WQ
WIRELESS QUARTER

EMPOWERING ABILITY:
TECH AIDS INCLUSIVITY FOR
PEOPLE WITH A DISABILITY

BETTER TOGETHER:
PARTNERSHIP MAKES
THE IoT DREAM WORK

ENERGY AUTONOMY:
SUSTAINABLE ENERGY
POWERS IoT SENSORS

Dog Gone

Smart pet wearables provide
peace of mind about the health and
whereabouts of humans' best friend

NORDIC BOOSTS CLOUD
SERVICES SUPPORT

PROMOTING SUPPLY
CHAIN SUSTAINABILITY

EMBEDDED ANTENNAS
FOR CELLULAR DESIGNS

NORDIC SEMICONDUCTOR

WORK SOMEWHERE AWESOME

We are increasing our global footprint and continuing our journey by opening new offices across the globe. Do you dare to join a wireless tech pioneer and be a part of our team?

Welcome

Svenn-Tore Larsen
CEO

Today's business environment demands commercial companies do far more than just make good products. Customers, investors and employees expect firms to supply their solutions in a sustainable way. Otherwise, they will go elsewhere to fulfill their requirements.

Sustainability has been at the top of Nordic's agenda for decades. For example, since the early 2000s the company has worked tirelessly to forge responsible supply chains.

More recently, Nordic was recognized as one of the top 100 companies by STOXX Global ESG Leaders Index, the benchmark for sustainability champions. Environmental, social and governance (ESG) initiatives are specific and measurable so this listing shows the company continues to make good progress.

Nordic is also proud to be a member of the Responsible Business Alliance (RBA) – an organization for firms that manufacture electronic goods and the world's largest industry coalition dedicated to corporate social responsibility in global supply chains. Later in this issue my management colleague Ebbe Rømcke, SVP Quality & Sustainability, explains more about our ESG intiatives.

The design of Nordic's products is also influenced by sustainable practices. Every device we produce is designed to maximize battery life – reducing the environmental impact of millions of batteries. Better yet, many of the IoT products supported by Nordic technology are being used in applications that improve the environment. Examples include air quality and energy monitors, protecting endangered species and mitigating deforestation.

As the fog of the pandemic lifts, looking after the planet will become one of the most important business imperatives and one which will continue to inform Nordic's future direction.

> Customers, investors and employees expect firms to supply their solutions in a sustainable way. Otherwise, they will go elsewhere

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News

The latest developments from Nordic Semiconductor

Education

Nordic backs digital education initiative for disadvantaged Nigerian students

Nordic Semiconductor has partnered with the Micro:bit Educational Foundation to support Teens Can Code, a social enterprise based in Nigeria. The organization provides computer programming training to disadvantaged students and equips them with skills to be creators in the digital economy.

The partnership will see Nordic provide a grant to help Teens Can Code inspire hundreds of school students, particularly girls and those from disadvantaged backgrounds, to learn digital skills and apply them to create social impact. The grant will also enable Teens Can Code to train teachers and volunteer educators in schools and community groups to support participants in the Micro:bit Educational Foundation's next do your:bit challenge. The do your:bit challenge is designed to add social purpose to digital learning by allowing students to apply their digital skills to real world issues.

Teens Can Code became involved in the do your:bit challenge in 2019, and with the benefit of external funding was able to carry out workshops and training across Nigeria to inspire young people to participate in the challenge.

Teens Can Code will use part of the funding to carry out an enhanced version of the previous year's training program including an additional technical session on how to code a micro:bit.

"The support provided by Nordic Semiconductor and the Micro:bit Educational Foundation allows Teens Can Code to recruit volunteers and teachers who are ready and willing to learn so they can pass the knowledge to students in various communities," says Damian Isaac Ezirim, Founder of Teens Can Code. "Otherwise these students may never even hear about the amazing opportunity the do your :bit challenge offers.

"Many of these students are going to be writing their first line of code or creating their first program, and many will be engaging in solving real-world problems for the first time."

"This collaboration with long-time partner the Micro:bit Educational Foundation reinforces Nordic's commitment to education by supporting young people from disadvantaged areas of Nigeria to get involved in the do your :bit challenge," says Geir Langeland, EVP Sales and Marketing, Nordic Semiconductor.

Smart City

Japan trials remote gas pipe monitoring

A Japanese IoT solutions company has launched a cellular IoT-based monitoring system that enables utilities and contractors to remotely identify gas pipe faults.

Problems with the gas supply can occur for a variety of reasons including the structural failure of old pipes, road construction and water leaking into the pipe as a result of a crack. Such faults require the gas supply to be immediately cut off and a maintenance crew dispatched to identify the affected area and perform repairs. Locating the source of the fault has traditionally required a trial-and-error-based approach from

the contractor's maintenance crew.

The Gas Pipe Dew Point/Gas Pressure Remote Monitoring System enables the gas supply to be up and running faster than previously possible, and was jointly developed by Braveridge and Japan's City Gas Companies Association.

Multiple devices are installed across the gas pipe network. Each unit employs two pressure sensors to monitor and record the air pressure difference across the pipe which can indicate the presence of a potential leak. A temperature and humidity sensor monitors dew point to identify pipe water seepage.

The sensors integrate Nordic's nRF9160 SiP to provide LTE-M connectivity to relay data to the cellular network and in turn to Braveridge's BraveGATE Cloud Service where management can review the data.

Smart Home

Nordic joins CSA in China to drive smart home interoperability

Nordic Semiconductor has joined the Connectivity Standards Alliance Member Group China (CMGC), a branch of the Connectivity Standards Alliance (CSA) dedicated to promoting and achieving smart home device interoperability in China by harmonizing technology standards and ecosystems.

Nordic is joining CMGC to bring the promotion of Matter (previously known as Project CHIP) to the next level having taken a leading role in its development from the early days of Project CHIP.

Backed by more than 180 companies worldwide, Matter is a unified and secure IP-based application layer for the smart home. The CSA believes Matter will ensure seamless connectivity among Matter-certified devices and home hubs from various ecosystem suppliers, for example Apple, Google and Amazon.

Matter aims to create a universal application layer on top of the mature Transmission Control Protocol (TCP) and User Datagram Protocol (UDP)—ideal for delivering seamless,

end-to-end security between a wireless devices and another device, app or service. This ensures interoperability between devices, platforms and ecosystems. The CMGC will be driving the initiative in China, and Nordic Semiconductor will take a leading role to help fulfill this vision.

"As a strong believer in open connectivity standards, Nordic maintains a conviction that Matter will ignite significant growth in the smart home market. The company sees this as the ideal time to join forces with the other members of the CMGC to promote Matter and other connectivity standards in China," says Ken Lam, Technical Marketing Manager – APAC, Nordic Semiconductor.

"Nordic Semiconductor has been involved in low power wireless technology for many years, and has deeply participated in the alliance's technology development process," says Laura Shang, China Representative, CSA. "We look forward to working together to promote [the standard] in the Chinese market, making connections more convenient."

Smart Health

Continuous glucose monitoring system works non-stop for 15 days

Chinese medical equipment manufacturer, MeiQi, has launched a continuous glucose monitoring system that allows people living with diabetes to continuously test and record their blood sugar levels for up to 15 days.

The RGMS-III solution consists of a sterilized disposable sensor which is attached to the user's upper arm or abdomen using an applicator; a transmitter connected to the sensor; a handheld smart device that displays blood glucose data; as well as a smartphone app. The transmitter relays the data to the smart device and/or the smartphone app using Bluetooth LE wireless connectivity provided by Nordic Semiconductor's nRF52810 SoC.

Nordic's nRF52840 SoC integrated in the smart device provides both the wireless connectivity to the transmitter, and the processing power for the smart device's

functionality. Its Arm Cortex M4 processor with floating point unit provides ample computational power to run both the complex sensor algorithms that convert the sensor data from the transmitter into the blood glucose value displayed on the smart device, as well as heart rate monitoring and step counter features. The watch can also provide alerts when blood glucose levels are either too high or low.

From the app the user can also monitor current blood glucose levels, set alarms, as well as view a full report of glucose level fluctuation over the relevant period. This data can help users view changes and analyze potential causes of any glucose fluctuation.

NORDIC COMMITS TO INDIAN WI-FI HUB

Following its acquisition of Imagination Technologies Group's Wi-Fi development team, expertise and IP tech assets, Nordic Semiconductor has announced plans to create a global Wi-Fi R&D hub at a former Imagination location in Hyderabad, India. Nordic now plans to actively recruit Wi-Fi specialists across a range of engineering disciplines including R&D, test and verification, security, low-power design and interoperability. The firm said the Hyderabad Wi-Fi hub has a lab with RF chambers, Wi-Fi Alliance pre-certification facilities and an interoperability lab to ensure seamless operation with other Wi-Fi vendors.

INTERNET OF MEDICAL THINGS ON THE RISE

The COVID-19 pandemic and consumer interest in health and wellbeing has driven demand for Internet-enabled telemedicine and telediagnostic solutions, according to medical innovation solution provider, MIDI Medical Product Development. The firm said wearable biosensing lifestyle devices that allowed the collection of critical biometric data in real time were driving the growth of the Internet of Medical Things (IoMT). The company said the pandemic had created a huge need for digital health infrastructure for remote patient monitoring, and that the world would be unlikely to return to face-to-face healthcare, where avoidable, even once the pandemic had run its course.

NORDIC SEMI GROWS PRESENCE IN SINGAPORE

Nordic has opened a representative office in Singapore that will allow the company to develop a deeper understanding of the city-state's market and customer base for short range wireless and low power cellular IoT solutions. Singapore has long been an important market for Nordic in Southeast Asia, and the extended local presence will build on this by developing stronger relationships with potential customers, researching demand for wireless IoT solutions and providing close-to-hand support for all product-related inquiries. Nordic's increased presence comes at a time when the city-state is rapidly accelerating its adoption of IoT technologies.

Sports & Fitness

Australian smart bike lights trial aims to improve rider safety

Australia's Victoria state government is set to launch a national–first trial—and the largest of its kind worldwide—using sensor–based wireless bike light technology to find new ways of improving road cyclist safety. The Transport Accident Commission (TAC), in collaboration with research partners, will oversee the 12–month Light Insights Trial (LIT) involving a diverse group of 1000 participants given access to a smart bike light developed by See.Sense, a Northern Ireland–based cycling sensor technology startup.

In addition to providing increased visibility and safety features including a brighter flash in high risk situations, the See.Sense solution uses proprietary built–in sensor technology to capture crucial road safety data including collisions, 'near–miss' incidents, abrupt acceleration and deceleration, swerving, average speeds, and road surface and route conditions throughout a ride.

The smart light uses integrated wireless connectivity to transmit the data to a compatible smartphone, from where the See.Sense app can be used to access all the information.

Aggregated and depersonalized ride insights, including rider feedback, can also be shared with See.Sense partners to improve

conditions for city cycling around the world.

Data from the Victoria trial is expected to provide valuable new insights into how people ride and what factors impact their safety. LIT stakeholders also anticipate the research findings could help inform future policy planning and infrastructure improvements for cyclists in the region.

See.Sense is the innovative company behind See.Sense AIR—a complementary solution to the smart bike lights and powered by Nordic's nRF9160 SiP—which it claims is

the world's first NB–IoT cellular bike security tracker. Performing like an electronic tag for a bicycle, the compact, lightweight 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 then notified of any incidents through the associated smartphone app, either via short range Bluetooth LE if they are within 50 meters, or via NB–IoT, if they are further away. (*See* WQ *Issue 3, 2020 pg26*.)

Smart dock enables IT managers to monitor peripheral devices

Good Way Technology has launched an IT system integration solution using Bluetooth mesh technology. The product enables IT managers to remotely control and monitor IT devices and ports in the workplace without the need for an external host.

The Smart Dock can be deployed across multiple workstations enabling staff to temporarily connect their peripheral devices, such as a monitor or hard disk drive, to the docking station via HDMI or USB port. IT managers can then monitor and control the peripheral devices from a supervisory Cloud dashboard.

The Smart Docks are wirelessly connected by a Nordic nRF52832 SoC–enabled Bluetooth mesh network, taking the load off the local Wi–Fi network and helping to avoid system crashes due to large uplink connections.

IT managers can use an Android app software tool, or the Smart Dock Management Portal Cloud–based dashboard, to rapidly deploy

large numbers of Smart Docks. They can then control and monitor peripheral devices connected to each Smart Dock, set schedules to automatically upgrade firmware for docks being deployed and remotely update firmware in one click. Managers can also monitor or enable/disable I/O ports and receive push notifications when a dock appears abnormal, or a peripheral is connected or disconnected.

In addition, Smart Docks can be used to extend the Bluetooth mesh network infrastructure to remote IoT sensors and/or tags for indoor positioning or environmental control applications.

Connecting patients and doctors remotely

Healthcare solutions startup, Stel Life, has released a Bluetooth LE– and cellular IoT–powered gateway that connects vitals monitoring devices to electronic health records, enabling medical professionals to remotely monitor patients.

Designed to integrate with devices such as scales, blood pressure monitors and wearables, the Stel Vitals Hub collects and sends vitals data to patients' preferred Electronic Health Records (EHR) or digital health platform. This allows care teams to monitor patient health trends.

The hub captures the health data from the vitals devices using Nordic SoC–enabled Bluetooth LE connectivity, then instantly transmits the information to the EHR using the cellular IoT connectivity provided by Nordic's nRF9160 SiP.

Industrial IoT

HPI companies offered remote monitoring

A cellular IoT–based sensor that allows hydrocarbon processing industry (HPI) companies to remotely monitor pipelines for corrosion–under–insulation (CUI) to identify impending pipeline failure has been launched by IoT technology company, Trisense.

The Fusion 310 CUI Sensor helps oil and gas companies and refineries remotely monitor pipelines for CUI. CUI (whereby water has penetrated the pipe's insulation and caused degradation) is a costly yet avoidable issue that impacts steel piping, storage tanks, container vessels and other process equipment in plants that are subject to extreme temperature fluctuations.

Multiple Fusion 310 CUI Sensor units are installed at appropriate locations along critical stretches of a pipeline. Each unit integrates sensors measuring relative humidity, temperature and water presence inside the insulation to detect problems and predict the failure of a pipeline, as well as locate the corrosion. The system eliminates the need to dismantle kilometers of cladding to inspect the

full length of the pipe, allowing users to reduce the costs associated with the inspection and upgrade of insulated pipelines.

Each device integrates a Nordic nRF9160 SiP to provide LTE–M/NB–IoT connectivity to relay the sensor data to the cellular network and in turn to a Cloud–based platform for remote monitoring and analysis. This eliminates the need to deploy additional infrastructure such as a gateway.

Each Fusion 310 device is powered by two primary lithium batteries, providing a battery life of above ten years. This extended battery life avoids the need for frequent battery replacement in areas that are difficult or potentially hazardous to access.

Smart Health

Helping asthma patients breathe easy

Aptar Pharma, a leading provider of drug delivery solutions, has unveiled a Bluetooth LE device that ensures asthma patients correctly use their metered dose inhalers (MDIs).

The smart solution is designed for use in conjunction with pressurized MDIs to effectively treat asthma and chronic obstructive pulmonary disease (COPD).

The Connected Device for MDIs platform enables an asthma patient and their healthcare provider to monitor adherence to medication, compliance, training, coordination improvement and flow sensing. This ensures the patient correctly uses their metered dose inhaler—which is vital for prevention and control of the disease—and provides valuable insights for the patient, healthcare professional and caregiver.

The Connected Device for MDIs attaches to the top of an MDI asthma canister. Using Bluetooth LE connectivity provided by Nordic Semiconductor's nRF52810 SoC, all the data generated on the device can be wirelessly transmitted to the patient's smartphone. A

mobile–hosted app can then be used to monitor information on how successfully medication has been administered. For example, the patient can see the date and time stamp of when the medication was taken, whether they shook the MDI as required and whether they inhaled and depressed the canister at a time when the drug has the best chance of good deposition into the lungs.

A Cloud–connected health platform also enables healthcare professionals to review the data to connect with patients and help track their respiratory care.

"We are thrilled Aptar Pharma has chosen Nordic as a key supplier for its connected drug delivery platform," says Thomas Søderholm, Director Business Development with Nordic. "Healthcare is very important to us."

"We selected Nordic's nRF52810 SoC [for our product] due to the chip's power consumption and generous memory allocation, but also because Nordic is a reliable industry partner," says Jerome Praquin, Director Industrialization with Aptar Pharma.

Wearables

Smartband tracks and records ten days of fitness data on single charge

Titan Company Limited, one of India's leading lifestyle brands, has unveiled a smartband that tracks detailed fitness metrics for up to ten days between recharge. The product employs Nordic Semiconductor's nRF52832 SoC to process and transmit the data to a smartphone app.

The Fastrack Reflex 3.0 smartband features a full-touch color display, more than ten different sports modes, a 24/7 continuous heart rate monitor and sleep tracker. The IP67-rated product has been designed for the youth-oriented fitness market with a range of dual color straps.

The smartband records a range of user data—including step count, calories burned, distance run or cycled—and relays this to a partner app on the user's smartphone using Bluetooth LE wireless connectivity provided by the Nordic SoC. From the smartband the user can also remotely control smartphone functionality, for example operate the camera or commence music playback, as well as view notification alerts.

Once the smartband has been paired with the user's smartphone, the wearer can analyze their activity and sleep patterns from the Fastrack Reflex Word app, with detailed daily fitness and sleep statistics, as well as a

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full monthly report. Sleep and step goals can be set through the smartband or app, and 'Z points' are earned by completing fitness tasks. These points are then collated, and rank the user locally and globally, to provide a sense of community during fitness activity.

An AutoHR feature also measures the wearer's heart rate at set intervals, providing the user with a comprehensive overview of their most effective fitness activities each day. The Nordic SoC's Arm Cortex M4 processor with floating point unit provides ample computational power to manage the complex algorithms that convert sensor data inputs into meaningful fitness and sleep feedback to the user. Sedentary reminders can also be set to ensure the user remains on track with their fitness goals.

Smart Home

Bluetooth LE liquid heater provides sustainable kettle alternative

Designed as an alternative to the often wasteful and expensive electricity requirements of a traditional kettle, BrandBrandNew has launched Heatle, a smart liquid heater that combines induction and immersion technology to heat any fluid directly in its intended vessel to a specified temperature.

