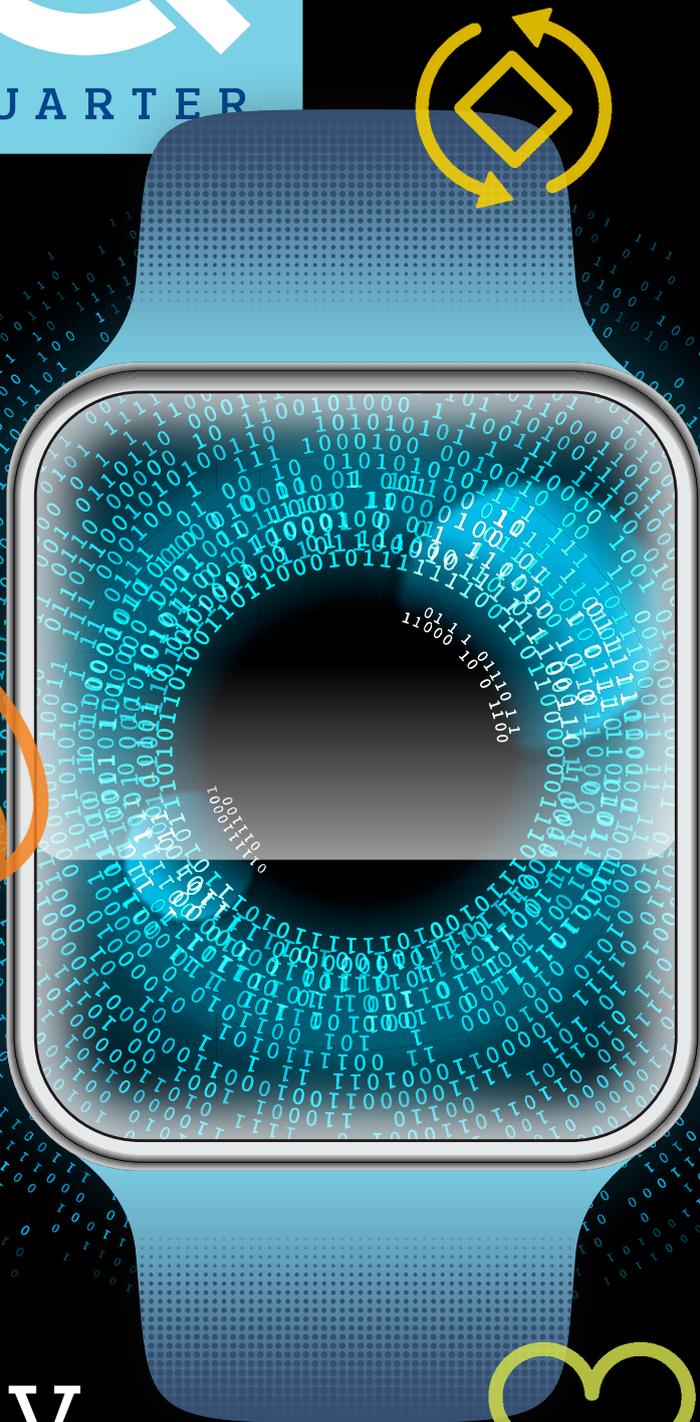


WIRELESS QUARTER

Issue 4, 2022

IN THE LINE OF FIRE:
IoT TECH PROMISES TO TACKLE
GLOBAL WILDFIRES

TOY STORIES:
SMART TOYS TO ENGAGE
AND EDUCATE CHILDREN



WQ Special Report

Sensory Perception

How the IoT uses the data from billions of sensors to comprehend the world around us



NORDIC PLAYS KEY
ROLE IN MATTER

IoT TECH TO TRANSFORM
WORLD BY 2030

GETTING STARTED ON
MATTER 1.0 PROJECTS



NORDIC
SEMICONDUCTOR

WORK SOMEWHERE AWESOME

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

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Welcome

Geir Langeland
EVP Sales & Marketing



Recent global events have provided a catalyst for dramatic growth of the IoT. Almost daily we see innovative products from our customers that are helping enhance people's health, education, happiness and prosperity. Increasingly, these new products are being built in more sustainable ways.

