food is suitable for them based on their unique genetic traits.

The DnaBand uses the consumer's DNA to determine which of half a million food products are best matched to their health and activity levels

Once the barcode is scanned, the device's LED display flashes either green, to indicate a suitable food choice, or red, to indicate a choice less well-matched to their DNA profile. When the wearable is also used to monitor the user's activity, an amber LED indicates a scanned product that might usually be suitable is not recommended because of the wearer's lack of activity. So, for example, if a person has a high sensitivity to sugar, saturated fat or salt, and scans the barcode on a product with high levels of these ingredients they can be offered a healthier alternative.

According to DnaNudge CEO and Co-Founder, Professor Chris Toumazou, the technology has the ability to transform both shopping behavior and an individual's long-term health. "Quite simply, [short term] diets don't really work, and the usual guidelines about healthy eating are too easily ignored," says Toumazou.

"[By] using genetic insight into well-understood health risks and combining this with lifestyle 'nudges' based on your inactivity levels, we can all make better day-to-day

decisions. This is a completely new way of thinking about what we're eating, how much we're moving, and making a big impact through small changes."

SLEEP WELL AND DESTRESS

While DnaNudge is designed to address two of the key wellness factors in nutrition and exercise, New York–based MDCN Technologies has developed a solution that targets two others – sleep and stress. Earlier this year the company launched its NeoRhythm smart headband designed to "stimulate brainwaves" to help the user sleep better, destress and focus.

While it may look like it belongs in the prop department of a science fiction movie, the device is in fact based on well-established scientific principles.

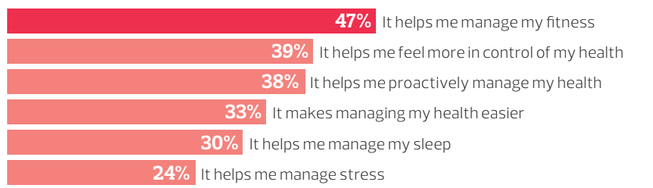
Employing U.S. Food and Drug Administration (FDA)-approved pulsed electromagnetic field (PEMF) technology, the wearable's five magnetic field-generating inverted coils produce frequencies which encourage the human mind to function in an individual's preferred state. The coils target specific areas in the brain (prefrontal cortex, temporal lobes, cerebellum, parietal lobe and occipital lobe) or spinal cord, and generate specific dominant rhythms that mirror the mind's naturally-occurring frequencies that humans associate with specific activities. The wearer then selects from a range of stimulation programs—for example, sleep, relaxation, meditation and pain control—from a smartphone app using a Nordic-powered Bluetooth LE link.

For those still raising a suspicious eyebrow at the science behind PEMF technology, MDCN Technologies CEO, Marko Kadunc, is happy to explain.

"How does PEMF really work?" asks Kadunc. "If you've ever felt yourself sleepy while on a train ride, [it's] the repetitive [rhythm] of the wheels lulling you to sleep [and] there's a neurological reason for that. The rhythm of the wheels matches a brain wave state that encourages relaxation and sleep. Our brains take a cue from the

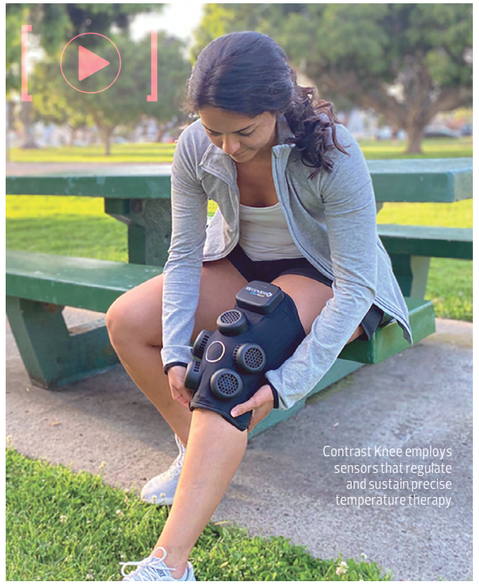
> While the gains to be had from good nutrition, sleeping well and managing stress are becoming better understood, the benefits of exercise to our health and wellness are fully established

State of Play
Why We Want Wearables



Consumer technology market research company, GlobalWebIndex, asked 1,961 smartwatch/fitness tracker owners across the U.S. and U.K., aged between 16 and 64, what they found useful about their wearable. While the leading use was managing fitness, wearable owners also want the ability to manage sleep issues, track their breathing rate and manage stress. These requirements highlight how this technology is giving people the ability to quantify their physical and mental wellbeing and reinforcing how wearables now have the capabilities to track less obvious measures of our personal wellbeing.

Sources:GlobalWebIndex, March 2020


Contrast Knee employs sensors that regulate and sustain precise temperature therapy

movements [and] the result is that your state of mind shifts into sleep mode.

"We want to bring PEMF to people to help them train their brain to work for them, not against them and in the comfort of their own home and before a clinical condition comes up. We try to offer our customers as much advice as we can on making their lives better, besides using our product."

As far as the wellness technology industry as a whole is concerned, Kadunc sees only further growth ahead. "With technological development, the IoT and the rise of wireless solutions that are becoming more and more available, it gives scientists, developers and entrepreneurs unlimited possibilities to create products that could change people's lives for the better in many ways," says Kadunc. "Once the product is launched ... that's only the beginning. It's an ongoing journey and improvement never really ends."

EXERCISE AND RECOVERY

While the gains to be had from good nutrition, sleeping well and managing stress are becoming better understood, the benefits of exercise to our health and wellness are fully established. Wristworn fitness trackers can reasonably lay claim to being one of the foundation stones of the wearable technology revolution that exploded into life over a decade ago and fitness monitoring remains the primary use case of wearable tech.

Whether you are a professional athlete or a Sunday stroller, exercise trackers are designed to motivate the user to keep going and achieve a greater level of fitness. What they don't all do is tell the wearer when they are overreaching, at risk of injury or chronic pain or need to focus on recovery.

"High-impact sports take a toll on your body, and endurance sports wear you down. It is increasingly important to be proactive about taking care of yourself to continue performing at a high-level," says Dan Evans, Co-Founder and CTO of RecoverX, a U.S.-based technology startup taking a different approach to wellness wearables.

Earlier this year the company released Contrast Knee, a Nordic-powered Bluetooth LE knee brace that provides electric-powered alternating heating and cooling therapy. Once strapped around the user's knee the product employs built-in temperature sensors that regulate and sustain precise temperature therapy, controlled via the user's smartphone. The varied phases of recovery help the user successfully manage inflammation, relieve pain and return to an active lifestyle.

ONLY PART OF THE ANSWER

However, amidst the almost universal clamor for wellness technology, there are others who encourage a degree of caution. Alison Spender, lead author of a 2018 discussion paper on wearables, the IoT and considerations for the life and health insurance industries, said the research was clear that for now wearables and the IoT were part of the wellness solution, not the solution itself.

"In the excitement and rush to adopt this emerging technology ... there is an unfounded belief among some that the technology alone can drive behavior change for the better," says Spender. "Wearables are not a panacea. That is not to say that technology should not be part of a behavior change program, indeed it should be exactly that – part of the solution, permitting real time feedback and driving motivation in a broader campaign of change."

It's true that technology alone will never be the prerequisite to wellness—it can't after all do the exercise, healthy eating, sleeping and social interaction for you—but it is the ideal enabler. Increasingly technology's role can tell you when you should or shouldn't work out, recover, relax or eat. The technology can also tell you how effective your activity, sleep or dietary habits have been.

The business of wellness is here and booming and the wireless technology to help us stay well is more than keeping pace. But because the technology is in its infancy, what happens next will be very interesting. (See sidebar *Today's solutions show what's next for wellness tech.*)

NeoRhythm stimulates brainwaves to help the user sleep better, destress or focus

Tech Check

Nordic's nRF52832 Bluetooth LE multiprotocol SoC provides low latency wireless connectivity for the DnaBand, NeoRhythm and Contrast Knee. The SoC's powerful 64MHz, 32-bit Arm Cortex M4 processor with floating point unit supports the complex computations required by sophisticated wearables

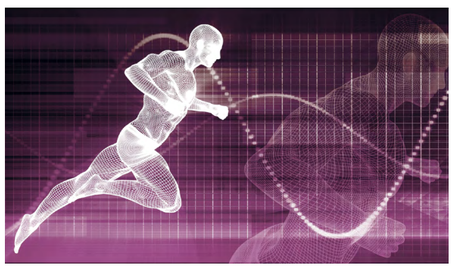
Today's solutions show what's next for wellness tech

U.S. computer scientist and inventor of the overlapping windows GUI, Alan Kay, once observed: "The only way to predict the future is to build it". So to forecast where wellness tech will go next, the best place to look is at today's solutions. The breadth of wellness products powered by wireless technology today is stunning. There are rings that promote general wellbeing, head-worn solutions to improve sleep and manage our weight. Compression leggings that tell you how hard your muscles are working, wearables that change your heart rate for you, devices that stick to your fingernail and coordinate with your smartphone to alert you if you are being exposed to too much UV light. And many more. Wireless sensors can already help determine a host of measurements that directly or indirectly impact our wellness, including: Blood pressure, blood sugar, body composition, galvanic skin response, fitness, posture and balance, sleep duration and quality, weight, and where it all began, steps. Combined with machine learning algorithms this sensor data can be transformed into actionable health data.