Heatle consists of a base unit and a standalone rod with an integrated temperature sensor and a heating disc. In operation, the user sets the desired temperature via the Heatle smartphone app. The temperature information is communicated to the base unit using Bluetooth LE connectivity provided by Nordic's nRF52832 SoC, and in turn relayed to heating rod that employs Nordic's nRF52805 Wafer Level Chip Scale Package (WLCSP).

When the vessel and liquid to be heated is

[▶]

placed on the base unit, and the rod and heating disc is immersed in the liquid, the induction heating process begins. When the liquid reaches the desired heat as determined by the in-built temperature sensor, this information is relayed back to the base unit, and user's smartphone, instructing that the liquid is at the requested temperature.

While the base unit is mains-powered, the rod employs an energy-harvesting circuit that draws power from the base unit's magnetic field and charges two 300 mF capacitors small enough to fit inside the rod's 5.4 mm diameter hollow tube. The energy harvesting system's efficiency is boosted by the ultra low power consumption of the nRF52805 WLCSP.

Smart Health

Smart shirts watch your heart health

Smart clothing developed by Texas-based Rice University (RU) is taking heart monitoring to the next level by employing conductive nanotube thread to weave wireless functionality into regular apparel.

The Brown School of Engineering lab at RU has sewed nanotube fibers into athletic wear to monitor the heart rate and take a continual electrocardiogram (ECG) of the wearer. The developers claim when compared with commercial medical electrode monitors, the carbon nanotube shirt gave slightly better ECGs.

The fibers are just as conductive as metal wires, but washable, comfortable and far less likely to break when a body is in motion, the researchers claim. The fibers provided not only steady electrical contact with the wearer's skin but also served as electrodes to connect Bluetooth LE transmitters to relay data to a smartphone.

Logistics & Transport

Bluetooth LE tracker makes location finding easy with Apple Find My app

Slovenian firm, Chipolo, has launched the Chipolo ONE Spot, a Bluetooth LE tracker that helps users locate lost items as part of the Apple Find My network accessory program.

Chipolo ONE Spot is a lightweight, water resistant item finder designed to help users find their missing valuable items. The solution works exclusively with the Apple Find My network, made up of hundreds of millions of Apple devices around the world. By attaching the Find My-enabled Chipolo ONE Spot to personal belongings such as keys or luggage, and adding it to the Apple Find My app on their iPhones or iPads, users can find missing or misplaced valuables through the private and secure Apple Find My network.

If Chipolo ONE Spot is nearby, a loud 120 dB ring can be triggered from the device by using the Find My app to easily locate the missing item. If Chipolo ONE Spot is missing, nearby devices in the Apple Find My network will help locate it. The device's Bluetooth

LE connectivity is powered by Nordic Semiconductor's nRF52833 SoC. The SoC's Arm Cortex M4 processor with floating point unit, ensures the device works seamlessly with the Apple Find My app.

The entire process is end-to-end encrypted and anonymous, so no one else, not even Apple, Chipolo, or Nordic Semiconductor can view an item's location, or the location or identity of any device that helped locate it. Should an item ever get truly lost, it can be put in Lost Mode to display a message and contact information to anyone who might find it.

Internet of Things

Ericsson forecasts huge growth for Massive IoT

As NB-IoT and LTE-M technologies continue to be rolled out around the world, new research by global telco infrastructure leader Ericsson predicts the total number of cellular IoT connections will increase by almost 80 percent during 2021 to reach 330 million.

According to the latest Ericsson Mobility Report, by 2026 these technologies—known collectively as Massive IoT—will make up almost half (46 percent) of all cellular IoT connections. The most deployed Massive IoT devices to date include meters, sensors and tracking devices.

Ericsson also predicts 'Broadband IoT' (4G/5G technology) will this year overtake 2G and 3G as the segment that enables the biggest share of IoT applications. Broadband IoT includes wide area use cases that require

higher throughput, lower latency, and larger data volumes. The report predicted 44 percent of cellular IoT connections would be Broadband IoT-based by the end of 2026.

The ICT services provider also noted 5G is expected to be the fastest deployed mobile communication technology in history; from an estimated population coverage of approximately 15 percent (over 1 billion people) at the end of 2020 to a forecast 60 percent of the world's population in 2026. It is anticipated that 5G will begin to support more IoT device types, such as cameras, VR headsets and unmanned aerial vehicles, during the second half of 2021.

Cloud Services

Nordic enhances cellular IoT support with launch of nRF Cloud Location Services

The first of several planned services, Nordic now provides trusted support for cellular IoT devices, including cellular network and assisted & predicted GPS location services, and firmware over the air updates

The pandemic has provided a stimulus for online shopping and home delivery services. These industries were gaining speed before the virus emerged, but the impact of SARS–CoV–2 has dramatically accelerated the trend. Today, consumers expect hot food, groceries, medicines and an array of consumer goods to routinely arrive at their front door in short order and in perfect condition.

To make this happen, logistics companies have increasingly turned to wireless asset tracking and location services. They need the data to not only know the precise geographical position of products in transit but also to establish how much time was spent in transit, check if routes or journey durations deviate from expectation, monitor how the asset has been handled and learn how to automate more of their business. Some industry analysts suggest that a decade from now, we'll look back at 2021 as the start of a new location services economy.

### Responding to customer demand

The key to making location services work is robust and reliable IoT connectivity. But designing and developing IoT devices such as asset trackers is a tough engineering challenge. Nordic Semiconductor's long term strategy, from its short range wireless solutions through to its low power cellular IoT products, is to help its customers overcome this challenge. The strategy is based on abstracting away complexity to help the developer focus on his or her application.

In recent years, the strategy has extended to helping developers set–up Cloud interfaces to locate, analyze and present the data from their prototype IoT devices with the Nordic's nRF Cloud platform. Such was the success of the platform customers started to turn to Nordic for additional Cloud support beyond prototypes. "As a supplier they trust, developers asked Nordic to provide a simple and convenient way to manage cellular IoT devices in the field," says Ville–Veikko Helppi, Product Manager – Cloud Solutions with Nordic.

Now Nordic has responded to that demand with the launch of nRF Cloud Location Services. The unveiling provides customers with access to detailed, fast and accurate commercial location services for their Nordic nRF9160 SiP–based cellular IoT devices.

"With its cellular IoT products and development tools, Nordic has made access to the IoT much easier and simpler for all," explains Helppi. "nRF Cloud Location Services and nRF Cloud will extend that strategy to the configuration, management and maintenance of fleets of cellular IoT devices."

nRF Cloud Location Services builds upon Nordic's versatile cellular IoT connectivity enabler, nRF Cloud. The product provides Nordic customers access to a full
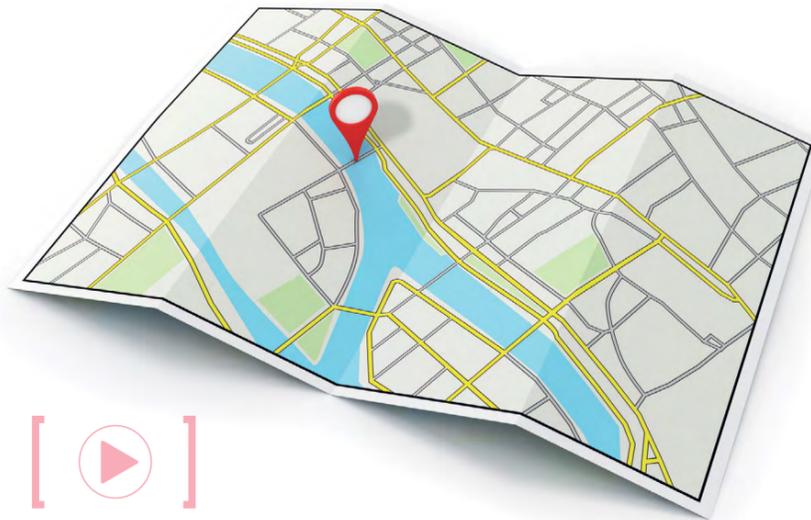
commercial location services model once their cellular IoT products are commercially deployed. nRF Cloud will offer those same customers firmware over the air (FOTA) updates for devices in the field.

The solution will initially comprise location services using single– and multi–cell location, and Assisted– and Predicted–GPS for indoor and outdoor applications. Each technique offers a different trade–off between position precision and battery life. (*See sidebar: How location services help IoT devices know where they are.*)

Nordic is partnering with multiple third–parties to ensure a high–quality service for Nordic devices and nRF Cloud customers. These partners will provide GPS assistance data, and an inexpensive and easy–to–access location history with timestamp information for each of the customer's IoT devices. nRF Cloud Location Services can also be interfaced to customers' own applications and Cloud–presence via a user–friendly representational state transfer (REST) application programming interface (API) as well as integrated with other third–party applications.

"nRF Cloud takes away all the hassle of setting up with an untried Cloud services provider and allows the customer to choose only the service they need," says Helppi. "And by building on the established nRF Cloud platform, nRF Cloud Location Services offers Nordic customers the familiar Nordic look and feel but now with the high–quality and long–term commercial support needed to deploy large numbers of cellular IoT devices."

A WQ Live webinar entitled *From silicon to Cloud services* **discusses the Nordic nRF Cloud Location Services offering. The webinar can be viewed here: https://bit.ly/3hirQ9I**

Tech Check

The nRF9160 SiP features built–in Assisted–GPS. The SiP combines location data from the Cloud with GPS satellite trilateration for remote monitoring of a device's position. The SiP is a highly efficient and optimized low power cellular IoT product for a wide range of applications

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How location services help IoT devices know where they are

The nRF Cloud Location Services offering will initially comprise location services using single– and multi–cell location, and Assisted– and Predicted–GPS (A–GPS and P–GPS) for indoor and outdoor applications. Each technology trades–off positional precision against power consumption.

The single–cell location method relies on identifying in which cell the tracked device is situated and then referencing the cell identification against a database of known base station locations. It offers accuracy down to kilometer level while maximizing battery life because it does not require operation of the GPS modem.

Multi–cell location builds on the single–cell technique by referencing the position of several nearby base stations instead of just one to offer accuracy down to a few hundred meters while still keeping power consumption low.

For accuracy of just a few meters IoT devices typically employ GPS. The device switches the GPS on, looks for the satellites and, once it has found several, waits for the satellite assistance data. The downside is that a cold–start GPS modem 'time–to–first–fix' (TTFF) on a group of satellites can take several minutes and use significant battery capacity.

To shorten TTFF, satellite assistance data is sent down to a ground based GPS receiver and stored in a GPS database. The satellite data can then be relayed to the IoT device via the LTE–M network at a rate up to 3000 times faster than it is delivered from the satellite itself. The rapid transmissions limits the Iot device's on–air time and saving significant power. When required, the IoT device is then able to find the satellites in seconds, saving further power and extending battery life.

The P–GPS technique builds on A–GPS by providing over two weeks' of assistance data to the IoT device. The result is a short TTFF and accurate location determination but with even greater power savings because of the lower frequency of assistance data requests to the cellular network by the IoT device compared with the A–GPS method.

Using P–GPS does increase the computational load on the IoT device's processor, but in the case of the nRF9160 SiP, its powerful Arm M–33 processor has ample overhead to cope. The processor is also highly efficient so the extra processor operational time has only a small impact on battery life.

nRF Cloud Location Services offers customers a combination of either A–GPS or P–GPS, or a combination of both (A+P GPS) for IoT devices. When using the solution, the device requests the assistance data over the cell network and includes the connected cell tower ID in that request. nRF Cloud then returns the assistance data to the IoT device. (*See figure below.*)

1 Device collects cell details

2 Device connects to cloud and sends cell details to cloud

3 Cloud gets GPS assistance data from database

GPS Database (managed by 3rd party)

nRF Cloud

4 Cloud sends assistance data to device

5 Device uses assistance data and GPS to acquire location

Corporate Social Responsibility

Corporate social responsibility sparks positive change in global electronics supply

To combat sustainability challenges in the electronics value chain, industry stakeholders are reconsidering the social, economic and environmental impacts of their products and practices

> "
>
> Responsible Business Alliance members are more likely to require their suppliers, partners and customers to meet similar corporate social responsibility goals

Since the 1980s, the electronics industry has grown exponentially. In 2020 there were 2.17 billion global shipments of major consumer technology devices—including millions of shipments of smartphones, tablets, TVs, cameras and wearables, and IoT-enabled wireless electronic products like smart home automation systems—according to data compiled by analyst Statista.

While these products improve people's lives in myriad ways, there are inevitable downsides to a boom of this magnitude. From material sourcing and processing, to manufacture, distribution, retail and consumption, and end-of-life, electronic products have been linked to range of negative sustainability practices.

These gloomy outcomes cover the full gamut. Human and labor rights abuses; links to conflict materials; smuggling, corruption and illegal taxation; hazardous chemical use; by-products and waste; environmental degradation; fossil fuel use; land use and biodiversity. For example, e-waste—one of the fastest-growing waste streams with an estimated 65 million tons generated globally in 2017, contains toxic substances which, if not dismantled and disposed of correctly, pose a danger to both human health and the environment, according to a recent report from the *Journal of Cleaner Production*.
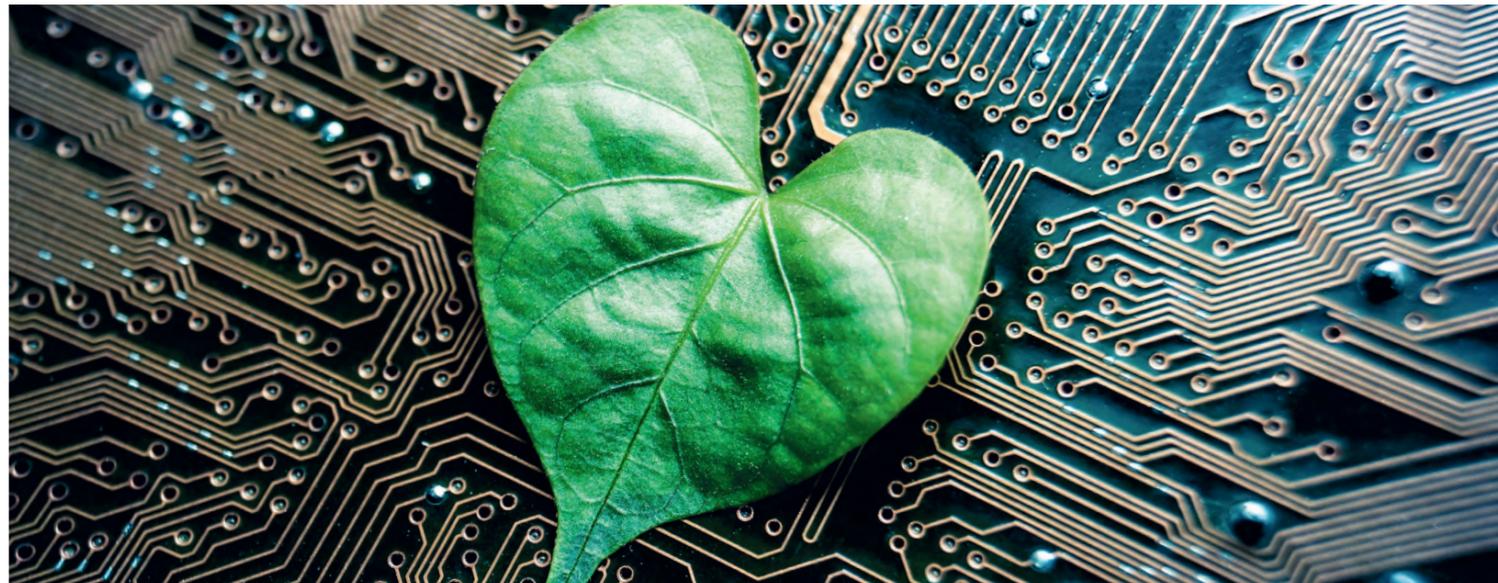
While all these risks occur globally, developing countries and communities are often disproportionately affected. The question for industries is whether the world can afford for supply chain problems to go unchallenged.

Recognition for Nordic's ESG initiatives

According to Ebbe Rømcke, Senior Vice President Quality & Sustainability with Nordic Semiconductor, the onus falls on industry stakeholders to strive for positive change. "IoT solutions providers and partners should ideally contribute to sustainability through more efficient resource usage, a reduced footprint on the environment and engagement in ethical business practices throughout the global supply chain," says Rømcke.

Nordic has just been recognized as one of the top 100 companies by STOXX Global ESG Leaders Index, the benchmark for sustainability champions. Environmental, social and governance (ESG) initiatives are specific and measurable so this listing demonstrates just how seriously the company takes its green responsibilities.

But the search for sustainability in the electronics value chain remains a complex challenge. Electronics are produced, consumed and ultimately disposed of through a fragmented, disconnected and globalized system, which creates obstacles to effective sustainability governance. And limitations on corporate supply chain transparency can undermine efforts to combat the many concerns. As a result, unsustainable components and practices permeate the global market. And accountability among

Need to Know

The Responsible Business Alliance's (RBA) Code of Conduct references international standards including the Universal Declaration of Human Rights, International Labour Standards and OECD Guidelines for Multinational Enterprises. RBA membership is open to firms that manufacture or contract the manufacture of electronic goods or products in which electronics are essential to the product, or supply materials used in the electronics content of those goods.

contributing forces is difficult to gauge, let alone enforce. Such serious challenges call for an equally serious response from industry stakeholders. Social and environmental responsibility is increasingly being integrated into the corporate strategies of companies that leverage global supply chains. Commonly referred to as corporate social responsibility (CSR) the purpose of this self-regulating business model is to support a corporation intending to have a positive influence by pursuing social accountability alongside profits. This accountability is to stakeholders and the public.

"No organization can single-handedly ensure the absence of social and environmental risks but, collectively, a group of committed organizations can work to drive continual improvement in a shared supply chain," states the Responsible Business Alliance (RBA), the world's largest industry coalition dedicated to CSR in global supply chains. "Participating in a common methodology allows companies to gain efficiencies by following a defined and accepted outline. This saves time and drives scale in their CSR programs."

But can CSR initiatives improve company value and performance as well? Deloitte Consulting's *2019 Global Human Capital Trends* survey revealed, for the first time ever, CEOs named societal impact as the top success factor for annual performance. Meanwhile, 90 percent of consumers would switch brands to support a good cause and boycott a brand due to irresponsible business practices, according to a 2016 Deloitte report, *Social purpose and value creation: The business returns

of social impact. And a 2015 Nielsen global survey, *The Sustainability Imperative — New Insights on Consumer Expectations*, found 66 percent of consumers were willing to pay more for products and services from companies that demonstrated a commitment to positive social and environmental impact, while brands with a commitment to sustainability saw average sales growth outperform those of brands without this commitment fourfold.