But some things have not changed. For over 50 years, CES has remained a constant as one of the world's premier tech shows. Billed as "the global stage for innovation," CES 23 in Las Vegas will be the ideal showcase for Nordic tech (booth 52039 at Venetian Expo).

This year, for the first time, we'll be using this global stage to demonstrate our entire wireless connectivity portfolio. From our latest solutions in [Bluetooth LE](#)—the technology in which Nordic leads the world—to [cellular IoT](#), where we're disrupting the market, and [Wi-Fi](#), where our new nRF7002 product is making waves. All of this will be at the exhibition, as well as our exciting solutions for Matter 1.0. With this product portfolio, we are one of few global firms bringing solutions for all three of the IoT's foundation technologies – and all with Nordic's renowned ultra low power performance.

But Nordic is much more than just a chip company; it plays a key role in the development of the open standards that underpin the IoT. We are members of the ANT+ Alliance, Bluetooth SIG, Thread Group, Connectivity Standards Alliance, Wi-Fi Alliance and GSMA.

Our engineers have a significant input into the specifications behind today's IoT technologies. For example, Nordic has played a key role in the [Matter](#) specification. Matter will bring order to the fragmentation of smart home tech (see pg10). [Thread](#) and [DECT NR+](#) are other important standards that Nordic is helping to develop and promote.

If you do visit CES, we'd be delighted to see you at our booth. Otherwise please keep in touch with developments in the IoT by visiting nordicsemi.com, engaging with us on social media and by subscribing to WQ at bit.ly/3VEv4W8.



Nordic is much more than just a chip company; we also play a significant role in the development of the open standards that underpin the IoT



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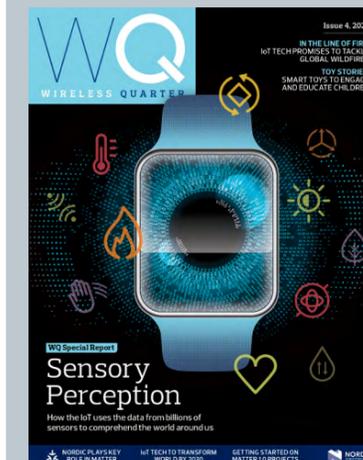
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Smart Agriculture

Smart vineyard device uses cellular IoT for frost warnings

A microclimate measuring solution for use in vineyards and employing cellular IoT connectivity to send data to the Cloud, has been launched by voestalpine Kremis GmbH. The leova SMART device was developed by IoT company, Microtronics, and uses Nordic Semiconductor's nRF9160 low power SiP with integrated LTE-M/NB-IoT modem and GNSS.

The product provides winemakers with a remote crop monitoring solution to supply reports on rainfall and fungal diseases, as well as warn of potential upcoming frost events that could damage crops.

The leova SMART device includes a rain gauge, an air condition sensor, a dual leaf wetness sensor (which can help differentiate between rain and dew) and an add-on frost sensor. It uses the nRF9160's 64 MHz Arm Cortex-M33 processor to oversee the various sensors and collate data. The Nordic SiP is then able to transmit the data to the leova SMART Cloud platform, where the historical information is stored.

From the associated app, the user can view the infection stress of their vineyard to help them better protect their crops. It also offers forecasts based on past data, and can send frost warnings as text messages.



The leova SMART device includes a rain gauge, an air condition sensor, a dual leaf wetness sensor and an add-on frost sensor.

"This device has been designed to measure the microclimate directly in each user's vineyard and enables sustainable and optimized resource management in viticulture," says Matthias Stumvoll, leova SMART Sales Manager. "The recorded microclimate data on leaf wetness, temperature and humidity are the basis of the forecasts for fungal diseases. From there, the viticulturist can implement crop protection.