While wearable wellness technology has to date been largely focused on devices that capture physical and biometric information, technology either still subject to research or at the cutting-edge is investigating, for example, how we can track and analyze emotional states using voice patterns, brainwaves and electrodermal activity, even by breath analysis. Also under development are wearables that track physiological performance and dysfunction from an analysis of the molecular biomarkers in our sweat; while brain-computer interfaces will allow our brain signals to be directly merged with computers.

At some point in the not too distant future some of these devices will move from wearable to implantable. No different to microchipping the family pet, this will—once we have provided our initial consent—offer the ability to reliably capture biometric data and monitor our wellness passively and continuously.

Dr Pedro Lopes of the University of Chicago is already working on a wearable that uses electrical stimulation to help a user's muscles perform tasks they didn't otherwise know how to do, offering a raft of potential wellness possibilities. According to author and futurist, Bernard Marr, this seamless blending of us and technology will give rise to 'augmented humans' or 'humans 2.0', or as Elon Musk predicted, a future in which humans could have the option of "merging with AI".



Guiding Lights

Street lighting offers a go-to platform for interconnected smart cities; and dual-mode IoT connectivity is smoothing the transition

The dream of an interconnected smart city, where digital technologies knit together multiple distinct civic functions to bring efficiency and intelligence to operations, is a heady one. It proposes that city-living, which will draw 70 percent of the global population by 2050, can be healthy, happy and safe. Crucially, it promises it can be green – that humankind has one last card up its sleeve to stop short of wrecking the planet.

But smart cities are hard. New technology is expensive, local governments are hard-up and politics turns on short-term electoral cycles. A model for centralized technology deployments, which delivers operational and financial efficiencies, and repeats across urban locales, either globally or nationally, is out of grasp. In truth most of the leading smart cities in top-ten lists in glossy news titles are only really a collection of disparate tech pilots and district side-projects. Nothing looks like it can scale.

Think about garbage bins and parking lots, made smart with sensors, and run-through with analytics; ROI in such cases is difficult to calculate and standardize, especially when government is so fragmented – between public authorities and private services, and between towns, cities, regions and countries. Think about air quality monitoring; how does a city easily calculate the impact of clean air on health services? The logic says smart cities are hard, so do the skeptics.

But there is a light on the murky horizon of digital change. Street lighting, of all municipal services, affords a platform for cities to get smart and unite multiple applications for the first time. Consider the varied smart street-lighting projects in San Diego in the U.S. and Copenhagen in Denmark, among an increasing number. These combine an array of sensors in modular hardware units affixed to light poles, enabling remote control of the luminaires themselves, plus an engine to run other functions, such as traffic counters, air quality monitors and even gun-shot detectors.

From up high, on light poles, cities have started to get a handle on the 'livability' of their streets – of traffic flow and mobility, noise and air pollution, and of new commercial opportunities. Even parking sensors, traditionally buried in tarmac, can be hooked up cheaply and effectively to lighting infrastructure. Whole cities can be networked and optimized, suddenly, without digging streets or renting space, or resolving abstract calculations about healthier living and safer streets.

In Short

Smart cities are hard to fund and complex to build. The concept of integrated city-wide digital operations has remained largely out of reach, until recently

Street lighting offers a modular hardware platform and a coherent business case to make cities smart for the first time on a much grander scale

The combination of different IoT networking technologies in street lighting platforms further expands the potential scope and impact of smart cities

New developments in embedded computing to combine multiple wireless technologies in the same hardware promise to bring even closer integration and even lower costs

It promises to work because the calculation in most smart street-lighting cases is not gambled in the first instance on the savings delivered by the intelligence of the solution. Instead, the feasibility of digital revolution in cities is a serendipitous consequence of concurrent advances in lighting apparatus.

The energy savings afforded by the switch from incandescent sodium bulbs to solid-state LED lighting, along with the ready supply of power and the ubiquity of lighting infrastructure, have made smart cities viable.

The pace of LED swap-outs is flat-out already; the trend for smart lighting has a head of steam up too. Nine out of 10 streetlights—out of 363 million globally—will use LEDs by 2027, says smart infrastructure analyst Northeast Group; a third will be running smart apps as well - from a standing start a couple of years ago. Until the sums are worked through and blueprints disseminated, nothing else makes the case for smart cities at scale like street lighting, as a networked infrastructure from which to hang all manner of digital pyrotechnics.

PIGGYBACKING ON LED SAVINGS

The rule-of-thumb, presented by lighting and sensor makers, says smart lighting delivers a 50-70 percent reduction in the management and maintenance costs associated with the infrastructure. But most of that – about 50 percent, enough to swing the case – is achieved just by switching to power-efficient LED bulbs. The rest comes from connecting and controlling the luminaires, and delivering sparks of intelligence about their working status across the lighting network. (*See WQ Issue 3, 2019 pg10.*)

Maintenance costs can be slashed dramatically just with centralized tweaks and insights. The ways are multiple and all add up: Scheduling, seasonal controls and trim times; fault diagnosis and reduced truck rolls. The impact rises with the scale of the lighting network and flows back into the original ROI case. This way the outlay can be clawed back in about five years, says the market, and potentially less with the integration of 'softer' smart-city concepts – like those parking sensors, traffic monitors, air quality controls and gun-shot detectors.

Analyst firm, Guidehouse Insights, tracks 200-odd cities to gauge the pace of urban change; a quarter are rolling out smart lighting initiatives, it says. Sales of smart systems are skyrocketing; ABI Research calculates global revenues will jump ten-fold by 2026, to $1.7 billion. The planet's 'lightbulb moment' is just that; street lighting infrastructure, mapped to human activity, is the way forward as a platform for smart cities in a wider context. Over two-thirds of new street light installations will be tied in with central management platforms as early as next year, says ABI, to integrate data from multiple smart city sensors.

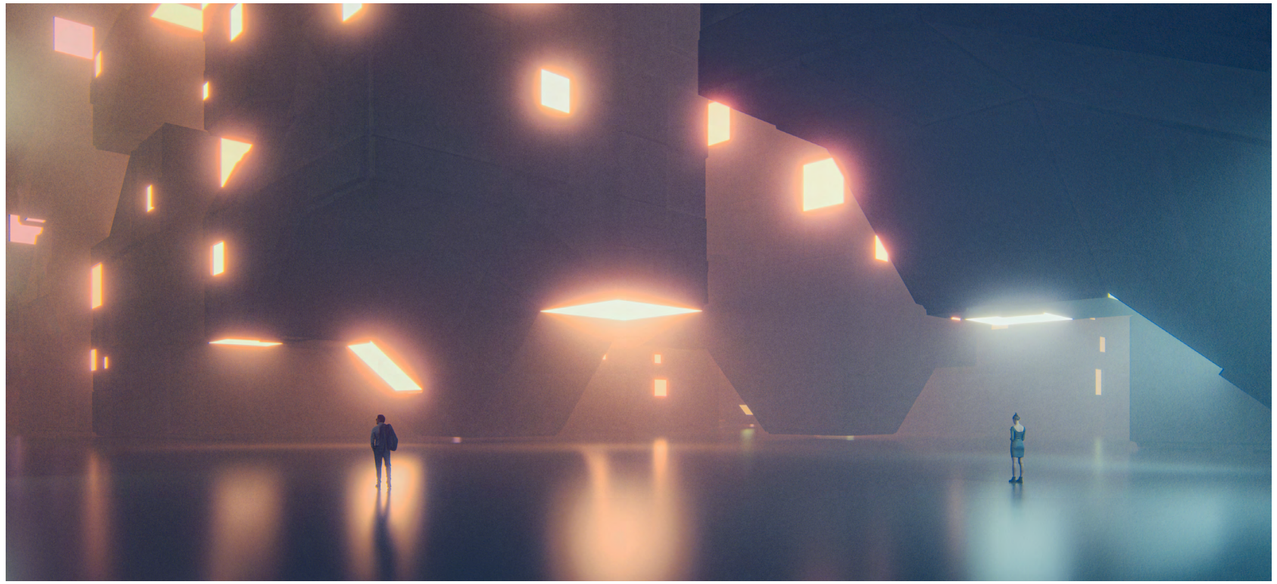
> “There is a light, on the murky horizon of digital change. Street lighting, of all municipal services, affords a developing platform for cities to unite multiple applications for the first time

"There are additional opportunities to be had by smart city suppliers leveraging street pole infrastructure by hosting wireless connectivity, environmental sensors and even intelligent cameras," says Adarsh Krishnan, principal analyst at ABI Research. "The challenge is finding a feasible business model that encourages deployment of multi-sensor solutions cost-effectively at scale."

The question is no longer whether to connect, but how to connect – and how much to connect from the start. This is partly about business models, as Krishnan observes, but funding has started to flow in the smart city space via cooperative public-private partnership (PPP) vehicles, where the financial risk is shouldered by the private enterprise in return for a stake in the venture's success. Subscription-based 'as-a-service' contracts, spreading investments into the payback period, have also stimulated activity.