The United Nations (UN) Sustainable Development Goals, established in 2015, have helped to generate greater industry interest in the benefits of CSR. This in turn has led to a sharper focus on CSR reporting as organizations and investors seek to better understand the sustainability of their practices and investments respectively. Moreover, this shift has sparked sustainability ratings, new legislation and government incentives on sustainable practices – or penalty fees on non-sustainable practices.

More than 170 members of the RBA have now committed to driving sustainable value for workers, the environment and business throughout the global supply chain. Members, including Nordic, are accountable to a Code of Conduct.

"For corporations, change begins with enhanced visibility and control of the supply chain itself," says Rømcke. "RBA members are more likely to require their suppliers, partners and customers to meet similar CSR goals by following the RBA Code of Conduct, which sets a baseline for all CSR areas including business ethics, diversity, non-discrimination, workers' rights and privacy."

If the current trend continues, CSR will transform from a well-intentioned ideal to a *bona fide* way of doing business.

Ebbe Rømcke
Senior Vice President Quality & Sustainability, Nordic Semiconductor

Why corporate social responsibility matters

With its membership of the RBA, Nordic underscores its sustainability strategy

Ten years ago Corporate Social Responsibility (CSR) wasn't seen as a major issue, yet today it's one of the first thing new Nordic employees ask about. They don't want glib answers, rather proof of how Nordic is an ethical company upholding its CSR commitments. And since the UN unveiled its Sustainable Development Goals in 2015, Nordic has seen increased interest on CSR reporting from investors who also want to see Nordic doing the right thing.

As far back as the early 2000s we have delivered on concerns like hazardous substances, waste handling and responsible supply chains. Nordic's membership of the Responsible Business Alliance (RBA), the world's largest industry coalition dedicated to CSR, is further proof of the company's commitment.

As far back as 2007, Nordic pledged to follow the RBA's Code of Conduct and began integrating even more CSR topics into its management systems. This includes since 2010 being compliant with non-use of conflict metals (traditionally gold, tungsten, tin, and tantalum sourced from volatile parts of the African continent). Nordic also requires its customers and their suppliers to follow the RBA code of conduct which includes guidance on business ethics, diversity, non-discrimination, worker's rights, anti-corruption, and data privacy and security.

Since 2015, Nordic has monitored and improved its carbon footprint. This includes purchasing renewable and low carbon energy and adding solar to some of its offices. And since 2016, Nordic has signed up to the UN Global Compact principles, and last year committed to the UN's Sustainable Development Goals (SDGs). This includes making more use of recycled and recyclable material and reducing

its use of plastic in general. Nordic's commitment to sustainability will increase in the future.

Many of Nordic's customers are also ahead of the pack. They are developing products that significantly contribute towards sustainability. Application examples include smart agriculture, extreme weather warning, energy harvesting, deforestation and endangered animal protection.

Nordic intends to be an even better choice for these sustainable developers. To showcase this, we invited a group of students to create a smart beehive on the roof of our offices in Norway. By using out-of-the-box tools like the Thingy:91, Thingy:52, nRF Cloud, nRF Connect SDK and Edge Impulse machine learning tools they created a working prototype within a few weeks.

Nordic is also at the forefront of minimizing the power consumed by its wireless devices. This includes not only ultra low power consumption that can support energy harvesting (*see this issue pg28*), but also having the computational power to perform edge computing to minimize the data sent to power-hungry Cloud servers.

The COVID-19 pandemic has reminded us how strongly we depend on each other. And it has shown us that we need to all act responsibly, as employers and employees, as human beings, and as a global citizens of a world that is becoming increasingly smaller and more interconnected by the day.

Nordic's office roofs are home to smart beehives

Dog Gone

The explosion in human wearables is rapidly extending to animals as owners want to ensure their pets are fit, healthy and haven't gone missing

In Short

Following in the footsteps of the human fitness tracker boom, the smart pet wearables industry is now picking up pace

Emerging wireless pet monitoring and tracking solutions are providing owners with peace of mind about the health and location of their beloved companions

Short range and cellular IoT technologies are working together to extend the scope of applications and range of location tracking

Battery life is critical to the success of pet wearable solutions to ensure a valuable animal is monitored for as much time as possible

More than just companionship and plenty of cuddles, pet ownership comes with serious responsibility. Most pets, especially dogs, require at least some form of regular exercise and some demand more than others. For example, In Anchorage, AK, Mike Mitchell used an Apple Watch to track walks with his Shih Tzu, Chance, every day between 2013 and 2021. In that time the pair trooped the circumference of the planet, a distance of 40,000 kilometers.

While Chance is clearly receiving his recommended fitness needs, for most owners it's a challenge to determine if their pet is exercising enough, let alone being able to call on actionable behavioral and medical insights for themselves and veterinarians.

And animal health and fitness aren't the only concerns for owners. Pets are notoriously difficult to keep an eye on. They can break free from their leash or run away at the park. They can escape under, over or through home fences. They can injure themselves in a fight or on a neighborhood adventure. And, unfortunately, pedigree pets can also be stolen. We've all seen the hopeful (and often futile) street posters calling for help finding a missing cat or dog.

FOREVER LOST

Even a dog's loyalty can create challenges for owners. In 2012, for example, a three–year–old Labrador Retriever named Bucky went missing after owner Mark Wessells, who was relocating to South Carolina, temporarily left the dog with his father at a property in Virginia. Relying on an uncanny sense of smell, Bucky walked from Winchester, VA, to Myrtle Beach, SC, a journey of almost 800 kilometers, to find his owner. Found by a stranger, Bucky was taken to a nearby animal hospital, where a quick scan of his microchip revealed Wessells as the owner and his location just a short distance away. But while this story has a happy ending, all too often lost pets are never found.

The American Humane Association estimates one–third of all dogs and cats in the U.S. are reported missing in their lifetimes, while almost 10 million dogs and cats are lost or stolen in the country every year.

However, some studies suggest recovery rates are improving. In 2005 the Coalition for Reuniting Pets and Families asserted less than 23 percent of missing pets in the U.S. were reunited with their owners. Yet a 2012 study (*Frequency of Lost Dogs and Cats in the United States and the Methods Used to Locate Them*, Weiss et al.) commissioned by the American Society for the Prevention of Cruelty to Animals (ASPCA), estimated between 63 and 84 percent of lost cats and 86 and 97 percent of lost dogs are eventually found. But until both numbers reach 100 percent there remains room for improvement.

POWERING PET CARE

As recently as 15 years ago, human health and fitness wearables didn't exist. Today these smart devices are attached to wrists and bodies all over the world, gathering user activity data and sharing information to apps on smartphones for immediate consumption or ongoing review. What may have seemed like a craze in its earliest years has rapidly established itself as a fully–fledged, multibillion dollar industry. According to industry analyst Research and Markets, connected wearables have now entered another strong growth phase that will see shipments grow from 116 million units in 2018, to 238 million units by 2023. Fitness and activity trackers currently account for more than 50 percent of these shipments.

But what about wearables for animals? While wireless health monitoring and location tracking technology for pets—as well as wild animals, livestock, assistance animals, and police and military dogs, for example—remains a comparatively niche area for now, there's no doubt this emerging market is racing towards its own time in the sun. (*See sidebar pg17: Animal tracking: Wireless tech provides key health and location data.*) The global pet technology market, which accounted for over $5.5 billion in 2020, is set to grow at 22 percent CAGR from 2021 to 2027 when it will be worth over $20 billion, according to research by Global Market Insights. The analyst forecasts the global pet wearables market alone to reach $4.6 billion by 2027. And with roughly 471 million dogs and 373 million cats kept as pets worldwide in 2018 (Statista), any innovator or industry onlooker failing to recognize the market's potential must be barking mad.

Many of these innovative pet monitoring and tracking solutions are being developed to offer a helping hand. After all, no owner can be expected to keep an eye on their pet 24/7. It's now easier for pet owners to track every minute of every adventure and activity in an animal's life. This means removing the guesswork on whether a precious companion has had enough exercise, play or rest throughout the day or week, and whether it's still lounging in the garden, has briefly popped next door or has decided to wander further afield.

For these platforms to work, wireless connectivity must be reliable, data processing must be accurate, and the battery life of devices must be fit for purpose. One wireless canine activity monitoring device, PitPat, is making it simple for owners to track their dog's activity level, manage its weight, and have more fun with their pet's exercise routine. Dog owners can also use the PitPat system to monitor the exercise their dog gets while other people—such as a dog walker, kennel, friend or family member—are caring for their pet.

"PitPat is just like the activity monitors worn by millions of people on their wrists, but it's been specifically designed and engineered to work exclusively for dogs, with a dog's comfort and condition in mind," says Jake Apsey, Embedded Software Engineer at PitPatPet. "Our app then provides all the information, advice and recommendations the owner needs to maintain a healthy dog."

Designed in consultation with vets, PitPat weighs only 15 g and easily attaches to a dog's collar. A three–axis accelerometer captures and records all the dog's movements throughout the day. Advanced proprietary algorithms then analyze and interpret those complex movements every ten minutes to identify five specific activity states—walking, running, playing, pottering and

By the Numbers

The global pet care market is expected to reach

$202.6 billion

by 2025

Source: Grand View Research

69% of millennials are likely to use technology to keep track of their pets

Source: Wakefield Research

In the U.S. an estimated

7.6 million

companion animals enter animal shelters nationwide every year

Source: ASPCA

Around

9.5 million

pets are euthanized in U.S. shelters every year

Source: Peeva

resting—and how long the dog spends in each state. This specific activity recognition is important because some forms of dog activity are considered to be far more effective as exercise than others.

The algorithms determine what activity the dog was undertaking during a particular period, as well as informing estimations on daily distance covered and calories burnt. The PitPat device locally stores up to ten days of dog activity data, but the user can independently send all the information from the wearable to their smartphone or tablet using the Bluetooth LE connectivity provided by Nordic's nRF52810 SoC. Once activity data from PitPat is synced to the owner's smartphone or tablet, the associated PitPat app can be used to review the dog's activity data compared to guidelines for over 200 different breeds, as well as set and track a range of health goals.

The PitPat activity monitor has even enabled the company to analyze the data of over 100,000 dogs to build an algorithm that provides dog owners with personalized feeding recommendations via the PitPat app. These recommendations adjust daily to account for changes to a dog's activity levels, age and weight - meaning dog owners now know with confidence how much to feed their dog.

"The lifetime of the battery is one of the most important aspects of producing wearables for animals, since it would be quite challenging to train dogs to recharge their own devices," jokes Apsey. "PitPat's long battery life means charging will never get in the way of owner-and-dog adventures, and our data processing now executes much, much faster, which allows the device to revert to sleep mode quicker, [further] increasing battery life."

ENHANCING COVERAGE
Another Bluetooth LE pet tracking system developed by U.S.-based pet wearables startup, Huan, comprises small IP67-rated beacons that attach to a dog or cat's collar, as well as proprietary sensors and an iOS/Android-compatible smartphone app from which owners can track their pet's whereabouts. The Huan Tag pet wearable employs Nordic's nRF52810 SoC to wirelessly connect via Bluetooth LE with smartphones and the Nordic nRF52840 SoC-based Huan Sensors that can, for example, be deployed in public locations or other users' vehicles. In the event the pet wanders beyond Bluetooth range of its owner's smartphone but passes within range of any of those sensors, the sensor will detect the presence of the missing pet's collar-worn tag. The sensors act as a Bluetooth LE to Wi-Fi or LTE-M gateway, relaying the data of a missing pet's whereabouts to the owner and Huan's Pet Protection Network community via the Huan app.

"We wanted to make an extremely small form factor wearable that could be powered for several months by a single coin cell battery, and Nordic's nRF52810 SoC fit our requirements perfectly," says Huan founder, Gilad Rom. "Also, the nRF52810 and nRF52840 SoCs provide a clear upgrade path for Bluetooth Direction Finding and Long Range, both of which are on our roadmap."

Bluetooth LE connectivity also sits at the heart of Amazon Sidewalk, a secure wireless standard that helps devices including pet trackers work better at home and beyond the front door. Operated by Amazon at no financial charge to its customers, the shared neighborhood network

PitPat weighs only 15 g and easily attaches to a dog's collar. A three-axis accelerometer captures and records all the dog's activity

> The American Humane Association estimates one-third of all dogs and cats in the U.S. are reported missing in their lifetimes

Tech Check
The inclusion of the nRF9160 SiP with integrated LTE-M/NB-IoT modem and GPS in combination with the Wafer Level Chip Scale Package version of the nRF52840 Bluetooth LE SoC—has proved integral to Link's capabilities. For example, the combination of the nRF9160's Arm Cortex M33 dedicated application processor, and the nRF52840's Arm Cortex M4 processor with FPU, provides the smart collar with the processing power to comfortably handle its complex applications

is designed to extend the low bandwidth working range of ultra low power devices and allow them to stay online even if they travel outside the edge of the home Wi-Fi network. If your best friend has disappeared out an open gate, for example, a Sidewalk-enabled device can be used to locate the runaway over a considerable distance. One of the first devices to use the Sidewalk standard was a pet wearable called Fetch that clips to an animal's collar, allowing users to locate the pet through the Ring smartphone app, or from an Amazon Alexa-enabled device.

In the future, smart devices will allow more proactive rather than reactive care for animals, according to Dr Garnett Hall, BVSc, CEO of VetChip, a startup involving an Australian team of veterinarians and engineers developing what the company claims will be the world's first smart microchip designed to monitor a pet's health.

"Ordinarily, a pet's medical issues are only identified once they're noticeably unwell, which is often long after the onset of illness," says Dr Hall. "The idea behind a solution like VetChip is that, as soon as an abnormality is detected, owners will receive an alert via their smartphone, so they can seek appropriate treatment for their pet before the issue escalates."

In the longer term, Dr Hall believes society's expectations of higher standards of animal welfare will continue to progress. "The explosion in human health apps and wearable fitness technology provides further stimulus for change, as ... pet owners ... project their health and comfort needs onto their pets," he says.

COMPLEMENTARY TECH
In addition to the advantages provided by Bluetooth LE, cellular IoT is emerging as an important connectivity option for powerful new pet care technologies. An increasing number of wireless pet care solutions are set to leverage LTE-M and NB-IoT cellular networks all over the world enabling, for example, remote tracking to continue even when a companion animal is separated from its owner beyond the range of smartphone connectivity.

"We see Bluetooth LE and cellular IoT working in harmony in the future," says Zyrus Khambatta, CTO

with VetChip. "Bluetooth LE fulfills the requirement for simplicity of connectivity. Furthermore, the GATT [Generic Attribute Profile] hierarchy of Bluetooth LE provides a straightforward way to report health data in a globally recognized format with a user-friendly method to connect to a person's smartphone. Beacon style reporting allows inference based on the location of the receiving devices; this covers a swathe of use cases, and importantly in our case allows the relay of health parameters to our backend processing systems. Meanwhile, cellular IoT enables location reporting over an established cellular network when not in Bluetooth LE range."

Nordic's recently introduced nRF Cloud Location Services offers an accessible commercial service to support cellular IoT location services such as pet monitoring and asset tracking. (*See this issue pg10.*)

GLOBAL TRACKING
Another solution in this category is Link, a smart pet wearable enabling real time pet location and activity tracking. Developed by Jacksonville, FL-based technology company, Smart Tracking Technologies/Link, in collaboration with DiscoverTec for application development and engineering firm Paragon Innovations, the device features a temperature sensor and an advanced Inertial Measurement Unit (IMU) for tracking the animal's activity and reducing power consumption.

Link is paired to a smartphone using Bluetooth LE wireless connectivity provided by Nordic's nR52840 SoC, allowing owners and pet care facilities to locate and track a pet's whereabouts from a smartphone. Owners can receive notifications if the pet leaves a designated area, as well as access activity recommendations.

"As a smart pet wearable, Link is all about the pet and pet parent's lifestyle," says Donny Lamey, CEO of Smart Tracking Technologies/Link. "More than a GPS tracker or basic pet tech, the [product is] packed with training tools, customized activity monitoring and an unprecedented tracking system monitored by real humans."

But what elevates Link above competitors in this market is the integration of Nordic nRF9160 SiP-enabled LTE-M

Animal tracking:
Wireless tech provides key health and location data

Managing and protecting wild animals or livestock can be a challenge. To that end, the business case for connected farming and herd management is a strong one. By remotely tracking the precise location, movement and activity of animals, livestock farmers can identify preferred pastures, protect their herds and ensure animals don't stray beyond perimeters. At the same time, they also need to be aware of individual animal health or signs of abnormal behavior. Traditionally these tasks were carried out manually.

But the landscape is changing as animal tracking and monitoring solutions supported by low power wireless connectivity become the norm. These devices, which often integrate GPS location tracking and connect to smartphone apps and/or Cloud platforms via Bluetooth LE, cellular IoT and other networks, make it easier than ever before to maintain control of a farm and ensure animals remain healthy and safe. One feature of many such solutions is the ability to build a virtual geofence through an app or web-based dashboard, creating designated safe zones.

Finnish company Anicare, for example, developed a tracking device that attaches to the ear of a reindeer or other wild animal. The Healtag tracker incorporates both an accelerometer and thermal sensor to measure activity, temperature and different vital functions of the animal for up to five years. Data is sent to the Cloud using Nordic nRF9160 SiP-enabled NB-IoT cellular IoT so injured or ill animals can be identified for rescue.

U.S.-based agricultural technology company, Farm Jenny, developed an animal wearable and connected equine monitoring platform called Farm Jenny for Horses, which helps farmers monitor behaviors indicative of a horse's overall health status and any potential medical issues. The platform records animal activity levels while the device's sensors record temperature, humidity and atmospheric pressure, which helps provide context for evaluating animal behavior. It also tracks the animal's location, allowing the owner to follow its position in relation to facilities, food and water, as well as other horses.

The solution employs a network of wearable sensors, solar-powered field receivers, beacons and a gateway, which all communicate through Nordic's advanced concurrent Bluetooth LE and Thread short range wireless connectivity solutions.