"This is especially important due to the effects of global warming, as crop failures due to late frost have annual costs in the upper double-digit millions in the Austrian viticulture and fruit-growing sector alone."

As large vineyards tend not to have electricity or Internet access, Microtronics equipped the base stations with long-life cell alkaline batteries which allow the device to run reliably for extended periods.

Location & Tracking

Lightweight sensor helps scientists track wildlife

Druid Technology has released a cellular IoT and Bluetooth LE wildlife tracking solution to help scientists better understand the impact of human activities on the ecosystem. The DEBUT ULTRA 5G platform is designed to support the work of scientific research institutions, government departments, and national parks and reserves.

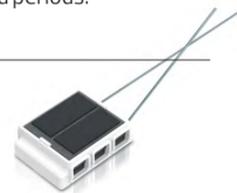
DEBUT (Devices of Biological Ubiquitous Telecommunication) ULTRA 5G is a smart

terminal and biological wearable. The compact device uses its built-in light, temperature and air pressure sensors to assess the microenvironment, especially during animal flight. It can also monitor and record latitude and longitude, altitude, speed and acceleration data, and be extended to any data collection application with strict equipment weight limitations.

A Nordic nRF9160 SiP performs as the main

processor for the integrated sensors and is powerful enough to perform edge computing for on-device behavior analysis. The SiP also provides the GNSS positioning and cellular IoT connectivity to relay data to the Cloud.

A Nordic nRF52840 SoC provides Bluetooth LE connectivity to an associated app from where users can control and configure the device, as well as visualize the location, trajectory and behavior of tracked animals.



Smart City

Smart waste solution measures fill levels and schedules collections

German-based company adhoc networks has released a smart waste management solution capable of measuring fill levels in waste containers. This allows businesses to better allocate collections and avoid over flow.

The adhoc smart waste device uses built-in optical sensors to monitor the fill levels of a variety of different containers, including underground waste systems which present additional monitoring challenges through reduced visibility and increased storage volume. The monitoring process is overseen by Nordic Semiconductor's nRF9160 SiP, which then collates the data and sends it to the Cloud, using its multimode LTE-M/NB-IoT modem.

Users can view this information through a centralized web platform, manage waste container assets, as well as review current and historical data. The platform can also perform self-learning fill level prediction modeling and offers dynamic route simulation to optimize rubbish collection crew productivity.

"Our platform has been tailored so our customers can easily manage their container fleet and conduct dynamic routing based on fill levels," says Christian Wedekind, Senior Product Manager at adhoc networks. "This helps save resources and reduces CO₂ emissions by only scheduling waste collection when containers are full. With our solution, emissions can be reduced by up to 40 percent. "A 100 percent reliable connection provided by the nRF9160 SiP is crucial for our subscription business model."

The product also includes a gyroscope—for detecting collection events—as well as a temperature sensor and optional humidity sensor, controlled by the nRF9160's dedicated 64 MHz Arm Cortex-M33 application processor, with 1MB Flash and 256 KB RAM. Powered by a single 3.6 V Li-Thionyl AA battery, the solution can operate for up to five years between battery replacement.



Education

Nordic launches DevAcademy to accelerate wireless IoT learning journey

Nordic has launched an interactive online learning platform that aims to teach people the technical information they need to build leading products using Nordic solutions. DevAcademy is for developers, makers, students and anyone interested in learning about the IoT and wireless technologies.

DevAcademy courses embrace all skill levels. Each course has a well-defined curriculum and is divided into individual easy-to-follow lessons that cover both tech theory and hands-on exercises. Users get to test their

knowledge through interactive quizzes. Users completing the course receive a certificate.

Nordic's courses are continuously enhanced. They help participants reduce time-to-market by teaching them about the latest solutions from Nordic and best design practices.