But the smart city question is also about the choice of technology. Different applications make different demands in terms of coverage, throughput and security. Street lighting has developed around different technologies in

Feature: Smart City



By the Numbers

90%
of streetlights – out of **363 million**, globally – will use LEDs by 2027

10x
growth in global smart street-lighting revenues by 2026 – to **$1.7 billion**

50-70%
energy savings from smart street-lighting

230 million
Bluetooth LE shipments into the smart city space in the next five years

Sources: Northeast Group, ABI Research, Bluetooth SIG

different markets. In the U.S., Zigbee-based short range mesh networks are a mainstay of smart metering with an 80 percent share, according to ABI; the same utilities own most of the public lighting network as well and Zigbee's utility-focused SEP (Smart Energy Profile) 2.0 profile is being reworked for lighting.

In Europe, by contrast, street lighting is being connected with traditional cellular (2G through LTE (4G), commonly), as well as the new cellular IoT LTE-M standard. Proprietary ultra-narrowband (UNB) technologies are also in play, along with Zigbee, smatterings of Bluetooth LE and IEEE 802.15.4 spinoffs.

The Bluetooth Special Interest Group (SIG) in particular is serious about smart cities. It predicts five-times growth of Bluetooth LE shipments in the space in the next five years (to 230 million annually). Most is linked to asset tracking in public venues, for example airports, stadiums, hospitals, malls and museums. But Bluetooth LE is pitched for outdoor networking too. "Asset management solutions increase utilization of smart city resources to help lower operational costs," says the Bluetooth SIG.

TWO TECHNOLOGIES ARE BETTER

There are arguments for each, although certain of them unravel under closer interrogation. UNB, for example, imposes tighter limits on payloads and delivery schedules, precluding parallel support for multiple sensor applications or for needier ones like cameras. Short-range technologies are cheaper and offer greater throughput for developing 'lighting as-a-platform' setups. Importantly they also bring redundancy in case the WAN signal drops out and a means for technicians to get direct access to sensors for commissioning and diagnostics. Bluetooth LE, for example, is interoperable with almost all smartphones on the market.

But while a denser mesh creates robustness, it also brings architectural complexity and places higher energy demand on interconnected point-to-point sensors. There is an issue with range too; coverage tops-out at a couple of hundred meters with Zigbee and Bluetooth LE. And while short-range technologies are clearly contenders and well-suited for meshing neighborhood-wide sensors, they are closed networks that ultimately require a gateway to get the signal back to the Cloud.

In the end, a cellular connection is usually integrated into the mix. The trend among smart lighting providers is to go with point-to-Cloud cellular, offering coverage of five-to-15 kilometers from gateways or sensor devices. Cellular brings range and simplicity; it also provides ready-built networks and higher-grade security, according to the cellular community. "Mobile operators ... possess total coverage over urban areas, [so] no additional infrastructure is necessary to connect city lights and sensors," says Neill Young, IoT Verticals Lead at the GSMA, the industry organization that represents the interests of mobile network operators. "The security and reliability of ... [cellular] networks in licensed spectrum [means] operators are best-placed to support large numbers of low cost devices requiring long battery lives, minimal maintenance and long ranges," adds Young.

ABI says cellular, out of all the connectivity technologies in play, will see most growth in the next few years. The clamor for 5G networks, and the struggle to host 5G infrastructure, has seen operators seize on light poles for small-cell infill in urban environments. In the U.S., Las Vegas and Sacramento are rolling out LTE and 5G, plus smart city sensors, on street lights with carriers AT&T and Verizon. And Hong Kong has just unveiled a plan to install 400 5G-ready lamp posts as part of a smart city drive.

But LTE and 5G are geared for more rarefied smart-city cases, requiring higher throughput and lower latency, such as high-definition camera surveillance. The IoT sector at large is propped up by low-power systems in the form of short-range technologies like Bluetooth LE and Zigbee, and cellular IoT LPWAN technologies NB-IoT and LTE-M. These can be combined to powerful effect in street lighting platforms, and elsewhere in smart cities, as part of lower-rate sensors bringing intelligence about city functions and environmental conditions.

"The solution is to team inexpensive but range- and resource-limited short-range wireless with cellular IoT so they complement each other. That way the data—about traffic flow and footfall, air quality and temperature, vibration and noise, or whatever else—can go from the sensor network to the Cloud via a secure and robust cellular network," says Svein-Egil Nielsen, CTO with Nordic Semiconductor, a short range wireless and low power cellular IoT solution provider.

TIGHT INTEGRATION IN HARDWARE

Nordic provides multimode short- and long-range products. Its nRF52840 SoC supports Bluetooth LE, Bluetooth mesh and Zigbee, as well as Thread and proprietary 2.4GHz systems. Nordic's cellular-based nRF9160 SiP offers both LTE-M and NB-IoT. "The combination of the two technologies brings advantages in terms of performance and cost," adds Nielsen.

Frequency separation allows these systems to coexist, with the former running in the unlicensed 2.4 GHz band and the latter going wherever LTE goes. There is a trade-off between wider-area coverage and larger-capacity throughput at lower and higher frequencies. But in lighting platforms, short-range wireless is being commonly deployed to interconnect sensors, edge-based compute power is being charged to direct insights and cellular IoT is being used for backhaul to the Cloud, and for higher-maintenance sensor controls.

As yet, twin short and long-range radios are being added separately; they are not embedded into the same silicon in the factory, and there is a case on one hand to keep components apart, as luminaires, sensors and radios all fail differently. At the same time, embedding twin radios into a single system will bring tighter technological integration and lower acquisition costs – which are prime considerations for smart cities.

The market is going that way, says Nordic; the firm has already combined short range wireless and cellular IoT connectivity technologies in hardware and software, at the developer level, for solution makers to run the pair together in test applications. The company's single-board DK for the nRF9160 SiP is designed for developers "to get their cellular IoT applications working"; the Nordic Thingy:91 is described as a "full-blown ready-to-go gateway," available as an off-the-shelf prototyping platform or proof of concept for early product designs.

Both feature the multimode cellular nRF9160 SiP and multiprotocol short range nRF52840 SoC. Embedded systems combining both sorts of technologies for commercial IoT deployments are only "a few months" from commercialization, suggests Nordic.

"Smart-city lighting platforms are playing host to all of these connectivity technologies already; the market shows very clearly the demand to combine them, and we're already providing developer boards for solution makers to test how they work together. It is only a matter of time before they are combined in commercial solutions, as well," says Nordic's Nielsen.

> "The security and reliability of LPWANs in licensed spectrum means operators are best-placed to support large numbers of low cost devices

Need to Know

Cellular 4G networks are already in place with dense cell tower coverage over most cities in the world. NB-IoT and LTE-M typical use cases will feature low activity making it possible to connect several tens of thousands of devices to a single base station. Moreover, cell towers host several base stations, multiplying deployment density and promoting massive scale

Street smarts:
A brief history of street lights

Street lights date back to ancient Rome, when oil lamps were used to illuminate paths and deter thieves; slaves were appointed just to watch and maintain the lamps. Oil lamps were used into the Middle Ages. In 1417, the city of London introduced a law that residents should hang and light lanterns outside their homes. It marked the introduction of organized public street lighting. Paris did the same in 1524.

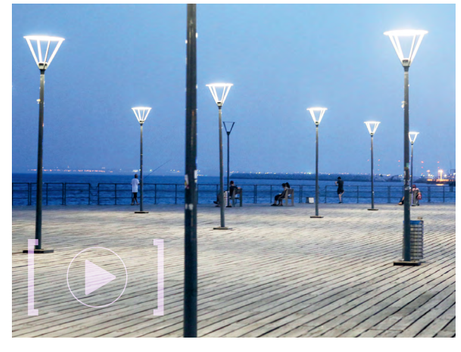
By then, candles were being used, and continued to be used for almost three centuries. By the 1800s, coal-fueled gas lights were in place, on poles along main streets. London was first, again, followed by Baltimore and Paris. London and Paris introduced electric street lights—carbon 'arc lamps', from Russian design—in 1878. These were modified by Thomas Edison as carbon-thread vacuum bulbs.

They lasted into the 1930s, when low-pressure sodium lamps were introduced, holding sway until the advent of the semiconductor-based LED. LED-based street lighting has grown in the past ten years, encouraging a focus among utilities and cities on energy, maintenance and cost savings. Milan was the first city to switch entirely to LEDs.

Meanwhile, the idea of smart street-lighting dates back to the last millennium, just. Texas-based firm Intelilite filed a patent in 1999 for a new "outdoor lighting system network" to provide automated "sensing, conveying, and recording [of] data ... so that both control and maintenance can be performed more efficiently." For the connectivity part, the system used the power line, itself, instead of "additional separate lines".

The first large scale implementation of a control network for street lighting did not appear until 2006, when Oslo commissioned the installation of 55,000 connected street light ballasts, also using power-line communications. Energy savings were calculated at 50 percent, plus maintenance efficiencies.