Need to Know
NB-IoT and LTE-M are cellular technologies specifically designed for IoT applications that require long battery life and reliable network coverage. NB-IoT is a good option for penetrating into building basements and stationary applications like smart meters. LTE-M offers higher throughput and suits mobile applications such as asset tracking. Nordic's nRF9160 SiP offers both NB-IoT and LTE-M connectivity

connectivity. This ensures remote tracking remains possible via established cellular network infrastructure even when the pet is separated from the owner outside of smartphone range. To conserve power, Link enters a battery-saving sleep mode whenever it is idle. Once the pet starts moving again a motion detection wakeup feature alerts the main processor to activate the monitoring device. Depending on the activity level of the animal, a 700 mAh Li-Poly battery achieves a life of at least one week between recharge – an extremely important feature for smart pet wearables.

"We approached Nordic's nRF9160 SiP as the 'big brother' in charge of the device, making use of UART communication to the nRF52840 SoC for controlling additional peripherals, sending/receiving commands or getting current status over Bluetooth LE," says Lamey. "Nordic's nRF9160 SiP offers a very small footprint and provides Link with extremely low current consumption when running the LTE-M in eDRX or PSM mode. And the WLCSP [Wafer Level Chip Scale Package] version of Nordic's nRF52840 SoC provides an excellent balance between power consumption and capability, as well as the design flexibility required for our compact hardware layout.

"While power usage was important, we couldn't compromise on capabilities. We knew the nRF9160 SiP had its own application processor and we [made] good use of it, but with the number of peripherals we realized we needed another processor to spread out the responsibilities.

"As the nRF52840 has its own application processor, we could treat the two radios in a very similar manner: They each manage the communications of a wireless interface, they each manage peripherals, and they talk to each other through a UART," explains Lamey.

What's more, Link was purpose-built to integrate third party pet technologies such as veterinary health records and pet daycare management systems. Such platforms will go a long way towards bringing pet healthcare up to scratch with its human equivalent.

As pet monitoring and tracking technology forges ahead, low power wireless connectivity will be by its side as the ultimate support network. With innovative pet care solutions leading the way, the result will be healthier, safer pets and happier, more informed pet owners and vets.

> Bluetooth LE fulfills the requirement for simplicity of connectivity and cellular IoT enables location reporting over an established cellular network when not in Bluetooth LE range

Tech Check:
Keeping track of man's best friend

Almost 10 million dogs and cats go missing in the U.S. every year, but wireless technology is now available to help us keep a watchful eye on our four-legged friends. Both short range wireless and cellular IoT tech are being employed in wearables to not only monitor the activity of our pets, but also to alert us in the event they decide to wander off on an adventure of their own

Illustration: Greg Bakes
http://www.illustratorsaustralia.com/portfolios/greg-bakes/

If all else fails, smart collars employing combined LTE-M and GPS connectivity can help a pet owner win an unwanted game of hide and seek. Using their smartphone to remotely interrogate the collar over the LTE-M network, the owner can receive the precise GPS location of the smart collar via an app and pinpoint the whereabouts of their absent pet within a few meters

In the U.S. 85 million families own a pet. Even eliminating goldfish owners, that's a large group of people who share a vested interest in seeing lost pets reunited with their owners. Smart collar developers are building an active community of app users whose smartphones can detect all smart collars and notify fellow pet owners of contact with a lost animal

Dogs are sociable creatures, and if the want-away pet does escape, it is likely to seek the company of others. To support smart collar technology, Bluetooth LE beacons can be deployed in dog parks and other public places. In the event the wandering pet passes in range of a beacon, it will detect the missing pet's collar-worn tag. The beacon also integrates an LTE-M cellular IoT gateway to relay the missing animal's whereabouts to the Cloud allowing the rescue mission to start

Beyond short range wireless solutions such as Bluetooth LE, smart collars are increasingly turning to cellular IoT to locate missing pets. Such devices employ LTE-M connectivity to enable cellular triangulation that can position the animal within a proximity of a kilometer, and then use the cell network to communicate with the owner. While not as accurate as GPS, LTE-M is far less demanding of the battery, giving more time to find a pet

If the family pet does decide to make a bid for freedom and ventures beyond Bluetooth range of its owner's smartphone or home Bluetooth network, all is not lost. Amazon Sidewalk is a neighborhood network designed to help devices such as pet wearables work better by extending their working range. Based on a new protocol in the 900 MHz band, Amazon Sidewalk can extend range by up to one kilometer, and could, for example, inform a pet owner that their smart-collar equipped animal has crossed the property boundary

A new breed of wearables can be attached to a pet's collar and connected to an owner's smartphone or home gateway. This allows the owner, whether they are at home or not, to keep a watchful eye on the dog via a smartphone app. Alerts can be sent to notify the user if the pet wanders out of range to enable the search for the errant animal to commence

If the pandemic has made contact tracing for humans routine, then pet wearables are set to follow suit. Future smart collars will likely offer a contact tracing facility, allowing two dogs with wearables to wirelessly record any close contact with each other. When one dog returns to its owner, its smart collar could relay the lost dog interaction to the owner's smartphone, and in turn notify the lost dog's owner

Image courtesy of Creative Commons / ColbyCliftes
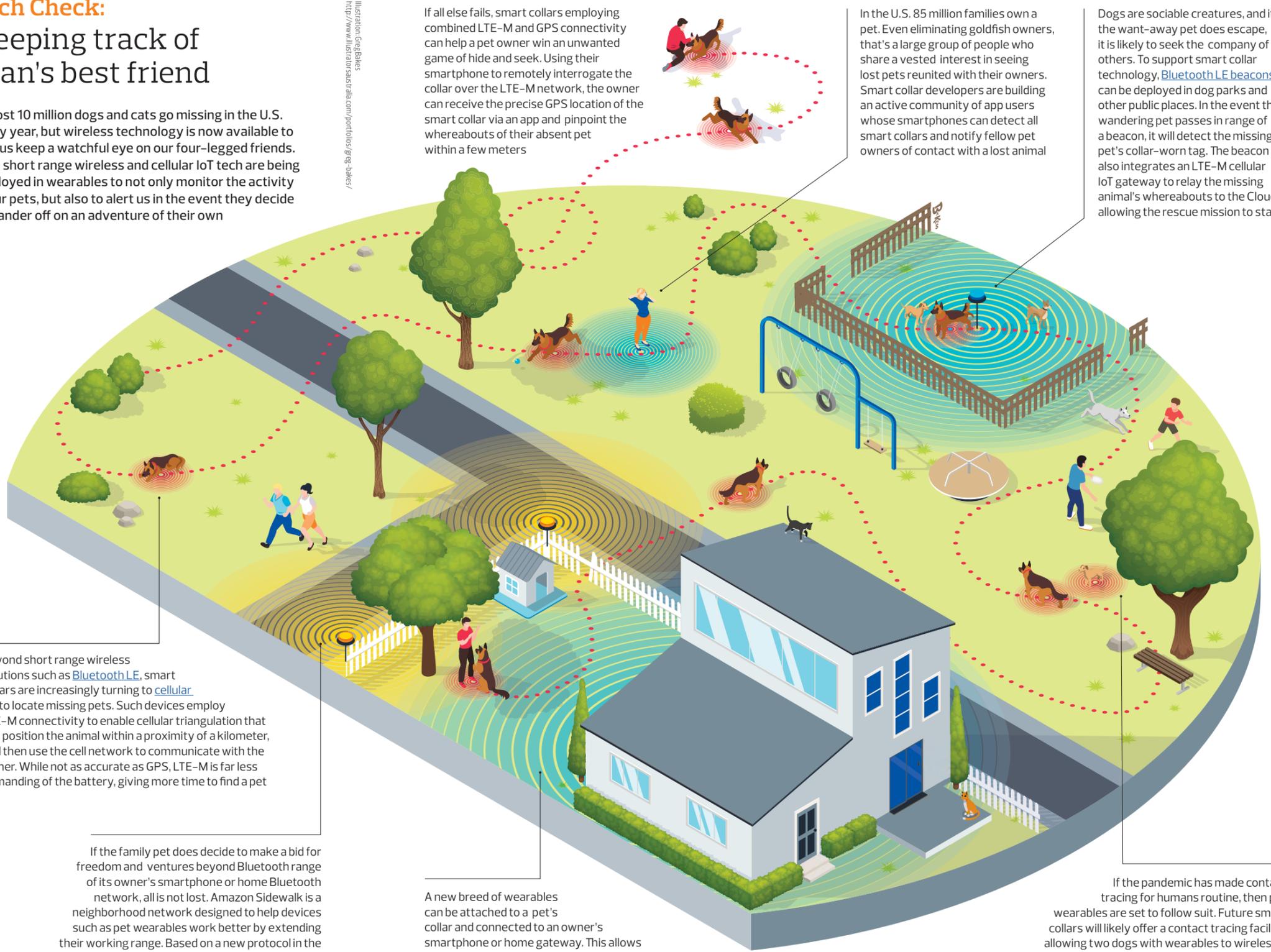
Empowering Ability

One in four people has a disability, but wireless technology is helping ensure they all have an inclusive future full of possibility

According to Greek mythology, Hephaestus crafted equipment for the gods including the shield of Achilles, Hermes' winged sandals and Apollo's golden chariot. For his work, he is appropriately known as the god of technology. He was also the only deity to have a disability.

"It was probably no accident that it was Hephaestus who made ingenious machines," observed Canadian-American writer Saul Bellow. No other person had to devise creative means of overcoming hindrances quite like Hephaestus, necessity was very much the mother of his invention. After all, who better? People with disabilities are the ultimate early adopters because they have more to gain than most by using new technology, and helping perfect it.

As Kristen Shinohara and Garreth Tigwell, both Assistant Professors of Computing and Information Sciences at the Rochester Institute of Technology in New York, noted: "While it is useful for designers to be aware of how users with disabilities interact with technologies, the most powerful insights may come from those with disabilities themselves. No matter how much empathy designers glean from researching user behavior and preferences, it can't replace the benefits of having a piece of technology built by people who actually use it." Or, as Microsoft's accessibility team (in large part comprised of people with disabilities) succinctly puts it: "Do nothing about us, without us."

Whether designed for, with, or by people with disabilities, assistive technology is a concern that has made seismic advances in every century since the ancient Greeks, and a

quantum leap since the advent of computerization. Indeed, there are now many everyday solutions that evolved from technology originally developed for people with disabilities. The typewriter, speech recognition solutions, eye gaze tracking technology used in cameras and cars, even the Segway two-wheeled self-balancing electric vehicle were all inspired by disability, and have since benefited millions more consumers than ever originally intended. Alexander Graham Bell may never have invented the 'electrical speech machine'—his prototype name for the telephone—had it not been for his hearing impaired mother and his life long work in support of the deaf.

If as a society we are generally of a like mind that technology is a good thing, then a characteristic of good technology is accessibility no matter who it is designed for, but particularly when it helps make life measurably better for people with disabilities. And, in that respect, we are now going places neither Bell nor even Hephaestus could ever have possibly imagined.

ACCESSIBILITY FOR EVERYONE

The issue of accessibility—the widely adopted term for designing technology that people with disabilities can use—is often viewed through the lens of moral obligation, that "it's the right thing to do" and fundamental to social participation, particularly since the advent of the smartphone. That's as may be, but Microsoft President Brad Smith, a company whose track record on accessibility and inclusion is well documented, says this misses the

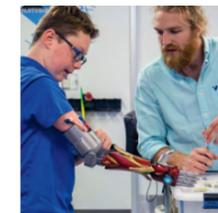Image courtesy of Limbitless Solutions / 3Dhope.com

point. "At some point, most of us likely will face some type of temporary, situational or permanent disability," says Smith. In fact, according to the most recent data from the U.S. Centers for Disease Control and Prevention (CDC), one in four of the U.S. population—61 million Americans—has a disability, while a further one in eight will be disabled for five years or more during their working lifetime. Globally that translates to somewhere in the order of two billion people. Factor in disabilities that come with aging, vision and hearing loss, and cognitive degeneration for example, and quickly it becomes apparent that accessibility to technology really is for everyone.

Even if you are fortunate enough to never suffer a disability, technology designed with accessibility in mind has already almost certainly benefited you. "There is a myth that accessibility impedes innovations, but history shows us the opposite is true," says Anne Taylor, Director of Supportability in Microsoft's Accessibility program. "[And] accessibility innovations are not reserved only for specialized assistive technology made for people with disabilities, they are essential to every product we create ... accessibility innovations benefit us all."

While much accessibility R&D has centered on smartphones, desktop computer screen readers, website navigation and user interface design, the rapid proliferation of, and growing community reliance on, wirelessly connected wearables, smart home solutions and other connected IoT technology demands developers ensure broader participation by people with disabilities. According to Nathan Moon, Paul Baker and Kenneth Goughnour, co-authors of a paper in the *Journal of Rehabilitation and Assistive Technologies Engineering*, connected technologies, such as environmental sensors, smart objects and wearables, are powerful tools because they provide inclusive and assistive information services in real time.

"The tools used to build smarter cities and smarter homes can help create a more accessible environment for people with disabilities," they say. "IoT, most broadly, and wearable devices, more specifically, have the potential to connect people with disabilities with their work [and] home ... for

monitoring, tracking, control and connectivity, which in turn encourage employment, community participation, and health and functional independence.

"Although most wearables are not specifically designated as assistive technology, these devices, sensors and supporting applications nevertheless can act in assistive and augmentative capacities to facilitate the social inclusion and participation of people with disabilities."

MAKING THE IMPOSSIBLE POSSIBLE

Beyond making all technology inclusive, tech that has been designed specifically to assist people with disability is proving equally empowering. As former member of IBM's National Support Center for Persons with Disabilities, Mary Pat Radabaugh, put it: "For most people, technology makes things easier. For people with disabilities, tech makes things possible." From wayfinding solutions for the blind, hearing aid technology for the hearing impaired, haptic sensors that enable the deaf to 'feel' music, the examples of wireless tech improving people's lives is now practically limitless, and in the case of those with limb differences — Limbitless.

Limbitless Solutions is the name of a U.S. non-profit organization founded by former students of the University of Central Florida, who are creating personalized bionic arms for children suffering from limb differences. The organization's prosthetic limbs employ electromyographic (EMG) sensors to pick up signals generated by muscle movements in the wearer's upper arm. Below this is a socket to hold the prosthetic in place regardless of whether the elbow is present, matched to the individual child. The forearm section of the bionic arm contains a battery pack that powers the motors controlling the different movements, while the hand unit contains the core electronics and motors for the fine control of the individual fingers.

This unit includes a Nordic Semiconductor-powered Insight SIP ISP1507-AX RF module that enables set-up, adjustment and monitoring of the arm using Bluetooth LE via an iOS or Android app, for example to precisely determine the degree of muscle flexing required to generate a certain force in the fingers. The aim is to make the bionic arms as lightweight, comfortable and easy to use as possible, and John Sparkman, the Head of R&D at Limbitless Solutions said that, in this respect, the miniature Bluetooth LE modules fit perfectly with the design philosophy.

Limbitless has developed games to assist the child in gaining control over their bionic arms, aimed at making the process of learning to use their new arms fun and engaging rather than potentially dull and frustrating. The Bluetooth LE connectivity enables a PC or tablet to act as a wireless game controller, taking a classic level-based approach, starting with simple gestures such as opening and closing the hand and then moving on to more complex manipulations. "Kids

> From wayfinding solutions for the blind to haptic sensors that enable the deaf to 'feel' music, the examples of wireless tech improving people's lives are widespread

Limbitless' prosthetics (here and in the main picture above) use Nordic wireless technology to set-up, adjust and monitor the limbs via a smartphone app.

with limb differences often face challenges ... [and] our research team is focused on creating new robotics that make everyday activities easier,'' says Albert Manero, Executive Director at Limbitless Solutions. ''Enabling parents to ... easily calibrate and adjust the bionic arm via Bluetooth LE made such a difference in their experience.''

A CONNECTION TO THE WORLD

Another company making advances for people with disabilities is Ohio-based developer of EMG devices, Control Bionics. The company's wearable assistive technology, NeuroNode, offers people with amyotrophic lateral sclerosis (ALS)—also known as motor neurone disease (MND)—the ability to communicate with family, friends, caregivers and clinicians despite paralysis or loss of speech. In its rudimentary stages of development, the late theoretical physicist Stephen Hawking tested the technology and provided feedback to its developer.

The small, non-invasive sensor is placed on the skin over the muscle chosen to be the 'switch'. When the user attempts to move that muscle, the NeuroNode interprets the signals sent from the brain to the muscle—even if there is no visible muscle movement—and uses those EMG signals to control the user's paired computer, tablet or smartphone, essentially functioning as a wireless keyboard using Bluetooth LE wireless connectivity provided by a Nordic Semiconductor nRF52832 SoC. By using the NeuroNode users with a disability can send and receive emails and text messages, play games, access social media, watch and download online entertainment, use environmental control systems and operate other external devices.

Technology is also changing the lives of people living with blindness. Wayfinding and indoor navigation solutions have been developed in recent years employing computer vision, augmented reality, RFID and wireless optical communications. Probably the best known project devoted to the implementation of a navigation system for visually impaired users is NavCog, developed by the Cognitive Assistance Lab at Carnegie Mellon University.

NavCog employs Bluetooth LE beacons and an iOS smartphone app to help people explore the world without vision, particularly in huge and complex environments such as an airport or a hospital. Beacons are deployed at between five and ten meters from each other in a grid throughout a facility, and using received signal strength indication (RSSI) can approximate the location of a user's smartphone.

> The NeuroNode interprets the signals sent from the brain to the muscle—even if there is no visible muscle movement—and uses those EMG signals to control the user's paired computer, tablet or smartphone

NeuroNode interprets signals sent from the brain to the muscle and uses those signals to control devices

The user selects their destination by using voice search and NavCog provides turn by turn audio feedback via the app until they reach their destination. The introduction of Bluetooth Direction Finding in version 5.1 of the Bluetooth Core Specification enables such solutions to improve their positioning accuracy yet further by using the angular phase-shifts that occur between antennas as they receive (Angle of Arrival) or transmit (Angle of Departure) RF signals. With the use of antenna arrays at either side of the communication link, phase shift data can be determined and from this, precise location can be calculated.

Another innovation that has helped people with blindness perform an activity those without vision impairment take for granted is the D.O.T braille watch. Released by Korean smart technology company, D.O.T, the watch's electro-dynamic cells power a refreshable Braille display. Once paired to a smartphone, a user with partial sight or blindness can not only tell the time and date, but also accept/decline incoming calls and view notifications such as text messages via the four-cell (24-dot) Braille display on the watch face. Two touch sensors allow the user to scroll through and read each notification, while two buttons and the crown dial operate the various functions.