There are currently two courses publicly available, with more to follow. The nRF Connect SDK Fundamentals course teaches how to develop RTOS-based applications for IoT products. The course teaches firmware development using the nRF Connect SDK.

The Cellular IoT Fundamentals course covers LTE-M and NB-IoT. By the end of this course, users will have learned how to develop firmware for cellular IoT prototypes based on Nordic development tools.

DevAcademy is sited at nordicsemi.com.



In Brief

KEEPING CYCLISTS SAFE



While the pandemic saw more people than ever take up cycling, it also saw more injuries and deaths on our roads because of traffic accidents.

It's a concern that Ford Motor Company hopes to solve with the help of Bluetooth LE technology. The carmaker is working with developers to explore how a smartphone app could warn drivers of pedestrians and cyclists they may not see. As someone sharing the road with a car, you would install the company's software on your phone. With the help of Bluetooth LE, vehicles with Ford's Sync infotainment system would see cyclists and pedestrians as 'beacons'. If the car then determines there's the potential for a crash, it will warn the driver using audiovisual cues.

NORDIC TO OPEN COPENHAGEN OFFICE



Nordic Semiconductor will open an office in Copenhagen, Denmark, in early 2023. The office will be home to a group of analog designers, while

also serving as a hub for attracting other talent. The move to open the office began with the identification of a team of talented engineers with a shared, long-established history of high performance. The expansion into Denmark is part of Nordic's long-term strategy of taking a global perspective when it comes to recruiting highly skilled engineers, and of establishing hubs in regions where relevant talent is concentrated. Nordic has successfully followed this strategy by expanding within Finland, Poland, the U.K., the U.S., Sweden and India.

INSURANCE EMBRACES THE IoT



The insurance industry is rapidly adopting IoT technologies to innovate and modernize its approach to risk assessment. According

to analyst, Allied Market Research, the IoT insurance market is expected to reach \$304 billion by 2027, from just \$8.63 billion in 2019. IoT technologies promise to substantially reduce losses and transform insurers' relationship with policyholders, providing rich data to more accurately assess and price risk. From a claims perspective, the IoT can power automated loss notification based on sensor data, and for insurance marketers provide valuable insight into customer behavior.

Audio & Music

Podcast system offers professional sound quality at touch of a button

A portable professional podcasting product that promises to remove set-up complexity and poor audio quality issues that trouble outdoor podcasting interviews, has been unveiled by Norwegian specialist, Nomono.

The Sound Capsule is a wireless solution from microphone-to-Cloud storage, and comprises four wireless microphones, a central hub recorder with spatial audio mic, and a charging unit that keeps everything topped-up.

"Great conversations can happen anywhere," says Brad Swanson, VP of Partnerships at Nomono. "But before now, professional interview-grade audio recordings for podcasting could not. Or at least not without a sound engineer or a complicated audio set-up and test procedure that even then did not reliably guarantee quality."

"With the Sound Capsule there are no levels to set and no [memory] cards to insert. All the set-up complexity is completely removed right down to setting the level of ambient noise, automatic mic sensitivity adjustments and Cloud-based signal processing. The outcome is a set of completely clean, professional grade audio files stored safely in the Cloud."



With the Sound Capsule professional podcasting product all the set-up complexity is completely removed

The Sound Capsule system integrates eight Nordic SoCs—including four flagship [nRF5340](#) SoCs and four [nRF52833](#) SoCs. The nRF5340's application processor can supervise the demanding task of encoding and decoding the audio stream, while the network processor takes care of communication.

"There's been a big reduction in the size of broadcast journalism teams in recent years,"

says Swanson. "At the same time print journalists are now being asked to do more and more podcasting. This has created a 'perfect storm' in terms of maintaining audio quality in the field. Journalists aren't necessarily technical sound engineers. And they don't necessarily want, or indeed have, the luxury of a costly sound engineer traveling around with them. The Sound Capsule is the solution."