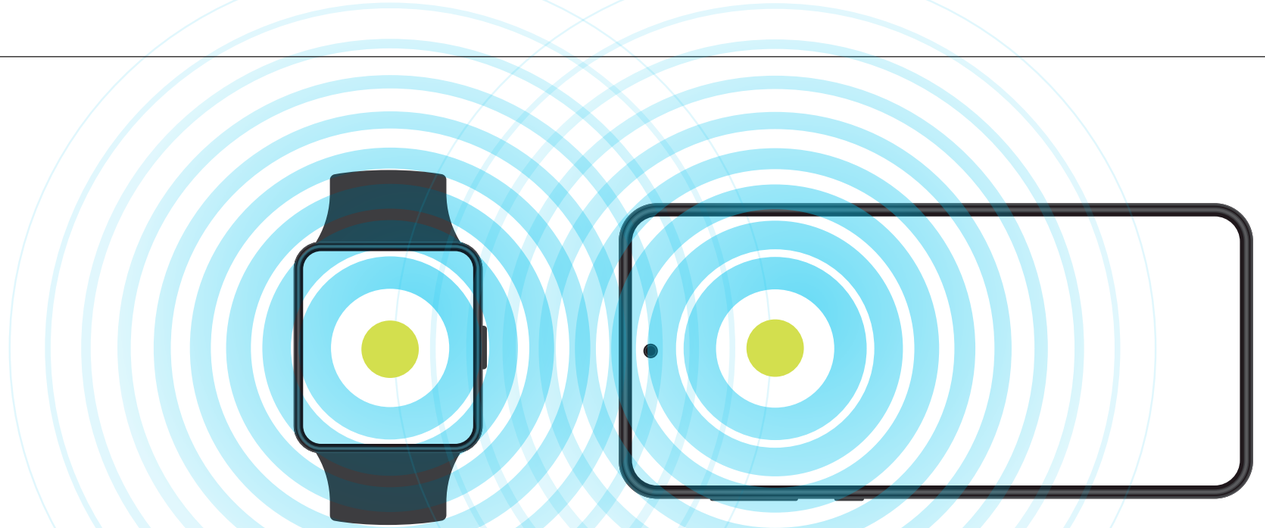
The Oslo project was important because it formed the basis for Europe's "E-Street" (a shortening of "European-Street") initiative to reduce energy in lighting systems and guide policy on outdoor lighting. It also inspired interest from other cities. Smart platforms are now being deployed with two thirds of new street lighting deployments.



Feature: Ultra Wideband

Precision Positioning

UWB is emerging as a solution for products demanding accurate position information. How does it work and what are the first applications?



Before SARS-CoV-2, the coronavirus behind the COVID-19 pandemic that still grips the world, real time location services (RTLS) were a nascent technology. Engineers were busy developing wireless technologies such as Bluetooth LE Direction Finding to enable devices to determine and report their position in three dimensions.

The market for RTLS is potentially huge—imagine the productivity gains for logistics companies if objects stored in a giant warehouse are able to instantly report their position with centimeter accuracy – but location services were previously proving slow to emerge.

Now the pandemic, like previous crises, has spurred innovation. For example, contact tracing—a key weapon in the battle against the virus which relies on knowing whether a person has been close to another who is later shown to be infectious—is now being supported by a slew of Bluetooth LE wearables. (*See WQ Issue 2, 2020, pg8.*)

Most of these solutions currently rely on Bluetooth LE's Received Signal Strength Indication (RSSI) to measure the distance of one person to another. RSSI estimates the distance between two transceivers by gauging how much the signal power has diminished since it left the transmitter. In perfect conditions the technique works well, but throw in a few walls, ceilings and furniture, and variable effects such as multipath fading, and signal strength becomes a much less precise indicator of distance.

What's needed is complementary technology that can piggy-back the many advantages of Bluetooth LE—such as its low power capabilities, maturity, wide industry support with SoCs boasting powerful embedded processors and generous memory, and smartphone interoperability—but is less prone to fading and other forms of signal attenuation. One promising candidate is Ultra Wideband (UWB), an RF technology that has traditional applications in radar imaging but has more recently emerged as an option for PC peripherals and contact tracing wearables.

In late 2019, smartphone giant, Apple, gave the technology a significant boost by incorporating UWB in its iPhone 11. According to *Computerworld* magazine, the idea was to "bring spatial awareness" to the smartphones and encourage new consumer applications, beyond PC peripherals and contact tracing, that would benefit from precision location technology.

WHERE AM I?

The U.S. Defense Advanced Research Projects Agency (DARPA) coined the term 'ultra wideband' in the 1990s and defined it as a system with a "fractional bandwidth" greater than 25 percent where fractional bandwidth is the ratio of signal bandwidth over the center frequency. The U.S. Federal Communication Commission (FCC) defines UWB as "an intentional radiator that has a fractional bandwidth equal to or greater than [20 percent] or has a ... bandwidth equal to or greater than 500 MHz".

Conventional short range RF technologies use narrowband technology; Bluetooth LE, for example, transmits on a one megahertz channel and carries information using Gaussian frequency shift keying (GFSK) modulation. In contrast, UWB spreads the radio energy across a wide bandwidth. The low power spectral density provides immunity to multipath fading and limits interference. Several modulation techniques are used, but the IEEE802.15.4 standard calls for a Burst Position Modulation – Binary Phase Shift Keying (BPM-BPSK) scheme. (See sidebar *An alternative PHY: Pulse Radio.*)

Information is sent using precisely timed pulses and it's this timing that makes UWB a good solution for RTLS applications. By timing how long it takes for a pulse to reach the receiver and for a response to come back (and subtracting the processing latency of the receiver), dividing by two and multiplying by the speed of light, the distance between two UWB radios can be accurately measured.

Because the measurement is based on timing rather than signal strength, attenuation due to multipath fading and other forms of signal degradation do not compromise distance measurement accuracy. In addition, UWB supports measurement of Angle of Arrival (AoA) of an incoming signal (by using multiple antennas and a technique also favored by Bluetooth Direction Finding) to determine the direction of the transmitter. Combining distance and direction data enables the system to determine precisely where, in three dimensions, the transmitter is located.

> UWB transmits information by generating radio pulses at specific, very short and precise time intervals across a large bandwidth

Combining UWB with Bluetooth LE creates a technology with excellent position-measuring capabilities but with a power consumption close to that of Bluetooth LE alone. By using the ultra low power Bluetooth LE radio to approximate the target object's position—a process which requires a relatively large amount of RF activity—and then switching from the native radio to the UWB radio for the shorter precision location operation, the on air time for the higher power UWB radio is kept to a minimum. This helps to extend battery life. The Bluetooth LE SoC's processor is used to control radio switching. Another advantage of the Bluetooth LE/UWB combination is that it allows for RSSI to be used as a fallback position-measuring technique should a non-UWB target device be encountered.

EARLY TO MARKET

Decawave (now part of Qorvo) offers a commercial UWB solution, the DW1000. The chip is targeted at RTLS applications and is compliant with the IEEE802.15.4-2011 standard. The DW1000 is designed for a distance measurement precision of 10 cm, supports six channels in the 3.5 to 6.5 GHz spectrum allocation and features data throughputs from 110 kbps up to 6.8 Mbps.

In June, Nordic Semiconductor and Qorvo extended their partnership to include dual UWB and Bluetooth LE products. Previous collaboration focused on Nordic's nRF9160 SiP, which uses an RF front end, advanced packaging and MicroShield technology from Qorvo.

Nordic and Qorvo customers are already taking advantage of a Bluetooth LE/UWB module from Decawave. For example, German developer, PHYTEC, is using the Decawave DWM1001C module—which combines the DW1000 with an nRF52832 SoC—in a UWB and Bluetooth workplace social distancing tracker that was developed specifically to combat COVID-19.

Called the Distancer, the device is worn around the neck like an employee ID card and produces accurate face-to-face separation measurements with what the company claims is greater certainty and accuracy than other COVID-19 wearables – avoiding unnecessary testing.

"The fact that the [Bluetooth LE/UWB module] employs a Nordic SoC was a key deciding factor when developing the Distancer," explains Jonas Remmert, R&D Engineer at PHYTEC. "Nordic's chips are by far the best-supported Bluetooth SoCs in Zephyr [an open source, RTOS] and as a result the Distancer was developed from initial concept to working prototype in just four weeks."

Insight SiP, a French maker of ultra-miniaturized electronic components, has also launched a wearable Bluetooth LE/UWB tag for social distancing monitoring. The product uses the company's ISP3010 module which is also based on Nordic's nRF52832 SoC. In addition to the wearable tag format, the device can also be integrated into other products, such as security equipment and hard hats.

Next up for Nordic and Qorvo is a product that combines Nordic's nRF52833 SoC, a 105°C qualified Bluetooth 5.2 SoC supporting Direction Finding and Bluetooth mesh, with Qorvo's UWB transceiver for products used in elevated temperature environments such as enterprise lighting.

While the pandemic has wreaked havoc on the global economy, the silver lining could be the mass-introduction of the Bluetooth LE/UWB RTLS solutions currently fighting the virus into new multibillion dollar industry sectors when the world bounces back.

By the Numbers

Source: Allied Market Research, Verified Market Research

30.2%
CAGR of RTLS market from 2019 to 2026

$23.1 billion
RTLS market size by 2026

$5.1 billion
RTLS healthcare sector value by 2027

Tech Check

In addition to Bluetooth LE connectivity, the Nordic nRF52832 SoC's 32 bit, 64 MHz Arm M4 processor with floating point unit (FPU) has ample computational resources to supervise the tricky UWB pulse time sequencing. Its large Flash memory allocation also accommodates complex application code and sensor data storage for later wireless transmission and the SoC is capable of over-the-air firmware updates

An alternative PHY: Pulse Radio

UWB transmits information by generating radio pulses at specific, very short (nano or even picosecond), precise time intervals across a large bandwidth and carries information by using pulse-position modulation or time modulation of these pulses. Other modulation techniques include encoding the polarity of the pulse, changing pulse amplitude and/or using orthogonal pulses. Each pulse occupies the entire UWB bandwidth and its low spectral density allows the signals to share spectrum with other RF protocols without the risk of interference. High throughput is achieved by employing high pulse repetition rates.