MEETING GLOBAL DEMAND

While vision impairment can affect motor, language, emotional, social and cognitive development, hearing loss can have equally serious consequences. Approximately 360 million people worldwide—more than five percent

The Dot Watch uses electrodynamic cells to power a refreshable Braille display

of the global population—suffer from a disabling level of hearing loss according to the World Health Organization (WHO). WHO estimates unaddressed hearing loss equates to an annual global cost of $980 billion, and that doesn't include the cost of hearing devices. As such, technology that addresses this disability meets not only an enormous societal demand, but a fiscal one too.

Hearing aid tech took a long time to progress, but the introduction of hearing aids employing Bluetooth LE in 2014, and the launch of LE Audio in version 5.2 of the Bluetooth Core Specification last year promises to take technology for the hearing impaired to new heights (*see sidebar: Hearing aids: Four centuries in the making*).

''LE Audio will be one of the most significant advances for users of hearing aids and hearing implants,'' said Stefan Zimmer, Secretary General of the European Hearing Instrument Manufacturers Association (EHIMA). ''EHIMA engineers have contributed their specialist knowledge to improve the audio experience especially for hard-of-hearing people. As a result, within a few years most new phones and TVs will be equally accessible to users with hearing loss.''

While LE Audio is still in its infancy, the latest hearing aid technology is unrecognizable from even 15 years ago. Global hearing technology company Oticon Hearing announced the launch of its Oticon More device earlier this year, said to be the world's first hearing aid to feature an on-board Deep Neural Network. This mimics how the brain works and recognizes sounds in fine detail, so it knows how they should ideally sound. The result is a more natural representation of all sounds in a clear, complete and balanced sound scene.

The hearing aids can run advanced DSP algorithms with always-on sound processing, and integrate the Zephyr RTOS to supervise the Bluetooth LE connectivity, while the Bluetooth LE controller was developed in close collaboration with Nordic. ''Connectivity has become an integral part of Oticon's product offering,'' says Asger Munk Nielsen, Firmware Developer at Oticon and member of the Zephyr Technical Steering Committee. ''Being directly connected to smartphones, TV sets and classroom microphones is providing hearing aid users much improved interaction with the surrounding world.''

This must surely be the goal of all assistive technology; to provide disabled users with a seamless engagement with the world around them, and the ability to participate in all aspects of life on equal terms with non-disabled people.

Hearing Aids:
Four centuries in the making

For the first 250 years of their history, hearing aids made practically no technological progress at all. At some point in the 17th century the ear trumpet was conceived as a means of concentrating sound, and other than the invention of a collapsible version in the 1790s, it wasn't until 1898 that anyone came up with anything better. That was when Miller Reece Hutchison invented the first electric hearing aid that used an electric current to amplify weak signals.

Even then it wasn't until the 1970s that the technology really began to take off, thanks to the introduction of the microprocessor and multichannel amplitude compression. The microprocessor brought miniaturization to a new level and the compression ushered in the use of digital technology.

By the 1990s we had the first all digital hearing aid, and by 2005, the first Bluetooth hearing aid debuted—the Starkey ELI—allowing users to route audio from their smartphone into the hearing aid itself. The problem was battery power; for a device intended to be discreet, the ELI required a bulky dongle to house the relatively power hungry Bluetooth Classic receiver and the battery that powered it. The release of Bluetooth LE helped the issue of battery life, and allowed users to wirelessly stream audio from a range of devices or take a hands free phone call. From a smartphone app, the hearing aid settings could also be easily controlled. The trade off was sound quality, and that Bluetooth LE still drains your hearing aid battery a lot faster than traditional devices.

The release of Bluetooth 5.2 last year heralded the introduction of LE Audio, promising hearing aid wearers all the benefits of Bluetooth LE, but with enhanced audio quality, better connectivity, simultaneous streaming to multiple devices and further improved battery life. (*See WQ, Issue 1, 2020 pg14.*)

Key to improved audio clarity and improved battery life is the Low Complexity Communication Codec (LC3) that offers an improvement in sound quality over the SBC codec included with Bluetooth Classic audio, even at a 50 percent lower bit rate.

Due to its low airtime utilization, LE Audio also offers a surplus of bandwidth to enable Multi-Stream Audio, allowing two people wearing hearing aids to simultaneously stream sounds from the same device, a TV for example. Finally, it also promises better listening connectivity in public settings. Venues that offer Location-Based Audio Sharing will be able to stream sounds directly to anyone in the audience with Bluetooth hearing aids.

Hearing aid tech may have been slow to get started, but when LE Audio devices hit the market in 2022 it will make up for lost time.

Tech Check

The NeuroNode is powered by Nordic Semiconductor's nRF52832 SoC. The ultra low power characteristics of the Nordic SoC — including the 2.4GHz radio's 5.5mA peak RX/TX currents and fully-automatic power management system — offer 58 CoreMark / mA power efficiency and ensure the device does not have to be frequently recharged

State of Play
The Digital Divide

Access to the Internet in highly resourced countries is often considered a given, but it is not only low-income countries that are under-represented when it comes to Internet use, so too are people living with disabilities, regardless of their country of origin. As of 2019, over 87 percent of people in developed countries had access to the Internet, and yet those with a disability are about three times less likely to go online than those without. Further, the amount of time people spend online, and their comfort level with technology, also varies by disability status, spawning the term the 'digital disability divide'

Internet usage in developed countries

Sources: WHO, Statista, Pew Research Center, ABS

87.3% of the general population

71.2% of people with psychosocial disability

61.9% of people with sensory or speech disability

61.5% of people with stroke, or head or brain injury
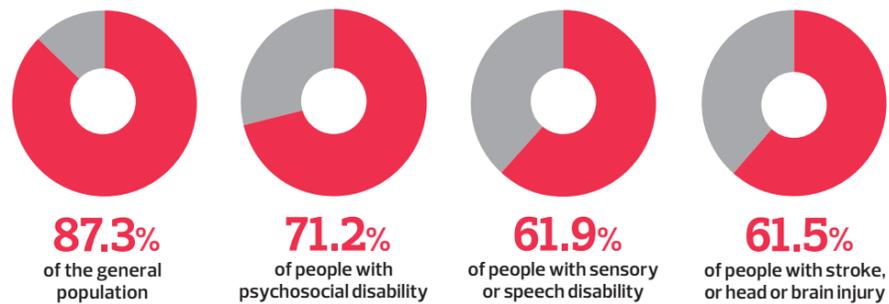
Better Together

Building complex products that span many technologies is a difficult task. The Nordic Partner Program makes things easier by bringing multiple providers together under a common framework

A ppealing to the spirit of collaboration, American automotive manufacturer Henry Ford said: "If everyone is moving forward together, then success takes care of itself". And as the gloom of COVID-19 settled on the globe in 2020, many among us wished for an upswell in cooperation to lift us from the crisis.

Fortunately, the hard times did spark partnerships. Both unusual and vital. A streaming service and fashion outlet joined forces to create 'inactivewear' for people in lockdown. McDonalds forged a 'personnel pact' with supermarket Aldi so its employees could help Aldi's understaffed teams. In the most consequential collaboration, governments, research institutions and pharmaceutical firms combined to develop a COVID-19 vaccination in record time, with a billion doses administered just 16 months after the virus was first identified.

Businesses globally seem to be imbued with a renewed spirit to work together. "A crisis can prompt companies to explore a greater number and even new kinds of partners," said Linus Dahlander and Martin Wallin, writing in the *Harvard Business Review*. This should bode well for IoT which, at its heart, is about the merging of disciplines – for instance, connectivity, industrial design and manufacturing. By adding sensors to physical objects and connecting them wirelessly to analytics platforms, the IoT promises efficiency and cost benefits in applications as diverse as manufacturing, home and building automation, environmental monitoring and transport.

TECH HESITANCY

About a decade ago, Cisco predicted the widespread networking of people, processes and things could generate $14.4 trillion of value for companies by 2025. Sadly though, some IoT solutions aren't rolling off the line so smoothly. "Many companies begin an IoT journey with great expectations, only to end up with disappointing business results," wrote IoT author and Cisco executive Maciej Kranz in the *Harvard Business Review*. About 60 percent of IoT projects stall at proof of concept stage, while a third are not

In Short

Despite the promise of technology, many businesses face challenges in deploying solutions successfully as they lack the skills or knowledge to cover all technologies involved in building a complex solution

Partnership programs allow players from across the tech spectrum to solve problems together for customers, and also help resolve broader challenges facing the industry

The Nordic Partner Program (NPP) comprises design and solution companies experienced at developing IoT solutions and bringing them to market
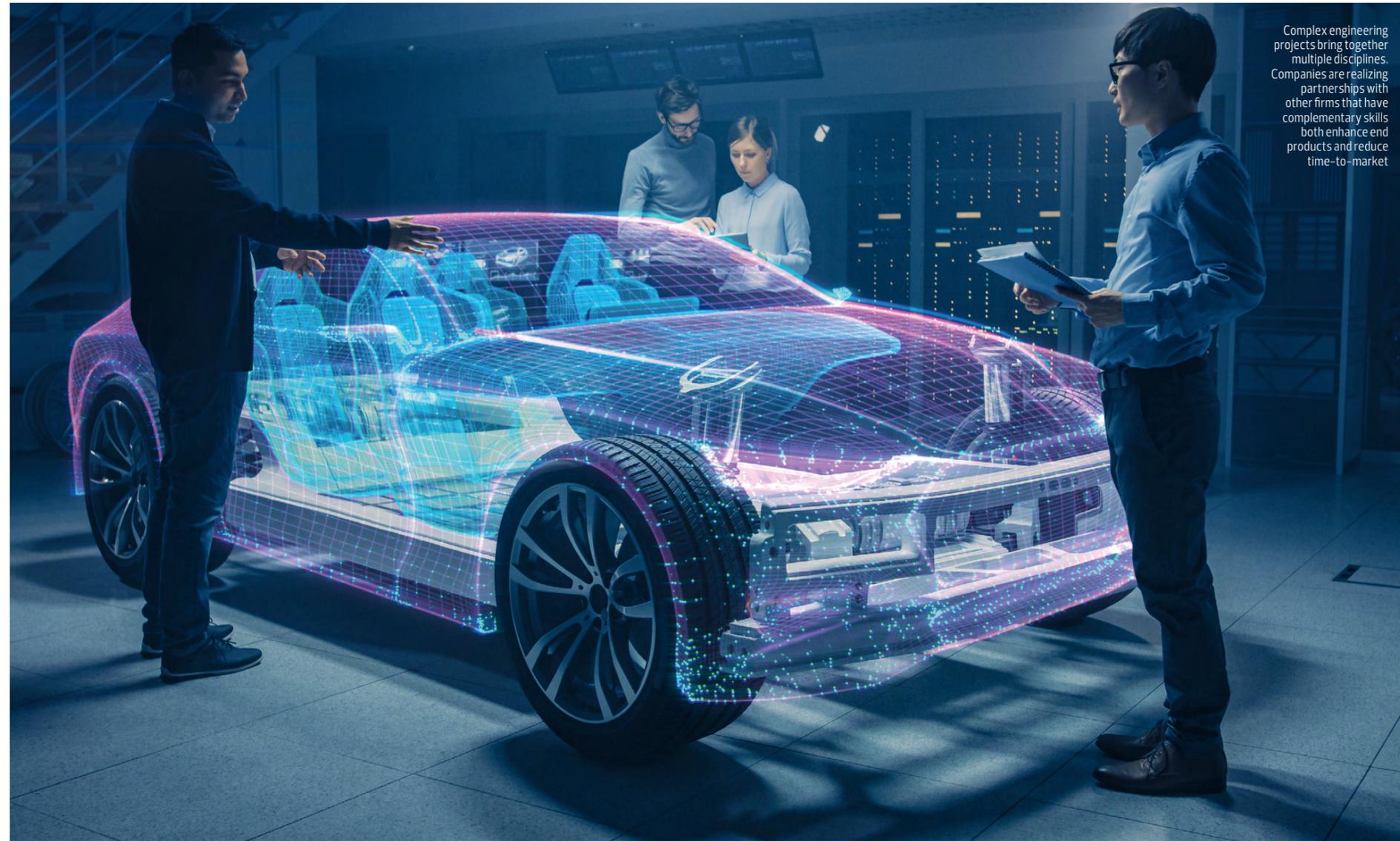
considered a success, according to another Cisco study.

Hesitancy among businesses may be building, a situation best illustrated by the use case of predictive maintenance. Predictive maintenance involves using wireless sensors to capture and transmit data about the health of equipment, allowing service teams to respond in a timely way. Savings from predictive maintenance are expected to hit $630 billion per year in 2025, while maintenance costs and equipment downtime could fall 40–50 percent, prompting some to describe predictive maintenance as IoT's 'killer app'.

Despite being initially excited by these benefits, 600 executives surveyed by management consultancy Bain and Company admitted their enthusiasm for predictive maintenance had waned. Manufacturers found it too hard to implement, with proof of concepts stalling due to a lack of technical expertise.

It highlights the inherent challenge with IoT solutions, complexity. "To build an IoT device or, more specifically, an end to end IoT system, many different components and technologies need to work seamlessly together," says Lorenzo Amicucci, Business Development Manager at Nordic Semiconductor. This includes hardware components,

software applications, connectivity solutions, security, Cloud technologies and analytics capabilities. "It is difficult for a single company to have the skills to cover all technologies or the time to build everything from scratch," says Amicucci.

Even if individual components can be built or sourced, ensuring they are interoperable and well integrated requires specialist knowledge. "Customers face a huge challenge when developing innovative end to end solutions," says Pascal Serwe from German IoT solution provider, grandcentrix. "Complexity is enormous and the possibilities and the challenges are difficult to master."

The problem is compounded by the background of businesses seeking connectivity for their products. "More and more of these companies come from non-IoT and non-technology backgrounds, for example manufacturing," says Amicucci. "They face great challenges because they have limited knowledge of embedded development, connectivity and Cloud." The result is greater risk. In recent years, Gartner has predicted 75 percent of IoT projects will take twice as long as planned. "The path to IoT will have many twists and turns as companies pursue big plans, hit

roadblocks, learn and adjust. Some will give up, while others will follow through," the analyst said.

A NEW WAY FORWARD

A paradigm shift is taking place to meet these challenges, one that draws not only from the ascendant collaborative spirit but also from the promise at the heart of IoT itself. "The essence of the IoT is interconnectivity," writes Cisco's Kranz. "But interconnectivity is about more than the connections between devices — it is [also] about the connections between customers, partners and suppliers. Companies must leave behind traditional models … and move toward those that embrace open and flexible structures in which partners solve problems together."

When IoT solution providers have adopted collaborative approaches, the early signs look promising. In its survey, Cisco found when organizations succeeded with IoT it was because they worked with an: "IoT partner ecosystem at every stage, implying that strong partnerships throughout the process can smooth out the learning curve."

Collaboration in technology also has precedents. The now booming Cloud-based technology services sector

Need to Know

Within the Nordic Partner Program (NPP) Design Partners fill knowledge gaps when customers lack specific competencies or want to speed up development. Solution Partners provide essential building blocks so customers don't need to start from scratch with their product development

was: "Aided by strategic, technical partnerships between providers of specialized services that further augmented the value of Cloud computing," says consultant McKinsey. In another report, McKinsey notes that Facebook, Amazon, and Google have built up: "Entire ecosystems around their platforms." Partnerships are also playing a positive role in traditional sectors, with German car giants BMW and Daimler partnering to develop mobile-based services.

Collaboration in IoT is also about bringing: "Teams from different companies and industries together in a collaborative environment focused on possibilities," says IBM. The focus on what is possible aligns to changing customer expectations, which today have shifted: "From product delivery to the enablement of outcomes," says Deloitte. In other words, companies no longer want discrete products or solutions, but are much more tuned to expect the positive outcomes the IoT can deliver — for example, increased equipment uptime. The takeaway here is a need to shift away from a delivery model in which customers engage with individual providers, towards a holistic approach that seamlessly threads together components from across the IoT solution spectrum.

THE NORDIC PARTNER PROGRAM

In line with these trends, a new partnership initiative is helping companies reduce risk and increase speed of development of IoT solutions. The Nordic Partner Program (NPP), operated by chip company Nordic Semiconductor, comprises design and solution firms experienced at developing IoT solutions and bringing them to market.

The program emerged from the semiconductor leader's experiences with customers who were enthusiastic about using its wireless chips as the basis of innovative solutions but were unsure how to proceed. Grappling with multiple protocols and components was typically beyond their capabilities, says Amicucci. "NPP solves these challenges by gathering together best in class partners who deliver design devices or solutions to accelerate the IoT journey."

As wireless connectivity is at the core of IoT solutions— be it cellular IoT or short range wireless—it follows that a successful IoT partner program must center around supporting companies to understand and implement connectivity solutions, which they often find to be overwhelming, according to Deloitte.

That's why the NPP revolves around partners with a strong track record and familiarity of Nordic's connectivity technologies, says Amicucci. "Partners with knowledge of these solutions are best positioned to help customers with product quality, development and product cost and time to market — the things clients are most concerned about," says Ron Kern from NPP design partner Indesign.

grandcentrix's Serwe adds that the history of reliability between NPP and partners fosters trust, which in turn supports greater agility in delivering projects.

Studies show partnership networks work best when partners perform discrete and complementary tasks. "The diversity of partners is critical in a partner program, as it needs to reflect the fragmentation of needs at the customer level," says Amicucci. The NPP accordingly comprises complementary design and solution partners.

Design partners help with a specific aspect of a complex design or provide turnkey solutions. These partners fill knowledge gaps helping customers accelerate new products. Examples include hardware and RF design, embedded software development and security design.

Solution partners meanwhile, provide customers with solutions or components that can be used as building blocks in building complex systems. This could range from software libraries through to cellular connectivity solutions.

Moreover, because Nordic abstracts away a lot of design complexity when employing its products and provides good documentation, it's easier for design and solution partners to stay up to date and provide a high quality service.

The early design partners in the NPP include CA Engineering, Indesign, Sigma Connectivity, Shenzhen Minew Technologies, Meshtech and NORBIT, while Telenor ASA is a solution partner. German firm grandcentrix is both a design and solution partner. Nordic anticipates more partners will join the scheme in the near future.