Wearables

IoT smartwatch enables telecare alerts

Hong Kong-based microelectronics company, Dayton Industrial, has launched a new [wearable](#) and web-based solution designed to enable remote healthcare application support from an open platform.

The Link2Care Smartwatch DA13700 features a 3D motion sensor for activity records, inactivity alerts, plus sleep monitoring and fall detection. By pressing the SOS key, the user can activate an SOS alert message which sends their health information—including name, gender, age, blood type and any drug allergies—and location to predefined mobile phone numbers and a Cloud server and service center for emergency response.

Nordic's [nRF52832](#) SoC provides the Bluetooth 5.3 connectivity enabling

incoming calls, schedules, messages, social media notifications and more to be relayed between the user's smartphone and the Link2Care Smartwatch DA13700. In addition, the SoC provides mesh networking capability, a beacon profile for indoor location tracking, and NFC support.

Nordic's [nRF9160](#) SiP provides the device with LTE-M/NB-IoT cellular connectivity and GNSS to report the location of the wearer to nominated caregivers and family members along with any SOS alerts.

Further information, including sleep and activity stats and wellness data such as daily step count/distance and calories burned, can be uploaded to the Cloud and customer service center via a cellular network.



Smart Home

Smart air purifier analyzes air quality data



Connected appliances firm, Sleekpoint Innovations, has released the Purelle (AP2) air purifier. The smart air purifier takes advantage of Apple HomeKit with Thread Accessory Protocol.

The air purifier includes a built-in sensor that detects potentially harmful contaminants smaller than 2.5 microns.

The air purifier uses Nordic's [nRF52840](#) SoC. The chip's powerful Arm Cortex M4 processor analyzes the sensor data which is then wirelessly transmitted to the associated Airversa Sleekpoint app on the user's smartphone.

The data can be used to generate daily, weekly or monthly charts to help consumers track long-term air quality.

Wearables

Smart helmet could help firefighters better locate victims

Wireless helmet technology which could help firefighters quickly map their surroundings, navigate hazardous environments and efficiently locate fire-scene victims is being developed by researchers in Scotland.

Combining feeds from thermal cameras, radar and inertial sensors mounted on a standard-issue firefighting helmet, the technology uses AI to provide wearers with information that can help detect victims, recognize teammates and provide an accurate understanding of their own location. This information can then be wirelessly relayed to scene commanders in real time.

Developed at the National Robotarium, a center for robotics and AI hosted by Heriot-Watt University and the University of Edinburgh, it's hoped that the tech could help firefighters and scene commanders safely navigate adverse or low-visibility conditions such as smoke-filled buildings, and reduce the time it takes to rescue victims.

"Firefighters often operate in environments with [restricted] visibility due to smoke," said Dr Chris Lu, a lecturer in Cyber-Physical Systems at the University of Edinburgh. "This



can make detecting the location of potential victims and... firefighters very challenging.

"This new tech has the potential to support on-the-ground firefighters and commanders to make crucial in-the-moment decisions."

The sensor rig weighs less than a kilogram and is composed of affordable, off-the-shelf components that can be easily retrofitted to existing standard helmets. The researchers are continuing to build capabilities, and plan to equip the helmet with the ability to generate 3D maps and an embedded display, which will provide even more spatial awareness.

Smart Home

Smart plug provides remote appliance management



MOKO Smart has developed a smart plug for energy management applications in the smart home and energy metering sectors to support both consumers and energy-solution providers. The MK117NB Smart Plug can be used to monitor energy usage and save power consumption by remotely controlling load switches. It features a power and energy meter and has a measurement accuracy of ±0.5 percent. Users can track energy consumption through a smartphone app.