Commercial UWB chips for smartphones, contact tracing and other applications are on the market. The chips are designed to comply with the requirements for an alternative physical layer (PHY) to the conventional short range radio PHYs already in the IEEE802.15.4 standard.

The standard continues to evolve, but under the most recent version, compliant UWB PHYs must support three independent bands of operation: A sub-gigahertz band (channel 0, 249.6 to 749.6 MHz) a low band (split into channels 1 to 4, 3.1 to 4.8 GHz) and a high band (split into channels 5 to 15, 5.8 to 10.6 GHz). Some channels support over one gigahertz of bandwidth (for example, channel 15 offers 1.35 GHz). Each channel supports four data rates, 110 and 850 kilobits per second, plus 6.8 and 27.24 megabits per second.

The standard defines a Burst Position Modulation – Binary Phase Shift Keying (BPM-BPSK) modulation scheme whereby a UWB symbol is capable of carrying two bits of information – one to determine the position of a pulse burst, and one to modulate the phase of the burst.

Sports & Fitness

Fliteboard

This Bluetooth LE–controlled electric board allows watersport enthusiasts to 'surf' above water

The global sports and leisure equipment market is expected to witness a surge in growth to 2025 on the back of an increase in health and fitness awareness and higher disposable incomes, according to analyst Grand View Research. The sports technology market meanwhile will grow to in excess of $30.9 billion at a CAGR of 20.1 percent

While the Fliteboard can reach speeds of up to 45 kph, the fastest speed recorded on a surfboard has been clocked at 78.26 kph by South African Josh Enslin. However, Enslin didn't reach the speed thanks to wave propulsion, but rather by being towed behind a car. He described the dangerous stunt as "calculated fun"

The exact origins of surfing are not certain, but it was first observed by Europeans from a ship in Tahiti back in 1767. Research suggests that surfing dates back to early Polynesian cultures, although the practice of riding a vessel on a wave was practiced since the pre-Incan civilization around 2000 years ago

A customized high-capacity battery management system enables the e-foil to travel up to 30 km before recharge, although the longest wave ever surfed was a 66 km ride behind a wave-creating boat on the Panama Canal by Panamanian surfing champion, Gary Saavedra. The marathon surf took Saavedra almost four hours

The Fliteboard's fully sealed subassembly is embedded directly into the carbon fiber shell and provides GPS data recording, motion measurement, telemetry transport and data transfer hardwired to the main eFoil module. As well as connecting the board to the handset, the Bluetooth LE link enables the board to communicate with the accompanying iOS-compatible Flite App

The Fliteboard system comprises a 6 kW brushless electric motor-powered hydrofoil board, as well as the remote-controlled handset. The handset relays control data to the board via low latency Bluetooth LE connectivity, enabling the rider to wirelessly control the speed of the motor, even when the devices are submerged in water

Tech Check

Both the Fliteboard and the Flite Controller remote handset integrate a Rigado BMD-350 Bluetooth LE module based on Nordic's nRF52832 SoC. Bidirectional connectivity allows the handset to receive key data from the board itself—such as telemetry and battery status—then display the information on the integrated screen

Sports & Fitness

‘World’s first’ NB-IoT cycle security tracker protects and locates bikes

Using built-in smart sensor technology, GPS and NB-IoT cellular connectivity, See.Sense AIR notifies cyclists when their bike is moved, damaged or stolen

> AIR was developed after listening to what the cycling community wanted. It’s a smart device, reacting automatically to its situation

For avid cyclists, the passion for riding is high, yet it comes with inherent risks and concerns. Their favorite bike is likely to be an expensive and desirable item making it attractive to thieves and in constant danger of being lost or stolen. Even the best locks and chains fail to prevent a determined pilferer.

And that’s not the end of the challenges; poor riding conditions can lead to spills, or worse, damage the bike owner’s two-wheeled pride and joy. There’s also the fear of being unable to contact loved ones following an accident in a remote location.

In an effort to break this cycle of uncertainty, Northern Ireland-based cycling sensor technology startup, See.Sense, developed what it claims is the world’s first NB-IoT cellular bike security tracker.

Performing like an electronic tag for a bicycle, the compact (65 by 50 mm), lightweight (80 g) See.Sense AIR protects and locates bikes anytime, anywhere. Once mounted discreetly under the saddle or below the bottle cage, the ‘fit-and-forget’ device uses See.Sense’s advanced sensor technology and GPS functionality to quickly and accurately detect whether the bike has been involved in a crash, moved or stolen. Riders are notified via an associated app on the user’s smartphone either via short range Bluetooth LE if they are within 50 meters or less or via the NB-IoT version of cellular IoT, a LPWAN wireless technology, if they are further away.

The See.Sense platform also ensures a better and safer overall riding experience by monitoring the surrounding environment to detect issues such as poor road surface and route conditions throughout a ride. What’s more, aggregated and depersonalized ride insights can be shared with See.Sense partners to improve conditions for cycling in cities around the world.

See.Sense AIR provides custom cycle protection modes based on the rider’s proximity to the device. In “Fight” mode, the always-on self defense setting, AIR sounds its built-in alarm if the bike is tampered with or moved. The user also receives an immediate SMS notification of the incident. Recognizing that the bike is being stolen, AIR then automatically switches to its “Flight” mode setting and rapidly transmits high-powered tracking signals enabling the bike’s location to be determined with an accuracy of just a few meters. In this situation, the owner can quickly pass on AIR’s GPS location to local law enforcement, significantly increasing the chances of recovery and return of the bike.

AIR can also help keep the rider safe by detecting if they’ve been involved in an accident and automatically sending an SMS alert with the precise location to an assigned emergency contact.

“Cyclists are fed up with bike vandalism and theft; it seems even the best locks and chains can’t stop a bike being damaged or stolen,” says Philip McAleese, CEO at See.Sense. “AIR was developed after listening to what the cycling community wanted. It’s a smart device, reacting automatically to its situation.”

Even the best locks and chains can’t stop a bike being damaged or stolen

Need to Know

Through its Kickstarter community, See.Sense creates innovative products like See.Sense AIR that will make a positive difference to cyclists everywhere. While AIR’s coverage is currently powered by the Vodafone NB-IoT network being rolled out across the globe, all major telecommunications providers are expected to support NB-IoT in the medium term

The NB-IoT advantage

A smart sensor solution like See.Sense AIR can only be as effective as the network coverage supporting it. Described by the company as the first bike tracking device to operate across an NB-IoT network—which trades-off low throughput for decent battery life—AIR allows users to locate and track their bikes from their smartphone for up to three months on a single charge of the device’s integrated LiPo battery.

While See.Sense considered a number of competitive LPWAN wireless technologies, including NB-IoT’s sister cellular technology, LTE-M, the company settled on NB-IoT cellular connectivity as the standout option.

“We narrowed the choice down to four criteria: Range; upload speed; power usage, and the suitability for use on a moving platform,” says McAleese. “NB-IoT was a clear winner, providing good range and upload speed at a reasonable power consumption. Testing quickly established that moving platforms also performed well. We found that NB-IoT also had fewer restrictions on duty cycles and data size than [competing LPWAN technologies], making it an appealing platform for AIR.”

See.Sense is based on Nordic Semiconductor’s nRF9160, a low power SiP with an integrated LTE-M/NB-IoT modem plus GPS. The SiP is certified for global cellular IoT applications.

“Nordic’s nRF9160 is an impressive platform with the ability to run our application from a single, small-sized unit and provide superb power consumption capability when idle,” McAleese says. “Unlike some NB-IoT chips, the nRF9160’s built-in ARM processor allowed us to run the firmware for the cellular modem off the SiP without the need for an external microcontroller.”

See.Sense’s technical team developed the complex firmware for AIR using Nordic’s recently released nRF Connect SDK with its expansive library of drivers and examples. “Nordic provides extensive information on all its chips, as well as fast and informative responses through the Nordic DevZone forum and incredibly detailed reference designs for prototyping and development,” adds McAleese. “Our engineers were able to seamlessly transition to the Zephyr RTOS used in the nRF Connect SDK thanks to the availability of amazing Nordic tutorials, webinars and support staff, allowing us to bring AIR to life at an accelerated pace.”

Supported by Nordic SiP-enabled GPS combined with cutting edge NB-IoT coverage, See.Sense AIR is set to become a major player in the bicycle security space. “We think it’s a game-changer,” concludes McAleese.

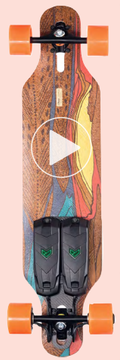
Juan Pablo Viera
Co-Founder and CTO, Unlimited

Sports and Bluetooth LE prove the perfect match

As wireless tech has become more sophisticated, so has the imagination of developers

The sports and fitness market has been key to the growth of wireless tech adoption because it’s a massive sector with all kinds of demands. And people are very familiar with the benefits of Bluetooth LE, thanks to its use in the sports and fitness solutions they use daily.

At Unlimited, we developed our Bluetooth LE-powered electric skateboard powertrain to solve the problem of ‘last kilometer’ commuting, too often solved by one person driving a 1000 kg car. As we developed prototypes, we quickly realized it wasn’t just practical but also fun, and that’s the key to why the sports and leisure technology market has grown quickly—fitness can now be fun. But to be successful it does require strong tech too.