The breadth and complementarity of these NPP participants provides customers a powerful value proposition, realizing an IoT vision isn't contingent on their own understanding of connectivity solutions. "The entire program is viable whether the customer is experienced or freshman," says Rosa Zeng, Shenzhen Minew Technologies. "We offer the support of top notch technology to transform the ideas of developers to business outcomes."

"[NPP] will help customers find companies that have the knowledge to benefit from all the advantages of Nordic technology," adds Eirik Aanonsen of Meshtech.

TAPPING INTO EXPERTISE

The long-term success of a partner ecosystem rests on the quality of partners, and the NPP has tapped into deep expertise. Though IoT as an integrated offering is recent, many of its component technologies—such as RF hardware and software—have existed for decades. For instance, NPP design partner CA Engineering has extensive hardware, software and firmware experience and a track record of delivering engineering consulting for complex wireless

By the Numbers

Widespread networking of people, processes and things could generate

$14.4 trillion

by 2025

Source: Cisco

60% of IoT projects stall at proof of concept

Source: Cisco

Thirteen

IoT companies are participating in the Nordic Partner Program pilot phase

Source: Nordic Semiconductor

solutions dating back to 1995. Another design partner, Sigma Connectivity boasts strong technical competence across its 600 engineers, and a mobile development team whose origins trace back to telecoms giant SonyEricsson.

Ultimately, the ideas behind the IoT are powerful and could radically transform societies for the better. McKinsey says the hype around the IoT may even understate its full potential. Programs like the NPP could help the IoT overcome current challenges and scale greater heights.

That said, awareness of the benefits of the IoT remains nascent in some areas. For example, almost 90 percent of businesses in The Netherlands are barely aware of the IoT's competitive advantages, according to Vodafone. But many of the IoT's strongest advocates—those with first hand experience—are not well equipped to speak of its successes. "We have traditionally been better at engineering than marketing," says Norbit's Arild Søraunet. A program like NPP not only brings together individual successes into a more complete picture of the IoT's possibilities, it also makes use of collective marketing capabilities to fire the imagination of businesses.

The partnership model can also help resolve the problem with interoperability. Due to the use of divergent technologies, standardization must play: "A key role in the development of an interoperable IoT ecosystem ... boosting innovation," says the OECD, a grouping of developed countries. Standards bodies are working hard, but the OECD says progress will ultimately come down to firms driving the adoption of particular standards. By nurturing more interactions between organizations, partnership programs like the NPP could fast-track IoT standardization.

When well-organized IoT partnership programs reach sufficient scale, a strong consistent voice for the IoT will emerge. Then we'll see fresh thinking on business models, advocacy for policy changes to propel industry, and ideas that attract the next generation of IoT talent. These are outcomes that bode well for a flourishing IoT future.

For more about the Nordic Partner Program, including how to join, go to nordicsemi.com/Nordic-Partners

> Customers face a huge challenge when developing innovative end to end solutions. Complexity is enormous and the possibilities and the challenges are difficult to master

Trading skills builds better businesses

A century ago, two German brothers combined their talents, fused their ambitions, and began making shoes in their parents' laundry . So good was the footwear that at the 1936 Olympic Games, athletes wearing the shoes—which included American sprinter Jesse Owens—would win seven gold medals.

A decade later, a dispute had turned brotherly love into fierce sibling rivalry. The brothers fell out and set up rival footwear companies on either side of a river in the small Bavarian town of Herzogenaurach. The names of those companies? Puma and Adidas. The fierce rivalry between the shoe giants persists today. It joins a legion of other famous rivalries marking the business landscape. Coke versus Pepsi, Airbus against Boeing, Apple competing with Samsung, the list goes on.

Conventional wisdom says competition makes businesses stronger. But a school of thought now gaining momentum suggests partnerships between competitors, rather than competition, might have more to offer.

The concept has even birthed a new term: 'Coopetition'. American business school professors Adam Brandenburger and Barry Nalebuff, who wrote the book *Coopetition*, recently described its benefits: "If a project is too big or too risky for one company to manage, collaboration may be the only option. In other cases, one party is better at doing A while the other is better at B, and they can trade skills."

Globally recognizable brands that have tried their hand at collaborative competition include Ford and Toyota, Apple and Microsoft, and Harvard and MIT. The benefits aren't limited to unions of two. Alliances and partnerships of multiple organizations are also increasingly common. For example, the Star Alliance network of airlines—which includes United, Lufthansa and Singapore Airlines—was established to save on logistics, marketing and ticketing costs.

The concept looks to have particular value when companies in traditional industries are contemplating the application of new tech, and too often realize developing these solutions quickly or cost effectively themselves might be a stretch. Recent collaborations in the automotive sector, such as Ford and Volkswagen's partnership on autonomous vehicles and BMW and Daimler's union on mobility services, are examples of this.

Airlines have cut costs by cooperating under groupings such as the Star Alliance

Energy Autonomy

By drawing power directly from the environment, tomorrow's wireless sensors will help the IoT take a significant step towards sustainability

That the Industrial IoT reduces maintenance costs is beyond debate. Continuously gathering operational data about machinery, fixtures and other equipment enables timely planned intervention well ahead of expensive breakdowns. One report from analyst McKinsey notes that this predictive maintenance approach helps reduce costs of servicing factory equipment by up to 40 percent. (*See WQ Issue 1, 2021 pg18*.)

But there is another side to the ledger; the wireless sensors that gather the data push up maintenance costs. Many of these sensors are powered by a battery that—even with the most frugal power budget—will eventually need replacement. While swapping an individual cell hardly compares with replacing the bearings on a machine tool's electric motor, changing the battery in a thousand sensors is of a different magnitude.

In a future world with 50 billion battery-powered IoT devices (about ten years hence according to projections by network equipment provider Cisco) the task becomes Herculean. Although battery technology will probably have advanced to the point that cells routinely last a decade, technicians across the globe would still be faced with changing some 14 million batteries every single day. But beyond the burden of thousands of extra maintenance hours, a huge IoT presents an even bigger issue: "[Not only is] the process of creating batteries bad for the environment ... but also the sheer number of batteries we'd need simply cannot be produced by manufacturers," Jan Willem Smeenk, Chief Architect of SODAQ, a Dutch maker of custom IoT solutions, told *WQ*. (*See WQ Issue 1, 2021 pg33*.) Then there's the not so small problem of safely disposing of all those exhausted cells.

TOWARDS SUSTAINABLE IoT

There is already considerable momentum towards a solution, one which is seeing collaboration between chip makers like Nordic Semiconductor, power management IC (PMIC) companies like Netherlands-based NOWI, OEMs such as SODAQ and battery makers too. "The answer lies first in making devices ready for alternative power sources such as solar and kinetic energy and by buffering the energy in rechargeable batteries ... and second by making these devices less hungry for energy," says Smeenk.

Smeenk neatly sums up a model for a sustainable IoT. Tomorrow's wireless sensors must harvest energy from the environment, use that energy to trickle charge a battery or supercapacitor, and employ clever power management to look after the power budget while highly efficient short range- or cellular IoT-connectivity solutions make the most of every last microwatt.

The efficiency of today's technology is such that only a tiny proportion of the energy available is harvested to do actual work. Consequently, engineers have tended to focus their efforts on the most reliable and abundant source, solar.

"Photovoltaic [PV] cells have the highest power density and highest power output compared to other typical energy harvesting options," says Martin Lesund, Technical Marketing Manager – Cellular IoT with Nordic Semiconductor. "This makes solar the most sought after energy source." (*See sidebar pg29: Batteries not required*.)

THE VARIABILITY CHALLENGE

A key challenge of solar is that energy from the Sun is variable; the difference between a cloudless summer's day and an overcast winter one is dramatic. Depending on your latitude, this might reduce solar output as much as 75 percent. "One of the biggest issues in energy harvesting is you can't control the power source and it will constantly fluctuate," says Simon van der Jagt, NOWI's CEO.
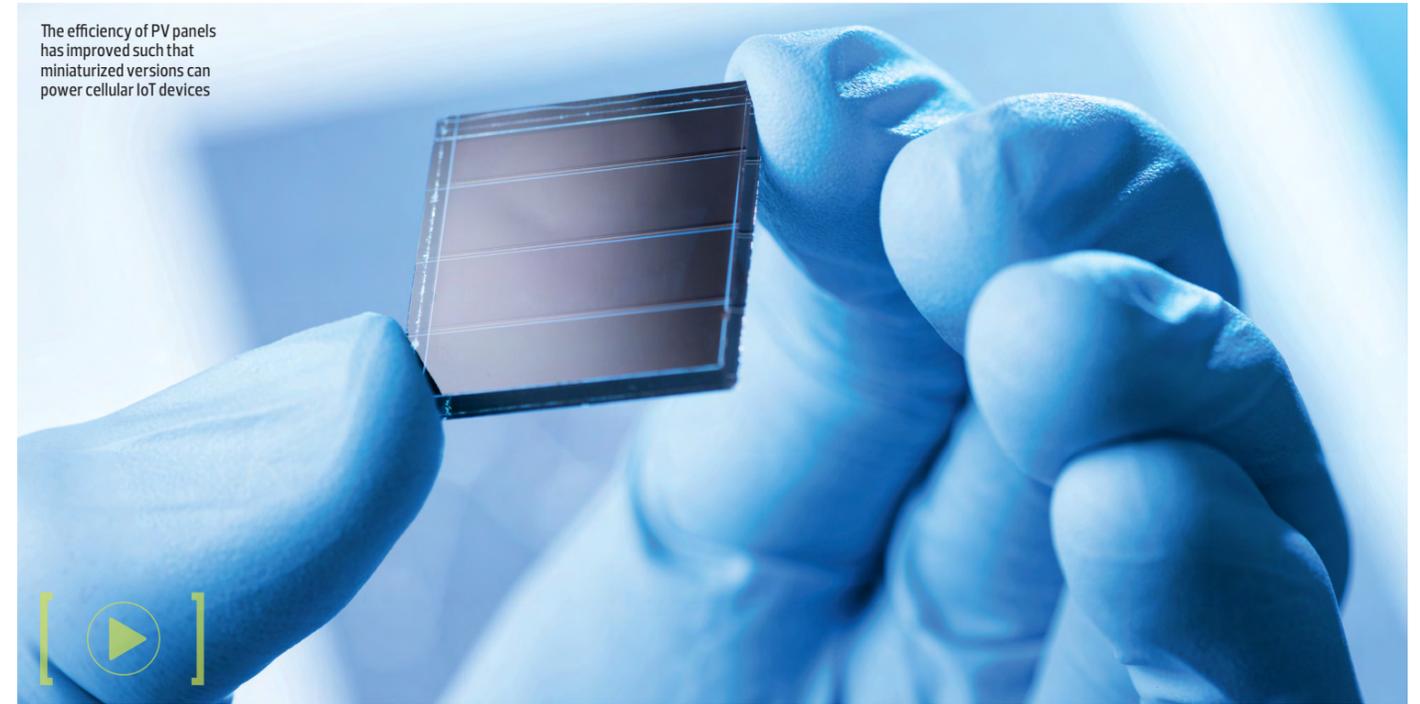
To smooth out some of this variability, designs typically include an energy reservoir such as a rechargeable Li-Poly battery or a supercapacitor. The sensor draws power directly from this reservoir, ensuring a clean and uninterrupted supply, while the energy harvester continuously tops the reservoir up. This means a battery must be manufactured and disposed of, but only one cell will be required for the lifetime of the sensor, eliminating maintenance and cutting the environmental impact.

Even with an energy reservoir, managing the harvested energy while ensuring high sensor availability is not trivial. NOWI has developed a PMIC for energy harvesting devices. "The PMIC stabilizes the sustainable energy source to make harvesting IoT applications viable," adds van der Jagt.

To assist engineers in developing a wireless sensor for cellular IoT applications, the company has also released the Blue Coral energy harvesting development platform—housing the company's NH2 PMIC and Nordic's nRF9160 low power cellular IoT SiP—which can be easily paired with a PV panel. The development platform demonstrates how to design applications for energy autonomy.

"It's not always just about minimizing power consumption, but also how power is drawn from its source over time that influence how well suited a product is for energy harvesting," says Kjetil Holstad, Nordic's EVP Product Management. "For example, it's important the developer understands how much energy and when it will be available to system components."

Nordic and NOWI staged a demonstration with the Blue Coral platform to illustrate this point. Powered from a Panasonic PV module under the Dutch winter sun, the NH2

The efficiency of PV panels has improved such that miniaturized versions can power cellular IoT devices

provided the platform's 800 mAh Li-Poly battery with a charging current of 240 µA (at 3.7 V). With the nRF9160 SiP powered up and running asset tracker application code (using LTE-M, with Power Save Mode (PSM) and sending a 1 kB message every hour) the average power consumption of the application was between 24 and 43 µA (at 3.7 V), demonstrating energy harvesting could support the IoT device indefinitely with enough overhead to decrease the message interval and/or increase the message payload.

NO COMPUTATIONAL COMPROMISE

Nordic has a long history of maximizing the energy efficiency of its wireless technology. "The nRF9160 was designed from the ground up to minimize power consumption and some of the design decisions were made with energy harvesting in mind," says Holstad. "Better yet, energy harvesting significantly extends the battery life of the application without placing any constraints on the chip's capability. However, the energy-harvesting implementation may put some constraints on the application's duty cycle which need to be carefully considered at the design phase." Fortunately, the flexibility built into Nordic products makes it easy to customize the trade off between duty cycle, throughput and battery life.

In time, a combination of more efficient PV panels, better power management and enhanced low power consumption SoCs and SiPs could see every IoT device free of a battery.

That's for tomorrow. For now, Nordic's Martin Lesund says contemporary battery-complementing technology is a good foundation for the future. "Energy harvesting is the closest we have to a renewable and sustainable energy source for the billions of IoT devices to come," he says.

That's not only good news for maintenance technicians across the world but also the planet's future generations.

A Nordic webinar entitled *How to power your cellular IoT product with solar energy harvesting* can be viewed here: https://bit.ly/3kRHw4m.

Batteries not required

The first law of thermodynamics states energy cannot be created or destroyed. That means the universe contains just as much energy now as it did nanoseconds after the Big Bang some 13.7 billion years ago. That's good news for engineers looking to harvest a few spare joules to boost their wireless sensor's energy reserves.

In our galactic neighborhood, the Sun is the source of virtually all that ancient energy. Averaged out over the surface of the planet, the star delivers around 1100 W/m². Plenty of energy then to top up a modest Li-Poly battery. But the hard part is turning that energy into useful power.

Photovoltaic (PV) cells use the PV effect to convert photons into electricity. If an incident photon is of sufficient energy to match the band gap of the panel's semiconductor material, it will dislodge an electron into the conduction band where it can be mobilized to form an electric current.

The Sun emits photons of a wide range of wavelengths. That means many that impinge on the PV panel will carry insufficient energy to liberate an electron and will hence do little more than heat things up. Photons with greater energy than that required to dislodge an electron will contribute to the current but will also add their excess energy to the heating process.

Most commercial PV panels for small scale energy harvesting are fabricated using a non-crystalline form of silicon which works better under lower light conditions than the crystalline panels seen on building roofs. Fortuitously, silicon's band gap of 1.10 electron volts makes it one of the best semiconductors for harvesting both light from the Sun and from artificial sources.

Theoretically, a small amorphous silicon panel can convert a maximum of 33 per cent of incident sunlight into electricity. The best commercial panels manage a creditable 20 to 25 percent. Multilayer panels, comprising three or four layers of semiconductors, each with a different band gap, soak up more rays and promise a theoretical maximum of 48 percent. But they are expensive to make and tend to be fragile.

Tech Check

In low duty cycle applications comprising up to eight pings a day, the SODAQ Track Solar device is powered by a PV panel and is claimed to operate perpetually on energy harvested power alone. The tracker is a cellular IoT solution based on Nordic's low power SiP with integrated LTE-M/NB-IoT modem and GPS, and integrates a light sensor, accelerometer, temperature sensor and status LEDs

Music & Audio

TraqFreq

This Bluetooth LE sensor helps musicians wirelessly monitor playing time and the climate conditions of their valuable instruments

The market for digital musical instruments and accessories is on the rise, forging a new subset of the IoT called the Internet of Musical Things (IoMusT). The vision of the IoMusT is for all musical devices to be connected to the Internet and transform how humans interact with musical objects

According to the *Hub Guitar* website, a person can achieve an introductory level of proficiency at the guitar in five months if practicing for an hour every day. To become a world class musician with the same level of practice, would take 55 years. With more practice proficiency can come a little quicker. Guns N' Roses lead guitarist Slash claims when he is touring he can be playing his guitar as much as 20 hours a day

TraqFreq is attached to an instrument and integrates an accelerometer, and temperature and humidity sensors, enabling it to monitor both climate conditions and playing time. Monitoring the instrument can assist in extending its lifespan. And by measuring playing time, TraqFreq can also determine the lifespan of instrument consumables

Designed for musicians at any skill level, including music teachers and students, TraqFreq allows the user to track and evaluate their playing behavior on a range of instruments including acoustic and electric guitars, violins, cellos, saxophones, trumpets and pianos. The accompanying smartphone app allows the user to review playing time and climate information, and when it's recommended, to replace instrument consumables

Musical instruments can be pricey, which is why TraqFreq measures temperature and humidity to avoid potential damage. But there is expensive and then there is the MacDonald Stradivarius Viola, one of only 10 surviving Stradivarius violas. The prized instrument that was crafted for an Italian nobleman in 1701 was put up for auction in 2014 with a reserve price of $45 million. It failed to secure a buyer

A full size symphony orchestra usually consists of around 100 musicians playing strings, brass, woodwind and percussion instruments. However some performances demand a bigger line-up. Hector Berlioz's Requiem Mass is scored for 429 musicians, while Havergal Brian's Symphony No. 1, the Gothic, requires over 800 musicians to perform, including no fewer than 82 string players

N52832
QFAAB0
1652FD

Tech Check

The nRF52832 SoC features a 64MHz, 32-bit Arm Cortex M4 processor with floating point unit (FPU) and a generous 512 kB Flash and 64 kB RAM, together providing ample computational power to supervise TraqFreq's sensors, as well as store up to 30 days of data

@thegrumpycocker.instagram

Logistics & Transport

Global two-way voice message communication over LTE-M

Supported by Nordic LTE-M cellular IoT connectivity and GPS, the BraveTALK PTT GPS Tracker allows voice communication at the push of a button between personnel anywhere

" We believe BraveTALK is the first solution of its kind to materialize voice transmission/reception using LTE-M, the basic standard for cellular IoT applications

The ability to share messages instantly, regardless of location, is a vital tool in the modern world. Each day millions of people must communicate with each other while simultaneously carrying out personal or professional responsibilities. In some industries it's also often necessary to not only talk to, but also track, remote personnel for safety reasons — such as workers on a construction site or delivery truck drivers en route to the next drop-off. Even parents or guardians might need to check the whereabouts of their children and make contact to discuss their movements.