MK117NB Smart Plug supports a range of plug types and can be used in many countries. It allows ordinary electrical devices to become IoT enabled, providing users with the ability to better understand their energy usage and convert real-time electricity consumption into accurate billing data. For example,

the device can easily manage all electrical equipment such that it turns off during non-working hours, reducing unnecessary power consumption and manual labor.

The device incorporates multiple protection mechanisms. When the plug detects the measured value is out of the safe range, and the duration exceeds the safe time, it will automatically switch off to reduce the risk of damage to the connected electrical device.

The smart plug integrates a Nordic nRF52833 SoC as the device's main processor for running sensor-based algorithms to monitor energy consumption and electrical parameters.

The product also includes Nordic's nRF9160 SiP to provide NB-IoT for low power consumption wireless data communication over a cellular IoT network.

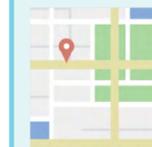
In Brief

GLOBAL SMART CITIES RANKED



A global study of 200 cities by ThoughtLab has analyzed how well cities are future-proofing their urban environments to prepare for tomorrow's smart cities. To assess the future-readiness of cities, the study investigated each city's progress across digital infrastructure, transportation, living and health, and other critical urban domains. The study uncovered many pivotal areas for future-readiness including driving digital transformation and innovation, and the use of tech to improve decision-making. According to the study the top 10 most future-ready cities are Tokyo, Hangzhou, Helsinki, Tallinn, Taipei, Durham, Aberdeen, Sapporo and Boulder.

POSTER PINCHER CAUGHT BY TECH



A mayoral candidate in Trumann, Arkansas, has put technology to use in a bid to stop thieves from making off with the signs she was erecting around town encouraging local residents to vote for her. Sheila Walters said it was a recurring problem with signs going missing, but that one location in particular appeared to be especially prone to the billboard bandits. To fight back, Walters decided to hide an Apple Air Tag inside some of the signs, and in so doing was able to track and catch one of the thieves. "The sign was in the ditch with grass on it and a few days later it was in the trash and ultimately, someone decided to take that sign and another sign to their home," Walters told media.

U.S. RAMPS UP IoT INNOVATION



Sixteen private and public sector professionals will form the inaugural IoT Advisory Board within the U.S. Department of Commerce, a body of experts whose job will be to advise the larger IoT Federal Working Group. The group will discuss the federal regulations and policy decisions that could provide "significant and scalable" IoT innovation and highlight opportunities where greater connectivity could provide solutions to societal problems, such as transit technology and improved supply chains. Other industries that the board will study include sustainable infrastructure projects, public safety and healthcare.

Wearables

Tracker notifies parents if child wanders off from caregiver

U.S.-based Littlebird has released a toddler-tracking device that can provide parents with peace-of-mind when they leave their young children with caregivers. The Littlebird CareTracker wrist-worn wearable also includes physiological sensors to monitor the child's heart rate, activity and sleep to provide regular wellbeing updates to both parents and caregivers.

The device is easily attached to a child's wrist and is connected to the Littlebird app on both the parent's and designated caregiver's smartphone. The Littlebird CareTracker employs Nordic's [nRF52840](#) SoC to act as a wireless 'tether' between the child and the caregiver. In the event the child or caregiver moves out of sight or earshot of one another and the Bluetooth LE connection is lost, the



device will automatically send an alert to the parent's and caregiver's smartphone using LTE-M wireless connectivity. The alert also includes the last known location of the child based on GNSS coordinates.

"When I developed the Littlebird CareTracker I wanted to empower parents and caregivers," says Monica Plath, CEO and Founder of Littlebird. "Having two toddler boys ... I also needed to know who was with my child when I was apart from them."

In addition to the [nRF52840](#) SoC, the Littlebird CareTracker integrates Nordic's [nRF9160](#) to provide cellular IoT wireless connectivity between the wearable and smartphone app via the Cloud. The [nRF9160](#) SiP combines LTE-M cellular network location data with GNSS trilateration for precise position monitoring of the device and child.