> Bluetooth LE is essential to maximize battery life and improve the user experience

We could have chosen a closed RF protocol for our skateboard-remote control link, but from the get-go we knew the app needed to be a big part of the solution and that made the choice of Bluetooth LE simple because of its interoperability with smartphones. Also Bluetooth LE, while not originally considered a long range or robust link, has improved to the point it is now a great choice for applications that require a combination of reliability and low power consumption. In our products, the battery life of both the handheld remote controller for the e-skate, and the pedal sensor for our e-bike conversion kit, is directly related to the energy consumption of the wireless link. Bluetooth LE is essential to maximize the battery life greatly improving the user experience.

Beyond battery life and smartphone connectivity, it is also now much easier to integrate wireless connectivity into mass-consumed products. That comes down to three things: Reduced hardware size; increased robustness of the link; and lower costs.

The road ahead

We probably won’t see huge changes in the next three years, just steady growth. More devices will be connected in some way, providing greater value for end-users.

For example, on our new e-bike, we are able to adapt the level of electrical assistance as a function of heart rate, by pairing the system to a Bluetooth LE heart rate monitor. Customers can configure this feature so that the e-bike assists them in personalized workouts.

In the longer term, I can’t say which market will dominate the industry, but I think the technology will bleed down to all kinds of user-facing electronics. We are already seeing this with ‘smart-everything’ devices. We are very aware of where the light-electric vehicle industry is headed and fully smart vehicles that interact with each other, and with other connected ‘things’ are a big part of it.

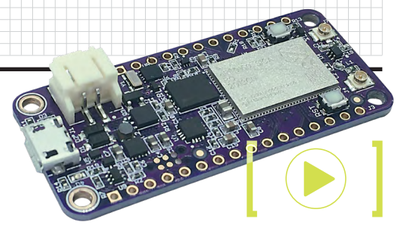
For massive adoption, several things need to happen. First, people need to think how they commute and how they move about. External factors such as government regulations, climate change or even this pandemic will have an influence. Governments need to catch up quickly too. For example, some countries prohibit electric kickscooters, and some cities are let down by poor infrastructure.

The change will come, but governments will need to be as agile as the technology developers to make it happen.

[Tech Zone]

An in-depth look at Nordic's wireless IoT solutions

Dev board simplifies prototyping of cellular IoT products



Electronic design company, Circuit Dojo, has announced its nRF9160 Feather development board, designed to simplify prototyping and speed time-to-market for makers, hobbyists and developers of cellular IoT-based solutions.

The nRF9160 Feather is supplied in a miniaturized 50.8 by 22.8 mm form factor and incorporates much of the functionality of Nordic's nRF9160 DK but in a more compact size.

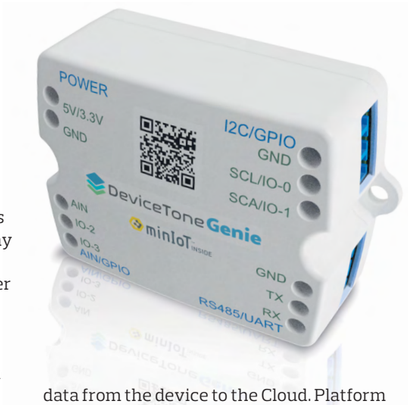
The product enables users to start development using Nordic's nRF Connect SDK which includes application layer protocols, application examples and LTE modem firmware offered as precertified and precompiled downloads. The SDK also incorporates the Zephyr real time operating system (RTOS) for constrained, energy-limited and secure IoT products.

Development with nRF Connect SDK and nRF9160 Feather allows makers, hobbyists and hackers to build highly reliable, efficient, multithreaded cellular IoT applications. The Zephyr RTOS is designed to safely and securely enable anything from very simple applications with one or two threads in a very compact build, occupying a small memory footprint, right up to applications running hundreds of threads.

The nRF9160 Feather's integrated nRF9160 SiP and an included Hologram Hyper SIM enables global out-of-the-box LTE-M and NB-IoT cellular IoT operation using precompiled firmware examples. The prototyping product is also pin-compatible with many Adafruit Featherwing accessory boards, for example the Air Quality Wing all-in-one air quality sensor, and features additional peripherals including a low power real time counter (RTC) and additional Flash memory.

The nRF9160 SiP is optimized for low power operation, supporting eDRX and PSM power saving modes. For example, in PSM, uploading 1 kB every 12 hours, the average current is 5.5 µA. When in sleep mode the average current is around 2 µA. The development board provides both USB and LiPo battery power options.

Plug-and-play IoT and Microsoft Azure IoT Cloud connectivity



IoT solutions company, Cloud of Things, has released DeviceTone Genie, a plug-and-play module designed for integration into any electronic product where the manufacturer wishes to introduce 'production-grade' IoT capabilities and Microsoft Azure IoT Cloud support.

Integrating Nordic's nRF52840 Bluetooth 5.2/Bluetooth LE advanced multiprotocol SoC, the module could, for example, be used in lighting or utility metering applications to make luminaires or meters 'smart'.

The 6 by 6 cm module connects to a product via a UART, RS485, GPIO or I2C interface, and comes pre-installed with a temperature sensor, GPS receiver and Cloud of Things DeviceTone Nano firmware.

Once the module is configured and provisioned via the company's Cloud-based DeviceTone Manager platform, the connected device is ready-to-run, and the user can immediately start sending data from the device to the Cloud. Platform users can configure and manage a range of features, for example, execute scheduling tasks, set alert parameters, review analytics and generate reports. Native support for Microsoft Azure IoT and IoT Plug & Play enables users to direct device data to their Azure IoT Cloud—either using a built-in cellular modem or via a gateway using the Nordic SoC's Bluetooth LE wireless connectivity—providing the flexibility to integrate devices with other Microsoft tools such as Azure Stream Analytics and Microsoft Flow.

Industrial IoT

Module suits harsh environments

Laird Connectivity has unveiled its BL653 module, based on Nordic's nRF52833 Bluetooth LE advanced multiprotocol SoC, designed for OEMs developing long range products for harsh operating environments.

The BL653 module comes in a 15 by 10 by 2.2 mm form factor and is qualified over an extended –40° to 105°C operating temperature range. The extended temperature range, memory and dynamic multiprotocol support makes the module suitable for a range of IIoT applications.

Full Speed USB operation allows the BL653 module to be used for USB-compatible wired peripheral applications. The connectivity enables device firmware updates (DFU)-over-USB.

The module also supports multiple programming options including the Nordic nRF5 SDK, Zephyr RTOS, AT command set as well as Laird Connectivity's own smartBASIC environment, offering maximum flexibility to developers.

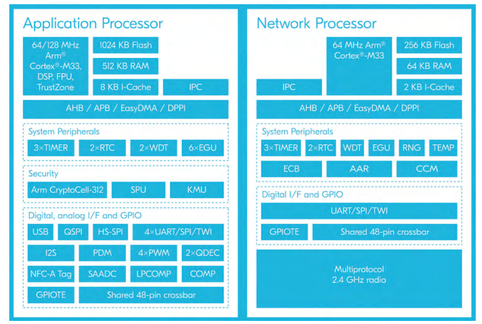
Tech Briefing

The advantages of a dual-core Bluetooth LE SoC

The nRF5340 SoC is equipped with two user-accessible processors allowing developers to build more complex applications with long battery life

Nordic Semiconductor pioneered the Bluetooth LE Arm processor-based SoC with the launch of the nRF51822 back in 2012. The clear size, power, cost and convenience advantages of a single-chip solution ensured the nRF51 Series' success. The nRF52 Series enhanced the concept with a more powerful Arm processor and greater Flash and RAM capacity to meet continued customer demand.

With the recent launch of the nRF5340 (*see* WQ *Issue 4, 2019, pg3*), Nordic has introduced a Bluetooth LE SoC with two user-accessible Arm Cortex M33 processor cores. The SoC changes the landscape for developers looking for a high-performance chip to support ever more complex wireless applications.



The nRF5340 features one Arm M33 processor optimized for performance and a second for efficiency. Both are accessible to the developer

Eliminating the trade-off

More powerful processors with faster clocks and associated larger memory capacity demand more power, yet developers expect each generation of short range wireless SoC to run longer from its batteries. This challenge is especially tough for a SoC with a single processor where there is a constant trade-off between the processor's computational power and its efficiency. For example, there is an energy cost for the computational overhead needed to run complex application software even when the processor is just waking up solely to perform a simple Bluetooth LE connection.

Nordic's dual-core SoC resolves this problem. The application processor is optimized for performance and can run at either 128 or 64 MHz. The choice of clocking frequency is determined by the developer's requirement for processor performance (510 CoreMark at 128 MHz) or efficiency (76 CoreMark/mA at 64 MHz). The processor only needs to wake up when it's time to run the complex application software algorithms.

The network processor is optimized for efficiency (101 CoreMark/mA at 64 MHz) and looks after the relatively simple Bluetooth LE stack operation. To make things even more battery friendly, each processor benefits from its own power management system. Compared with Nordic's advanced (single-core) nRF52840, the nRF5340 offers much greater computing performance yet superior power consumption.