Not only does two-way communication need to be possible; it needs to be safe, reliable and truly global. And for the highest convenience, individuals should be able to exchange instant voice messages from anywhere without touching a screen or tapping a keyboard.

Push for improved communication
That's where the latest solution from Japan-based IoT company, Braveridge, comes in. The BraveTALK PTT GPS Tracker takes the possibility of two-way voice message communication—at the push of a button—to places it's never been, with 24/7 availability. BraveTALK enables 'Push-To-Talk' (PTT) voice calls like a traditional 'walkie talkie', except using the LTE-M (cellular IoT) network.

Moreover, the platform provides GPS tracking of each BraveTALK device in the field. In action, this means system administrators have much greater flexibility to not only track the location of individuals or assets on a map, but to make direct verbal contact, in this case referred to as 'voice message communication' (as opposed to text message or telephone communication), as and when required.

"Unlike SNS [social networking services] where people communicate by entering text messages with their fingers, BraveTALK enables users to easily convey messages just by pushing a button," explains Yasunari Kohashi, CEO of Braveridge. "We believe BraveTALK is the first solution of its kind to materialize voice transmission/reception using LTE-M, the basic standard for cellular IoT applications."

BraveTALK's LTE-M cellular connectivity and GPS tracking functionality is made possible by Nordic's nRF9160 SiP, which integrates an LTE-M/NB-IoT modem and GPS and is certified for global cellular IoT applications. The GPS enables location detection on a map, while BraveTALK is also equipped with dual band Wi-Fi to support Wi-Fi location services. The product operates in conjunction with the BraveGATE Cloud Service, Braveridge's proprietary Cloud platform that allows an administrator to remotely monitor the GPS location of individual devices. Once data has been sent from BraveTALK to the cellular network using Nordic SiP-
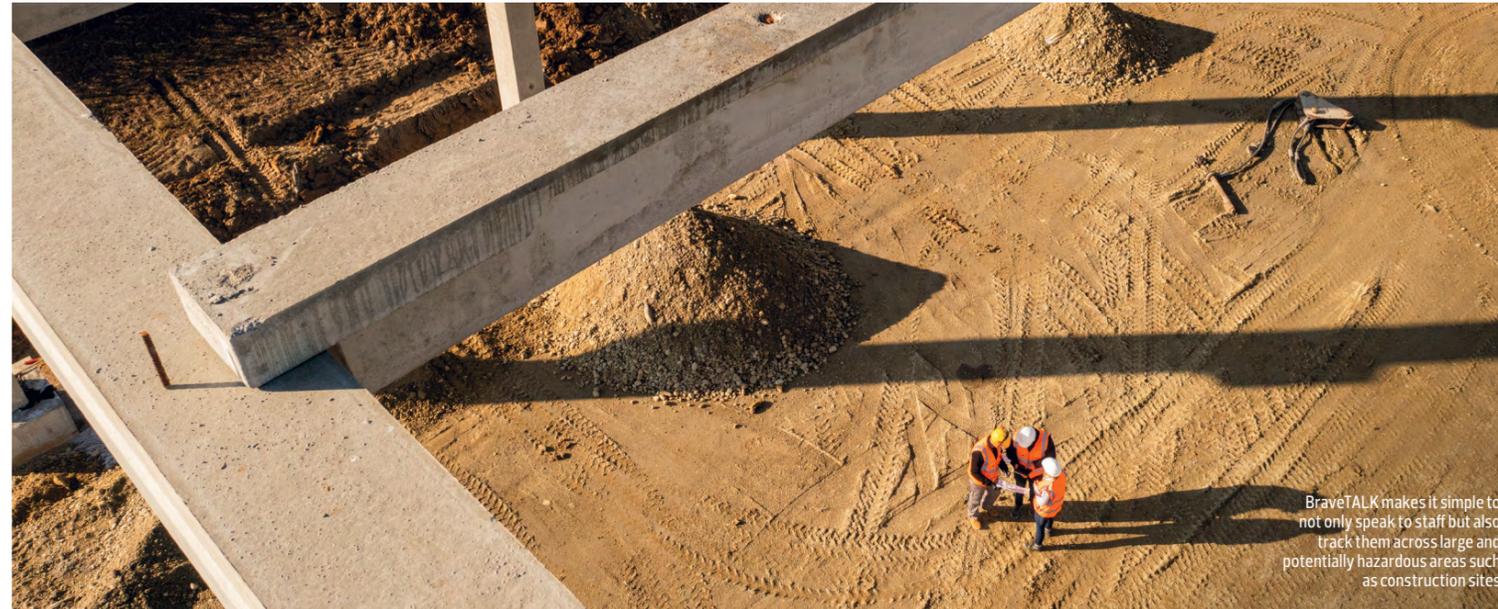
Tech Check
Nordic's nRF9160 is a compact, highly integrated, low power cellular IoT SiP. The integrated modem supports both LTE-M and NB-IoT wireless connectivity. Braveridge employs LTE-M in its BraveTALK PTT GPS Tracker as it perfectly meets the application's throughput requirements. LTE-M has a narrower bandwidth of 1.4 MHz compared to 20 MHz for regular LTE, giving longer range, but lower throughput

enabled LTE-M connectivity, the information can in turn be relayed to the BraveGATE Cloud Service for deeper review and analysis.

LTE-M global connectivity
Braveridge selected LTE-M cellular IoT over alternative LPWANs to provide the connectivity for BraveTALK because of the availability of global support for the product's RF design and its suitability for end-to-end secure connections and low power applications requiring medium throughput. The throughput achieved is 375 kbps uplink and 300 kbps downlink, providing approximately 100-to-150 kbps application throughput running IP. "Other LPWAN standards fail to provide sufficient uplink/downlink payload length to [support] voice message communication," says Kohashi.

This type of wireless remote communication and tracking technology relies heavily on a low power consumption to continue working over an extended period without access to alternative power. To that end, LTE-M connectivity and GPS is only activated for BraveTALK when the user makes or receives a voice call. The GPS function can be turned on/off according to the request from the client's web server, and the positioning cycle can be changed. This in turn extends the life of the Li-Poly STOBA battery used by the device. The low power optimized nRF9160 SiP, plays its part by supporting PSM and eDRX power saving modes. For both LTE-M and NB-IoT the PSM floor current is as low as 2.7 μA, and with an

eDRX interval of 655 seconds the average current is 6 μA for LTE-M and 9 μA for NB-IoT.

The nRF9160 incorporates not only a full LTE modem but also an Arm Cortex-M33 processor solely for applications. This separate application processor eases product design complexity. "Nordic's nRF9160 is the world's first and only cellular IoT SiP that integrates the application processor and thereby eliminates a UART interface to an external processor and the bug issues that can come with that interface," says Kohashi. "As a result, application development becomes overwhelmingly simple."

As a one-stop IoT solutions provider, Braveridge is aiming to accelerate the realization of the IoT by designing, developing and manufacturing various IoT devices, as well as Cloud-based IoT platforms, for growing markets.

By incorporating the nRF9160, with its powerful Arm processor, and generous memory allocation, the company's IoT applications have the computational power to not only support LTE-M connectivity and enable rapid response to GPS requests, but crucially to also perform edge processing of complex algorithms removing the need to send continuous streams of expensive data to the Cloud.

Hardware and software capabilities aside, Braveridge has also been impressed by the value of Nordic's ongoing technical support. "Nordic provided a great deal of [FAE and DevZone] support to realize the voice message communication for BraveTALK," says Kohashi. "The company truly understood our requirements and made [the product] possible."

BraveTALK makes it simple to not only speak to staff but also track them across large and potentially hazardous areas such as construction sites

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Bob Proctor
CEO, Link Labs

Tracking lower value assets in real time
The ability to track all assets accurately would benefit countless businesses. But until now, it's not been viable

The tracking of higher value assets is well-established. A prime example is vehicle fleet tracking using GPS systems. The assets are too valuable to lose sight of making the relatively high cost of GPS tracking solutions easily justified.

The problem when dealing with mid- and low-value assets is there haven't been any commercially viable options. Although GPS and UWB have long been the gold standard for precision tracking, GPS doesn't work indoors and UWB is expensive. This is why we have not seen the mass adoption of real time location systems (RTLS) for lower value assets.

Tracking all assets—regardless of value—would yield substantial productivity gains. But because of the lack of a cost-effective technology, most assets aren't tracked. Examples include plastic containers in the supply chain, power tools or calibrated

" I think we're now hitting a tipping point where RTLS solutions with a compelling ROI are appearing for the first time

instruments in manufacturing, or portable medical equipment in smaller same day surgery centers. But I think we're now hitting a tipping point where RTLS solutions with a compelling ROI are becoming available. In my view, Bluetooth LE offers the potential for 'good enough' accuracy at a very low price point.

As we emerge from the COVID-19 pandemic one thing that's common across economies is labor shortages. This is forcing many companies and organizations to rethink automation and productivity. At the same time, while just about everyone hit the pause button at the onset of the

pandemic, it's now 'all systems go' with new budgets and plans rapidly being put into place. And there's never been a better or more critical time to successfully differentiate from the competition and disrupt how things have traditionally been done in many industries and sectors. Particularly those that relied on manual labor.

Building it better
At Link Labs we have long recognized the potential of IoT asset tracking in real time to improve productivity and drive down costs. As such we have developed and engineered what we consider to be a unique asset tracking platform for lower value assets, called AirFinder OnSite. The product uses Nordic Semiconductor's Bluetooth LE wireless SoCs.

Compared to competing solutions, AirFinder OnSite extends battery life of Bluetooth LE locationing tags by more than 400 percent (providing up to three years operation). It also improves tracking accuracy to within one meter compared to a typical 3-5 meters for other approaches.

Instead of using traditional Received Signal Strength Indication (RSSI) or Angle of Arrival (AoA) indirect Bluetooth LE techniques to locate assets, AirFinder OnSite employs a proprietary and direct range finding method using multiple stationary beacons.

It was the constant tone extension (CTE) feature of the Bluetooth Core Specification Version 5.1 that opened up the possibility of doing this via phase ranging supported by the Nordic SoCs. This enabled a dramatic improvement in location accuracy, a dramatic decrease in power consumption to achieve this accuracy, and all at a completely viable ROI.

Our hope is that by developing such a solution, RTLS will go from a nice have to a must have for the tracking of all assets across multiple industries.
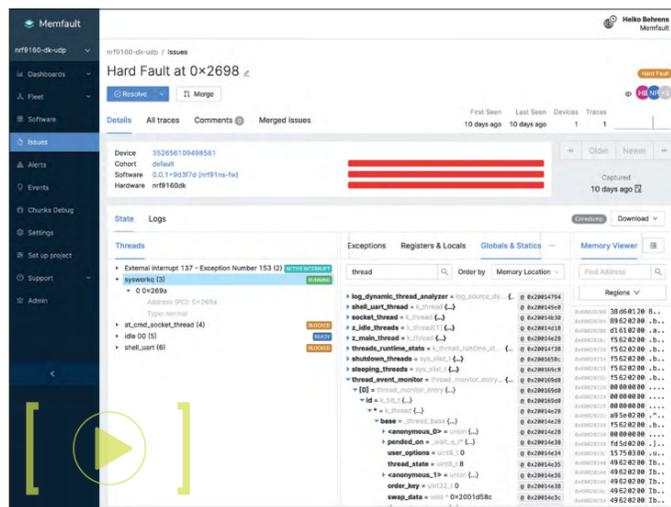

Debugging Nordic–powered IoT products made easy

Nordic Semiconductor has partnered with Cloud–based debugging specialist, Memfault, to enable developers using Nordic's nRF91 Series low power cellular IoT, and nRF53 and nRF52 Series short range wireless solutions to access the Memfault remote debugging and monitoring platform via its nRF Connect SDK.

The integration of the platform in the nRF Connect SDK provides Nordic customers free access to all the features of the Memfault platform enabling them to ship products with greater confidence.

Developers using the nRF Connect SDK with the Memfault platform receive notifications directly through the intuitive Cloud portal when a fault occurs. The interface displays the status of the device fleet and provides detailed reports with tailored diagnostic information for analysis. This can allow developers to identify if, for example, a software update could have resulted in a fault and what impact that fault is having. With this information, developers can locate the root cause of the issue and push updates to fix it before end users notice it.

"To manage the huge growth in connected devices, there is a shift from having a product that is 'good enough' at deployment, to having a product which is maintained and updated over its lifetime," says Joel Stapleton, Principal Engineering Manager with Nordic.

Memfault's remote debugging and monitoring platform is now available via Nordic's nRF Connect SDK

Industrial IoT

Bluetooth LE module enables long range IIoT

Panasonic Industry has released a Bluetooth LE module designed for long range Industrial IoT applications.

The PAN1781 employs Nordic's nRF52820 SoC. The SoC enables OEMs to take advantage of Bluetooth 5's high throughput (2 Mbps) and Long Range, and Bluetooth 5.1's Direction Finding capability. The module also supports Bluetooth mesh, Thread and Zigbee protocols, and is particularly suited to developing battery–powered applications thanks to its low idle sleep current of 1.2 µA (system ON, no RAM retention). The module integrates an external 32 kHz crystal oscillator for temperature stability over time and the high precision required for optimizing power consumption.

The PAN1781 also comes fully certified for CE RED, FCC and ISED, and is qualified over a –40° to 85° C temperature range.

Panasonic Industry also provides developers with the PAN1781 evaluation board with Arduino form factor.

LED Lighting

Bluetooth mesh sensor platform offers bright solution for smart lighting OEMs

Smart lighting control solutions company, Hytronik, has unveiled a smart lighting platform designed to enable lighting manufacturers or building managers to deliver Bluetooth mesh networking in large scale commercial and industrial smart lighting applications.

The ecosystem of smart devices includes motion sensors, LED drivers, dimmer/receiver nodes, real time keeper and repeater modules, quick connection boxes, and a gateway enabling remote access/monitoring. Each device integrates a Nordic nRF52832 SoC–based KMB01 proprietary module performing as a node within the Bluetooth mesh network. The sensors can be integrated into a wide range of new or existing luminaires, enabling lighting manufacturers with minimal RF engineering expertise to deliver wirelessly controllable and sensor–equipped lighting fixtures.

The mesh connectivity allows bulk commissioning of the devices and simple configuration and control of the sensor parameters for all luminaires in the network from a smartphone app. From the app, users can also set desired lighting levels, sync the profile settings to all luminaires, and create static/dynamic scenes and schedules. Alternatively, users can remotely manage the entire system and view detailed luminaire/energy data and analytics from a web-based dashboard.

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

"This enables [a] grouping feature which is essential for the professional lighting control industry," says Benny Cheng, Marketing Director at Hytronik. "The reliability and scalability of the Bluetooth mesh network unlocks all possibilities and provides maximum flexibility in project sites."

Smart Home

Bluetooth LE module aims to simplify occupancy detection

I-SYST has unveiled the BLUEPYRO-M3225 module designed for plug-and-play motion and proximity detection, enabling inexperienced passive infrared (PIR) users to quickly set up a system for wireless room occupancy detection in a range of home automation scenarios such as lighting control and security systems.

The compact module features Excelitas Technologies' DigiPyro PYD2592 (a dual-element PIR sensor with built-in signal processing, digital output and wake-up/sleep mode functionality), on-board ceramic antenna, DC/DC power mode configuration, as well as up to 27 programmable GPIOs. The integration of the PIR sensor in the module enables a wireless solution with low EMI characteristics. The PIR sensor's wake-up feature is important for battery-operated applications because its use means only the pyroelectric detector consumes power until a motion event is detected.

The module is powered by Nordic's nRF52832 SoC, which integrates a powerful

Arm Cortex M4 processor with floating point unit, and a 2.4 GHz multiprotocol radio featuring –96 dBm RX sensitivity, with 512 kB Flash memory and 64 kB RAM.

In addition to the module, I-SYST offers a full suite development kit which includes open source library drivers and software abstractions optimized for low power and performance—allowing users to write wireless application firmware in just a few lines of code—as well as firmware and hardware design services.

Nordic's nRF Connect SDK or nRF5 SDK can be used to port the application firmware directly on the module's Nordic SoC, eliminating the need for an external MCU.

Mesh network–optimized module targets massive IoT

Würth Elektronik has launched a module pre-installed with Wirepas Massive, a decentralized mesh networking solution for large-scale IoT networks.

The Thetis-I module is powered by Nordic's nRF52840 Bluetooth LE SoC. The module's powerful, pre-certified firmware enables robust and secure data transmissions in mesh configurations between Thetis-I modules and/or to other Wirepas-enabled sensor devices.

The module supports either single MCU operation—where a Thetis-I module integrates Wirepas Massive and the custom application as an individualized product—or dual MCU operation, where the application runs on an external microcontroller.

The agreement between Würth and Wirepas means companies can go into production without having a Wirepas Software License Agreement.

Embedding an antenna into a cellular IoT design

By following some simple design guidelines, a single compact antenna can serve multiple radios in a cellular IoT product

No matter how much innovation has gone into the design of the hardware and software of a cellular IoT device, if the antenna doesn't work properly, the product will be useless.

It is the antenna that generates the voltage and current which produces the transmitted electromagnetic (radio) wave, and in turn it's the antenna across which the incoming radio wave generates the voltage and current picked up by the receiver. Optimizing the antenna's efficiency ensures it converts as much of the transmitter power into radiated radio energy and harvests as much energy as possible from the incoming signal to feed the receiver. This in turn largely determines the range and throughput of the cellular device.

More challenging still, cellular IoT products use radios operating at multiple frequencies. Consider, for example, the Nordic Thingy:91 cellular IoT prototyping platform; the device incorporates an nRF9160 SiP (incorporating LTE-M/NB-IoT (operating on several bands in the 700 to 2200 MHz allocation) and GPS (1227 and 1575 MHz)), and the nRF52840 SoC (Bluetooth LE operating on 2.4 GHz). It is not uncommon for cellular IoT solutions to also include Wi-Fi (2.4 and 5 GHz). Following conventional design, that means incorporating several different bulky antennas (and their circuitry) into a single product.