The Bluetooth LE protocol software has hard real-time requirements and, often, the customer application has some real-time requirements of its own which don't combine well with those of the stack. In the medical market, for example, certain certified applications cannot be combined with the protocol software underlining the need for certainty of software behavior.

The challenges can be solved in a single-core SoC, but at the cost of higher software complexity and the associated risk of bugs that are difficult to resolve.

The arrangement of the nRF5340's cores is more like a two-chip solution in one SoC rather than a system that runs software in parallel. Each core has its own firmware images and set of tasks that run optimally on that core. This arrangement makes it easy to overcome the problems of clashes between application and protocol code in real-time environments.

Access all areas

A dual-core architecture does introduce some complexity because the SoC has more interacting components compared to a single-core chip. To overcome this, the nRF5340 architecture has been divided into clearly defined subsystems to maximize its flexibility.

For example, Nordic's engineers have designed an efficient and stable subsystem for RF protocol software operation. Because this subsystem has been perfectly optimized, the customer does not need to allocate development resource to it, allowing them to focus solely on the application processor subsystem and to ensure the differentiation of their product from their competition.

This does not mean the more ambitious developer is locked out from the network processor; customer access is available to both cores and then can be used as the developer wants – which is not always the case for competitive products.

For example, the network processor's programmability enables the developer to select elements of the application software to run on that processor while taking advantage of its higher efficiency compared with the application processor.

Customers that require just simple Bluetooth LE connectivity can fit the whole Bluetooth LE stack in the network domain, while others might target multiprotocol solutions where the upper layers will only fit in the application domain. (IoT applications requiring end-to-end encryption are best served by the CryptoCell-312, which only resides in the application domain.)

Nordic plans to provide software examples that demonstrate different approaches for combining the application and network processors to make the most of the dual-core accessibility.

> "The nRF5340 SoC changes the landscape for developers looking for a high-performance chip to support ever more complex wireless applications

Tech Check

Software development for the nRF5340 is performed through the nRF Connect SDK and nRF5340 preview development kit (PDK) (shown above). The SDK includes Zephyr RTOS, protocol stacks, application samples and hardware drivers, and has free SEGGER Embedded Studio IDE support

Tech Perspective

Using a blockchain for secure asset tracking

IoTeX is combining the security built into Nordic's nRF9160 and its blockchain technology to protect the integrity of critical asset tracking data

The commercialization of cellular IoT asset tracking solutions such as IoTeX's Pebble Tracker has the potential to revolutionize supply chain applications. The product, powered by Nordic Semiconductor's nRF9160 SiP, uses mature, secure cellular infrastructure to provide location, environment and motion tracking data for global asset tracking.

But more than that, Pebble Tracker promises to address problems such as the more than $400 billion in annual losses that result from supply chain errors such as temperature excursions. Each year compensation for these loses and many others are sought, and payouts from penalty clauses and insurance claims rely heavily on asset tracking data. (*See WQ Issue 2, 2020, pg22.*) Should there be any suspicion that asset tracking information has somehow been tampered with or falsified, claims could drag on for years. And worse, litigation could follow.

IoTeX is tackling the challenge by combining the Pebble Tracker's nRF9160 SiP's Arm TrustZone (for trusted execution) and Arm CryptoCell 310 (for application-layer security) protection features with the company's blockchain for large scale, decentralized and trusted asset tracking applications.

Trust built on hardware and the blockchain

The Arm TrustZone technology built into the nRF9160 forms a Trusted Execution Environment (TEE). The TEE is a secure area inside the Arm processor that runs in parallel but is isolated from (and often invisible to) the main operating system. Code and data inside the TEE are maintained with the highest level of integrity and confidentiality. Such a system protects the valuable code and data while enabling less valuable code and data to run unencumbered on the main operating system. (*See WQ Issue 3, 2019, pg25.*)

But a truly secure IoT device requires more than a TEE; additional roots of trust (RoTs) and security mechanisms are demanded. That's the role of Arm's CryptoCell.

CryptoCell is an embedded security platform for devices using TrustZone, comprising a multilayered architecture combining hardware data path, RoT management and operation control with a layer of security firmware. (*See WQ Issue 4, 2019, pg26.*)

Pebble Tracker sends its data to the IoTeX blockchain-based backend services to orchestrate large-scale, decentralized asset tracking applications. Blockchains are based on the concept of openly verifiable ledgers ensuring that all transactions are publicly confirmed and logged with an uncorruptible digital signature. (Only the transaction is visible, not the private data or content that triggered it.) Because of the use of open ledgers, tampering with blockchain data would quickly be exposed.

IoTeX's blockchain and IoT technology stack, which includes sophisticated middleware to pair with Nordic's hardware, offers SDKs that developers can use alongside one of Nordic's preferred operating systems, the open-sourced Zephyr, to build the trusted applications of tomorrow.

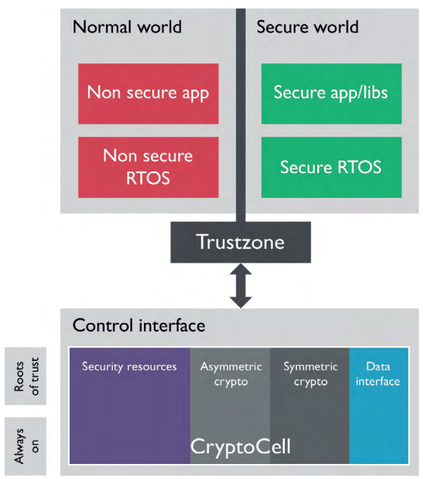
Security and privacy by design

Pebble Tracker makes use of built-in environmental and motion sensors from Bosch and TDK to capture real-time metrics, including GPS location, temperature, humidity, volatile organic compound (VOC) level, light, acceleration and orientation.

The product employs "security and privacy by design" methodology, and equipped with the nRF9160 SiP's powerful security features, it is built to ensure all data the device generates is trustworthy and owned exclusively by the device's owner.

The nRF9160 SiP enables LTE-M and NB-IoT network connectivity and integrated GPS support for precise, long range tracking of asset data. Via this cellular connectivity, Pebble Tracker continuously records real-time data and transmits the digitally signed information to the Cloud or other backend systems including the IoTeX blockchain.

The combination of hardware security and the blockchain ensures protection of all data points produced and brings end-to-end trust to tracking applications. The trusted data can then be used by backend services to fulfill predeployed smart contracts. For example, if a tracker detects an asset is mishandled, the blockchain contract can automatically penalize the company and compensate the customer without human intervention.



The Arm TrustZone technology built into the nRF9160 forms a Trusted Execution Environment. It works together with CryptoCell, an embedded security platform

> The combination of hardware security and the blockchain ensures protection of all data points produced and brings end-to-end trust to tracking applications

Tech Check

Pebble Tracker uses a 750 mAh LiPo battery, providing up to one week of battery life between recharge for a typical asset tracking application. The nRF9160 SiP has been engineered to minimize power consumption with, for example, support for eDRX and PSM power saving modes