Fortunately, modern chip antenna components offer an elegant solution with compact designs that can cope with the multiple frequencies used by different radios. The single antenna in the Thingy: 91, for example, services the platform's LTE-M/NB-IoT and GPS radios yet measures just 30 by 3 by 1 mm. (A separate antenna serves the Thingy:91's 2.4 GHz radio.) However, even with these clever chip antennas, there are some sensitivity compromises. That makes it important for the designer to follow some important design guidelines to maximize the antenna's efficiency and overall frequency response.

Where to place the antenna

The secret to modern chip antenna performance comes from the fact the device itself is only one part of the antenna system. The complete antenna system comprises the chip antenna, PCB ground plane and antenna matching circuit(s). The design of each part of the system directly affects its overall efficiency.

Chip antenna manufacturers, such as Nordic design partner Ignion, have expertise in maximizing the antenna's efficiency for short range radio and cellular IoT applications. The company also offers an alternative solution for single-, dual and multi-band systems. With knowledge of the end product's intended operational frequency band(s), it is relatively simple to narrow down the shortlist of suitable chip antennas from the catalogue.

Once the chip antenna has been selected the next step is to consider the ground plane. The size of the ground plane has a large impact on antenna efficiency. For example, at an operational frequency of 900 MHz, in a like–for–like comparison, a 10 cm^2 ground plane might exhibit 30 percent efficiency where a 40 cm^2 ground plane would boost that to 60 percent. Within the constraints of the end product form factor, it is good design practice to use

> A complete antenna system comprises the chip antenna, PCB ground plane and antenna matching circuit(s). The design of each part of the system directly affects the efficiency of the antenna

as large a PCB as possible and then dedicate one complete layer to the ground plane. (As the frequency increases, the ground plane size has less impact on antenna efficiency.)

Next, it's important to consider where to place the chip antenna on the PCB. A good guideline is to place the antenna at the corner of the device. It is also important to place the chip antenna as far as possible from other active components that could radiate energy during operation. For the transmission power levels typical of cellular IoT devices, a minimum clearance area of 20 mm from other components is satisfactory. The ground plane should be excluded from this clearance area. The only conductors in the clearance area are the PCB pads and traces connecting the chip antenna to the rest of the circuitry. It's also good practice to keep the antenna away from housing screws, brackets and other metallic parts.

Minimizing losses

Perhaps the most important part of the antenna system design is the matching circuit. The matching circuit sits between the chip antenna and the transceiver. Its purpose is to limit the energy reflected from the antenna or due to voltage standing wave ratio (VSWR) when the IoT device is transmitting.

Energy reflection or VSWR is minimized by transforming the antenna impedance to the system impedance, (normally 50 Ω). The matching network typically comprises inductors and capacitors in a network that transforms the impedance the transceiver 'sees' into the antenna in the intended frequency band(s). The use of high–quality factor (Q) and tight tolerance matching network components will enhance performance.

Designing matching networks can be challenging. The trick is to not only to design the appropriate circuit topology but also to select the appropriate inductor and capacitor values to transform the required impedance. For a single operational frequency band (for example 2.4 GHz) the design is relatively straightforward, but for a cellular IoT product operating in multiple frequency bands the matching circuit becomes much more complex. (See sidebar pg36: Designing matching networks for multiband antenna systems.)

The matching network should be placed as close as feasible to the antenna (while maintaining the clearance area) to minimize the length of the connecting traces. Where there must be a trace directly between the transceiver and the antenna, make sure it is designed as a 50 Ω transmission line. This minimizes trace impedance mismatch and the chance of traces acting as miniature antennas and upsetting the efficiency of the system.

While it is often possible to design a single matching network that works well for a multiband device, this might not always be the case, particularly in a compact device with a small ground plane. An alternative is to design matching networks that work well for each of the intended operational frequency bands and then switch between
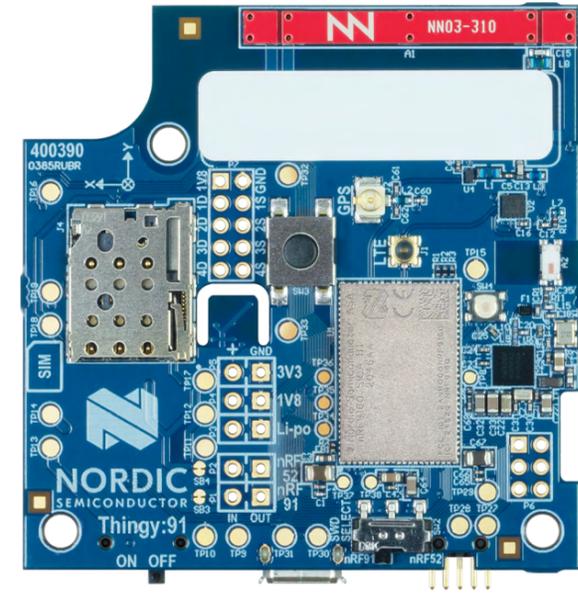
them as required. Because each network only has to meet the needs of a single frequency band, it can typically be made up of just a few components making it relatively inexpensive and compact. The Nordic Thingy:91, for example, features five matching networks for the various LTE-M/NB-IoT bands and Bluetooth LE, and a further matching network for the GPS signal. (This network also includes an LNA to boost the GPS input to the nRF9160.) Switching between networks is controlled by the nRF9160 SiP's Arm Cortex M-33 application processor.

Testing the antenna system

The final design must be tested to ensure it demonstrates not only the predicted radiative efficiency but is also approximately omnidirectional (transmits and receives in all directions). The first test can be done by connecting a 50 Ω micro–coaxial to the antenna, grounded at three or four points on the PCB and then connecting that cable to a network analyzer. The results will not only indicate efficiency but also frequency response and bandwidth. The test typically reveals if some adjustment to the matching network components is needed.

The final examination of the cellular IoT device's performance should be made in an anechoic chamber. This is the ultimate test of a design and often reveals weaknesses in efficiency and omnidirectional performance that don't show up during network analyzer testing and which require either revised chip antenna selection, ground plane and clearance area redesign and/or matching network tuning.

Even when adhering to proven development techniques, antenna design is challenging and often comes down to repeatedly testing a design's performance and then refining the layout. Moreover, small antennas are notoriously inefficient. If the design exhibits 50 to 60 percent efficiency, the designer has done a decent job. But there are often gains to be made so it's always worth a further thorough review of the design.

A Nordic technical webinar, made in collaboration with design partner Ignion (www.ignion.io) and entitled *How to embed a compact antenna for your global cellular IoT product*, **is available here: bit.ly/3zVn7I4.**

The Nordic Thingy:91 uses an Ignion Virtual Antenna. Note the position of the chip antenna (red) at the top right corner of the PCB and the clearance area between the antenna and the rest of the electronic components

Need to Know

The Ignion TRIO mXTEND Virtual Antenna used in the Nordic Thingy:91 can work in the cellular RF bands, GNSS bands for systems such as GPS, GLONASS and Beidou, and short range wireless bands for Bluetooth LE and Wi-Fi. The chip antenna measures just 30 by 3 by 3 mm and weighs 0.25 g. It has 50 Ω impedance, promises an omnidirectional radiation pattern and efficiency of 55 to 65 percent in a well–designed system

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Designing matching networks for multiband antenna systems

Matching networks for multiband antenna systems are challenging to design for even highly experienced engineers. Much of the design process comes down to trial and error. Fortunately, antenna suppliers such as Ignion offer software that makes the job much easier. Armed with knowledge of the PCB size, choice of chip antenna, frequency band requirements and S11 parameter (the reflection coefficient for the system which is a proxy for the target efficiency), the designer can use the software package to not only design the matching network but also determine the exact component values needed to approach the S11 parameter target. With the assistance of the software, it's possible, providing the PCB is large enough, to design an antenna system with just one chip antenna and matching network that meets the needs of a multiband system. Testing will still be required to determine the ultimate performance of the product. Figure A shows the output of a multiband system for an end product using cellular, GPS and Bluetooth LE radios and a single antenna. The gray bands indicate transceiver operational frequencies, the blue line is the antenna system efficiency and the brown line is the voltage standing wave ratio (VSWR). Figure B shows the matching network for this system

Figure A

Figure B
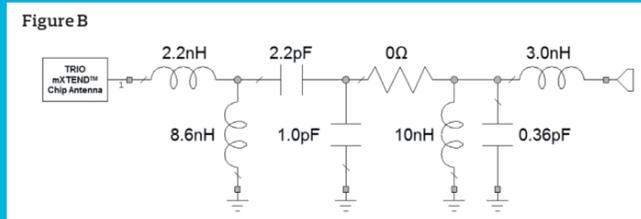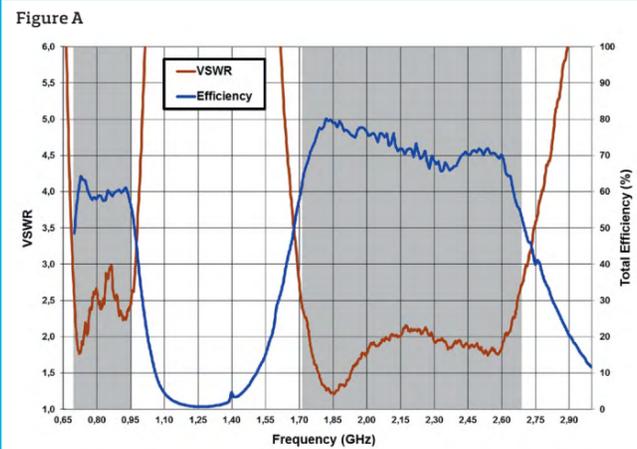
Online expert panel reveals Nordic's vision for Cloud location services

September's live panel debate explained how Nordic is making a fundamental shift in its business model to not just provide silicon but also services to its customers

WQ Live events are broadcast live each quarter and then made available on demand from the Nordic website. The events see *WQ*'s editors ask the questions and moderate. The first 40 minutes of each panel comprises a question and answer debate between the moderators and an expert panel. The last 20 minutes addresses questions posted by the audience during the event.

The expert panels comprise Nordic management and engineers, and guest customers or external experts. The debates attempt to answer the tricky questions facing the rapidly growing wireless IoT sector with lively, frank and informative discussion.

The third expert panel took place in September and featured Nordic's Svein-Egil Nielsen, CTO, Chris Hansen, Director R&D USA and Ville-Veikko Helppi, Product Manager, Cloud Services. Entitled *From silicon to Cloud services*, the panel debate explored in detail what's driving Nordic's shift from silicon to services.

Adapting to a moving market
Nordic's addition of services to its silicon and development tools solutions is driven by fundamental changes in the markets the company serves as the IoT spreads its reach.

"As the IoT has become more ubiquitous, we are seeing more Nordic customers who are [neither non-RF experts nor developers]. These [people] just want to know how easily we can make their product or application smart. That needs a different business model to [one that offers] just chips, software and development tools," said Chris Hansen, during the panel debate.

Under the new model, Nordic will seek to solve many development and application problems its customers commonly encounter. "What we're trying to do … is solve more problems for our customers," said Svein-Egil Nielsen during the discussion. "There's no point in Nordic customers spending 20-30 engineering years solving problems that Nordic has already solved better and more cost effectively than the customer could on their own."

During the debate, the participants discussed Nordic's launch of nRF Cloud Location Services. The platform has evolved from Nordic's nRF Cloud platform which has been available for several years for Nordic customers to use for prototyping their Cloud options.

nRF Cloud Location Services assures Nordic customers access to a full commercial location services model once their cellular IoT products are deployed. (*See pg10.*)
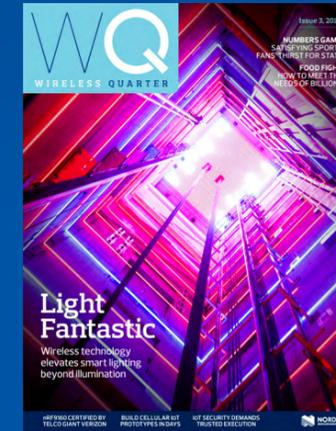
Location services are just the first in a range of services offerings planned by the company. "Nordic will develop dozens of services in the future. Many of these will be highly targeted to specific applications. And all will be optimized to run on Nordic silicon," explained Helppi, during the discussion.

This panel debate is essential viewing for any Nordic customer who feels their product or application may benefit from low cost, subscription-based Cloud services. The event is available to view here: https://bit.ly/3zgjUeU. The webpage at nordicsemi.com/Products/Cloud-services includes a fuller explanation of cell- and GPS-based location services.

For more WQ Live events, go to webinars.nordicsemi.com

> "There's no point in Nordic customers spending 20–30 engineering years solving problems that Nordic has already solved better and more cost effectively"

Product Summary

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

|	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		•	•	•	•	•	•	•	•			
LE AUDIO		•										
DIRECTION FINDING		•	•	•		•	•					
2 MBPS		•	•	•	•	•	•	•	•			
LONG RANGE		•	•	•		•	•					
BLUETOOTH MESH		•	•	•	•							
THREAD		•	•	•		•	•					
MATTER		•	•	•								
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	1MB Flash, 256 kB RAM	1MB Flash, 512 kB RAM +256 kB Flash, 64 kB RAM	1MB 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)	–98 dBm (1Mbps)	–95 dBm (1Mbps)	–96 dBm (1Mbps)	–96 dBm (1Mbps)	–95 dBm (1Mbps)	–97 dBm (1Mbps)	–96 dBm (1Mbps)	–97 dBm (1Mbps)	–93 dBm (1Mbps)	–93 dBm (1Mbps)	–93 dBm (1Mbps)
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, 2xUART	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	nordicsemi.com/9160cert	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 3.6 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	nRF9160DK, Nordic Thingy:91	nRF5340 DK	nRF52840DK, nRF52840 Dongle	nRF52833 DK	nRF52 DK, Nordic Thingy:52	nRF52833 DK	nRF52840 DK	nRF52 DK	nRF52 DK	nRF51DK, nRF51Dongle	nRF51DK, nRF51Dongle	nRF51DK, nRF51Dongle
PACKAGES	10x16x1.04 mm LGA	7x7 mm aQFN94 (48 GPIOs), 4.4x4.0 mm WLCSP95 (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), 3.175x3.175 mm WLCSP44 (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 (17 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

nRF52810

Description: The nRF52810 SoC is the baseline member of the nRF52 Series. The SoC supports the 2 Mbps throughput and channel selection algorithm #2 (CSA #2) of Bluetooth 5. The nRF52810 forms the ideal compromise between advanced performance, functionality and cost. It is powerful enough to be used as a standalone wireless SoC in middle-to-lower tier applications. Alternatively, the nRF52810 is a good solution as a companion network processor, combining Bluetooth 5 connectivity with a more powerful main application processor. Target applications include beacons, disposable medical sensors, remote controls and wireless charging.

SoC: The nRF52810 uses a powerful 64 MHz 32-bit Arm Cortex-M4 processor and includes 192 KB Flash plus 24 KB RAM. The multiprotocol radio offers between –20 dBm to +4 dBm power output (programmable in 4 dB steps) and –96 dBm sensitivity at 1 Mbps Bluetooth LE for a link budget of 100 dBm. The radio's peak power draw is only 5.8 mA TX (0 dBM, 1 Mbps) and 6.1 mA RX (1 Mbps) and the SoC's current draw is as low as 0.3 µA in System OFF (no RAM retention, wake on reset). The SoC integrates a balun with a 50 Ω single-ended output. The nRF52810 operates from a 1.7 to 3.6 V supply. Battery life is extended by using a sophisticated on-chip adaptive power management system. The SoC is available in 6 by 6 mm QFN48 with 32 GPIO, 5 by 5 mm QFN32 with 16 GPIO or 2.48 by 2.46 mm WLCSP with 15 GPIO.

Software: The nRF Connect SDK is recommended for nRF52810 software development. The SDK brings developers a wealth of varied examples, including Bluetooth LE profiles and driver support for all peripherals. The nRF Connect SDK supports applications using Bluetooth LE, Bluetooth mesh and Thread. The SDK also includes a migration of Nordic's Bluetooth SoftDevice Controller from the company's proven SoftDevices used with the nRF52 Series. The nRF5 SDK can also be used for development. (See bit.ly/3ijtlo3 for more information.) The nRF52810 fully supports over-the-air field updates of application software and RF protocol software.

Development tools: The nRF52 DK is the recommended development kit for the nRF52810. The DK is a versatile single board which can be used for Bluetooth LE and 2.4 GHz proprietary development on the nRF52810. nRF Connect for Visual Studio Code and Segger Embedded Studio Integrated Development Environments (IDEs) are supported by the DK. Other development tools for the nRF52810 include nRF Connect for Desktop, nRF Connect for Mobile and Power Profiler Kit II (for supply current monitoring).
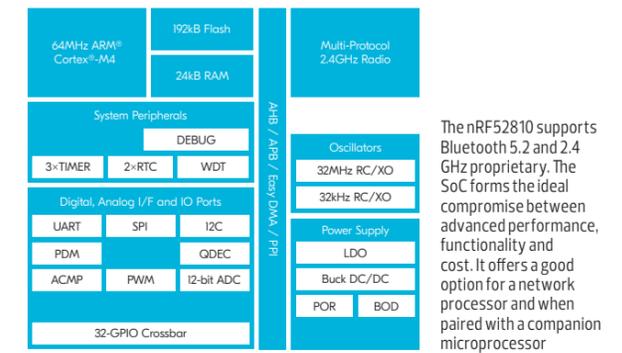
The nRF52810 supports Bluetooth 5.2 and 2.4 GHz proprietary. The SoC forms the ideal compromise between advanced performance, functionality and cost. It offers a good option for a network processor and when paired with a companion microprocessor
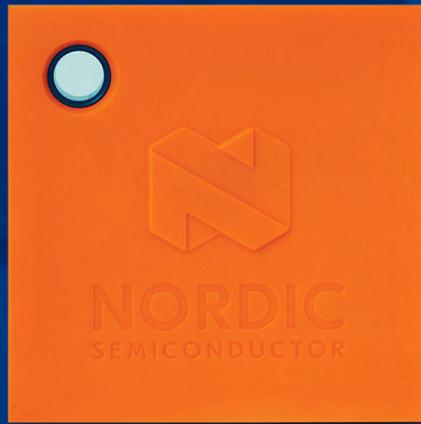
Nordic Thingy:91
Cellular IoT Prototyping Platform

An affordable, highly flexible rapid
prototyping kit for cellular IoT