Product Summary

Full product details at:
www.nordicsemi.com/Products

		nRF 9160 SERIES	nRF SERIES 53	nRF 52 SERIES							nRF 5 SERIES		
		nRF9160	nRF5340	nRF52840	nRF52833	nRF52832	nRF52820	nRF52811	nRF52810	nRF52805	nRF51822	nRF51422	nRF51824
WIRELESS PROTOCOL	LTE-M	●											
	NB-IOT	●											
	GPS	●											
	BLUETOOTH LOW ENERGY		●	●	●	●	●	●	●	●	●	●	●
	BLUETOOTH 5.2		●	●	●	●	●	●	●	●			
	DIRECTION FINDING		●		●		●	●					
	2 MBPS		●	●	●	●	●	●	●	●			
	LONG RANGE		●	●	●		●	●					
	BLUETOOTH MESH		●	●	●	●	●						
	THREAD		●	●	●		●	●					
	ZIGBEE		●	●	●		●						
	ANT		●	●		●			●			●	
	2.4 GHZ PROPRIETARY		●	●	●	●	●	●	●	●	●	●	●
	NFC		●	●	●	●							
TYPE	SYSTEM-ON-CHIP		●	●	●	●	●	●	●	●	●	●	●
	SYSTEM-IN-PACKAGE	●											
CORE SYSTEM	CPU	64 MHz Arm Cortex-M33	128 MHz Arm Cortex-M33 +64 MHz Arm Cortex-M33	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	16 MHz Arm Cortex-M0	16 MHz Arm Cortex-M0	16 MHz Arm Cortex-M0
	FPU	●	●	●	●	●							
	DSP INSTRUCTION SET	●	●	●	●	●	●	●	●	●			
	CACHE	●	●	●	●	●							
	MEMORY	1 MB Flash, 256 kB RAM	1 MB Flash, 512 kB RAM +256 kB Flash, 64 kB RAM	1 MB Flash, 256 kB RAM	512 kB Flash, 128 kB RAM	512 kB or 256 kB Flash, 64 kB or 32 kB RAM	256 kB Flash, 32 kB RAM	192 kB Flash, 24 kB RAM	192 kB Flash, 24 kB RAM	192 kB Flash, 24 kB RAM	128 kB or 256 kB Flash, 32 kB or 16 kB RAM	128 kB or 256 kB Flash, 32 kB or 16 kB RAM	256 kB Flash, 16 kB RAM
	CLOCKS	64 MHz / 32 kHz	128 MHz / 64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	16 MHz / 32 kHz	16 MHz / 32 kHz	16 MHz / 32 kHz
SECURITY	ARM TRUSTZONE	●	●										
	ARM CRYPTOCELL	310	312	310									
	ROOT-OF-TRUST	●	●	●									
	SECURE KEY STORAGE	●	●										
	AES ENCRYPTION	●	●	●	●	●	●	●	●	●	●	●	●
RADIO	LTE-M/NB-IOT/GPS MODEM	●											
	CERTIFIED LTE BANDS	1-5, 8, 12-14, 17-20, 25-26, 28, 66											
	FREQUENCY	700-2200 MHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz
	MAXIMUM TX POWER	23 dBm	3 dBm	8 dBm	8 dBm	4 dBm	8 dBm	4 dBm	4 dBm	4 dBm	4 dBm	4 dBm	4 dBm
	RX SENSITIVITY	-108 dBm (LTE-M), -114 dBm (NB-IoT), -155 dBm (GPS)	-97.5 dBm (1 Mbps)	-95 dBm (1 Mbps)	-95 dBm (1 Mbps)	-96 dBm (1 Mbps)	-95 dBm (1 Mbps)	-97 dBm (1 Mbps)	-96 dBm (1 Mbps)	-97 dBm (1 Mbps)	-93 dBm (1 Mbps)	-93 dBm (1 Mbps)	-93 dBm (1 Mbps)
	ANTENNA INTERFACE	50 Ω single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Differential	Differential	Differential
PERIPHERALS	HIGH SPEED SPI		●	●									
	TWI, SPI, UART	4xTWI/SPI/UART	4xTWI/SPI/UART +TWI/SPI/UART	2xTWI/SPI, SPI, 2xUART	2xTWI/SPI, SPI, 2xUART	2xTWI/SPI, SPI, UART	2xTWI/SPI, UART	TWI/SPI, SPI, UART	TWI, SPI, UART	TWI, SPI, UART	2xTWI/SPI, UART	2xTWI/SPI, UART	2xTWI/SPI, UART
	QSPI		●	●									
	USB		●	●	●		●						
	PWM	4	4	4	4	3		1	1				
	PDM	●	●	●	●	●		●	●				
	I2S	●	●	●	●	●							
	ADC, COMPARATOR	ADC	●	●	●	●	COMP	ADC, COMP	ADC, COMP	ADC	ADC, LPCOMP	ADC, LPCOMP	ADC, LPCOMP
	TIMER, RTC	3, 2	3, 2 + 3, 2	5, 3	5, 3	5, 3	4, 2	3, 2	3, 2	3, 2	3, 2	3, 2	3, 2
	TEMPERATURE SENSOR	●	●	●	●	●	●	●	●	●	●	●	●
APPLICATIONS	AGRICULTURE	●											
	ASSET TRACKING	●	●		●		●	●					
	AUTOMATION		●	●	●	●	●		●		●	●	●
	BEACON			●	●	●		●	●	●	●	●	●
	CONSUMER ELECTRONICS		●	●	●	●	●		●	●	●	●	
	DIRECTION FINDING		●		●		●	●					
	GAMING / VR + AR		●	●	●	●	●		●		●	●	
	HEALTHCARE & MEDICAL		●	●	●	●			●	●	●	●	
	INDUSTRIAL SYSTEMS	●	●	●	●		●						
	MESH NETWORKS		●	●	●	●	●				●		
	PC PERIPHERALS			●	●	●	●		●	●	●	●	
	PROFESSIONAL LIGHTING		●		●		●						
	SMART BUILDINGS	●	●	●	●		●						
	SMART CITY	●	●										
	SMART HOME	●	●	●	●	●	●	●	●		●	●	
	SMART METERING	●											
	SPORTS & FITNESS	●	●	●	●	●			●		●	●	
	TOYS		●	●	●	●			●		●	●	
	WEARABLES	●	●	●	●	●			●		●	●	
CERTIFICATIONS		GCF, PTCRB, CE, FCC, Verizon ++	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC
OPERATING TEMPERATURE		-40 to 85 °C	-40 to 105 °C	-40 to 85 °C	-40 to 105 °C	-40 to 85 °C	-40 to 105 °C	-40 to 85 °C	-40 to 85 °C	-40 to 85 °C	-40 to 85 °C	-40 to 85 °C	-40 to 105 °C
SUPPLY VOLTAGE RANGE		3.0 to 5.5 V	1.7 to 5.5 V	1.7 to 5.5 V	1.7 to 5.5 V	1.7 to 3.6 V	1.7 to 5.5 V	1.7 to 3.6 V	1.7 to 3.6 V	1.7 to 3.6 V	1.8 to 3.6 V	1.8 to 3.6 V	1.8 to 3.6 V
DEVELOPMENT KITS		nRF9160 DK, Nordic Thingy:91	nRF5340 PDK	nRF52840 DK nRF52840 Dongle	nRF52833 DK	nRF52 DK Nordic Thingy:52	nRF52833 DK	nRF52840 DK	nRF52 DK	nRF52 DK	nRF51 DK, nRF51 Dongle	nRF51 DK, nRF51 Dongle	nRF51 DK, nRF51 Dongle
PACKAGES		10x16x1 mm LGA	7x7 mm aQFN94 (48 GPIOs)	7x7 mm aQFN73 (48 GPIOs), 3.5x3.6 mm WLCSP94 (48 GPIOs)	7x7 mm aQFN73 (42 GPIOs), 5x5 mm QFN40 (18 GPIOs), 3.2x3.2 mm WLCSP (42 GPIOs)	6x6 mm QFN48 (32 GPIOs), 3.0x3.2 mm WLCSP50 (32 GPIOs)	5x5 mm QFN40 (18 GPIOs)	6x6 mm QFN48 (32 GPIOs), 5x5 mm QFN32 (17 GPIOs), 2.48x2.46 mm WLCSP33 (15 GPIOs)	6x6 mm QFN48 (32 GPIOs), 5x5 mm QFN32 (16 GPIOs), 2.48x2.46 mm WLCSP33 (15 GPIOs)	2.48x2.46 mm WLCSP28 (10 GPIOs)	6x6 mm QFN48, WLCSP48, Thin CSP	6x6 mm QFN48, WLCSP48	6x6 mm QFN48, WLCSP48

Tech Profile

nRF52805

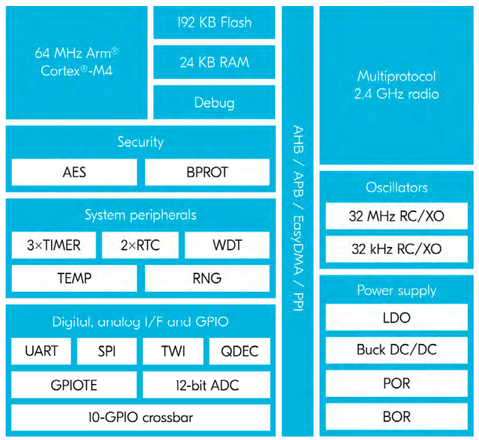
nRF 52 SERIES

Description: The nRF52805 SoC complements the other nRF52 Series SoCs with a Bluetooth 5.2 single-chip solution. The SoC is available in a 2.48 by 2.46 mm WLCSP optimized for small two-layer PCB designs, making it ideal for cost-constrained applications. The nRF52805 SoC is a good choice for beacons, disposable medical devices, sensors, styluses and presenters. It can also be selected as a network processor providing the wireless connectivity for a companion application processor.

Hardware: The nRF52805 features a powerful 64 MHz 32-bit Arm Cortex-M4 processor (144 CoreMark) with excellent efficiency (65 CoreMark/mA) and includes 192 KB Flash plus 24 KB RAM. The multiprotocol radio offers up to +4 dBm power output and -97 dBm sensitivity (1 Mbps Bluetooth LE throughout). The radio's peak power draw is only 4.6 mA (TX 0 dBM, RX 1 Mbps) and the SoC's current draw is as low as 0.3 µA in System OFF and 1.1 µA in System ON with 24 KB RAM retained and RTC running. The SoC features a range of analog and digital interfaces such as UART, SPI, TWI and QDEC, a two-channel 12-bit ADC and ten GPIOs. A 9.5 by 8.8 mm reference layout with all ten GPIOs is available, which requires only ten external components. The SoC can be powered from a 1.7 to 3.6 V supply and integrates LDO and DC-to-DC voltage regulators.

Software: The nRF52805 is supported by the S112 and S113 SoftDevices. These SoftDevices (Bluetooth 5.2-qualified protocol software) are memory-optimized peripheral 'stacks' supporting 2 Mbps throughput and CSA #2 features. The stacks support up to four connections as a Peripheral concurrently with a Broadcaster. The S112 and S113 support LE Secure Connections, improving security compared to LE Legacy Pairing. S113 also supports LE Data Packet Length Extension, resulting in higher throughput.

Development tools: The nRF52 DK is the recommended DK for the nRF52805. It emulates the SoC, and can be used as a starting point for development before moving over to a custom board. A guide on how to use nRF52805 with nRF5 SDK is available.



The nRF52805 SoC incorporates a 64 MHz 32-bit Arm Cortex M4 microprocessor, 192 KB Flash and 24 KB RAM, multiprotocol 2.4 GHz radio, power supply, peripherals and a range of interfaces in a 2.48 by 2.46 mm WLCSP