As well as location data, the Littlebird app can provide periodic status updates—for example if the child is active—based on data acquired from the device's sensors.

Wearables

Waterproof sensor could prevent drownings

A waterproof sensor that could monitor swimmers and divers to identify moments of distress in the water and alert others has been developed by a team of researchers at Fuzhou University in China.

To create the amphibious tracker, the team used a thin coating of a flexible, conductive fabric known as polydimethylsiloxane (PDMS) and tested its water-repelling efficacy when applied over a fabric sensor. Initial tests of the new design involved placing a sample of the fabric on a study participant's finger. Results showed the coated fabric to be conductive and water-repellent, but still breathable and comfortable.

Existing designs rely on thick safety insulation that makes the wearables cumbersome and uncomfortable. In secondary tests the device was attached to a motorized doll programmed to kick or remain



still, with the sensor's response monitored. The device correctly identified when the doll was still, in motion or showing erratic movement, sending an alert to a connected smartphone when there was no movement.

The design could provide an easy-to-use safety wearable for divers embarking on security or maintenance missions, or for young children or inexperienced swimmers at the beach or river.

Toys & Gaming

Drone tracker enables regulation compliance

IoT company, Braveridge, has launched a low power drone tracking and regulatory compliance solution. The Remote ID device can transmit the drone's published ID and precise position via Nordic [nRF52840](#) SoC-enabled Bluetooth 5 Long Range connectivity. In addition, Braveridge has developed a Remote ID receiver and associated app to display, monitor, and record the flight of multiple drones.

Reliable Bluetooth 5 Long Range capability is important for Remote ID because drones are required to transmit aircraft information—including ID, location and authentication—every second.

Recently updated regulations in Japan stipulate all unmanned aerial vehicles over 100 g must incorporate remote identification functionality.

Smart Health

Smart mouthguard controls devices

Individuals who have limited hand function could soon have a simple way of controlling devices such as computers, smartphones and wheelchairs by wearing a smart mouthguard that translates complex bite patterns accurately and quickly into instructions to control electronic gadgets.

The first-of-its-kind bite controlled optoelectronic system was invented by a team led by Professor Liu Xiaogang from the National University of Singapore (NUS) together with collaborators from Tsinghua University.

Various assistive technologies such as voice recognition, eye tracking and brain-computer interfaces have been developed in recent years to help people—especially those with limited dexterity or neurological disorders—control electronic devices. However, these technologies have limitations associated with interference, accuracy, cost and maintenance.

To offer a promising alternative to existing assistive technologies, Prof. Liu and his team have successfully designed and demonstrated a smart mouthguard containing integrated pressure sensors to detect occlusal patterns. These patterns are translated into data inputs that can be used to wirelessly control electronic and mechanical devices.

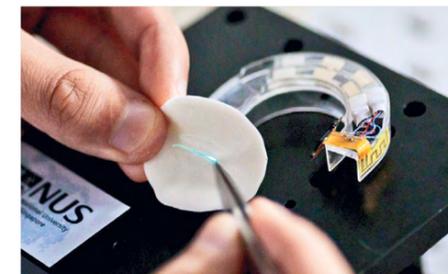


Photo: NUS

"Our bite-controlled optoelectronic system is capable of translating complex bite patterns into data inputs with 98 percent accuracy," says Prof. Liu.

"We have also demonstrated that our novel sensors can distinguish mechanical deformations, including strain, compression and bending, making them applicable to multifunctional mechanical sensing applications, such as force sensing, flexible electronics, artificial skin and dental diagnosis."

Besides supporting human-computer interaction, the interactive mouthguard, which weighs 7 g, can be used for medical assistance, healthcare devices and is said to require less training experience when compared to existing assistive technologies.

Beacons

Bluetooth 5 beacons monitor refrigeration equipment

Electronics manufacturer, Stratosfy, has launched a centralized, automated temperature monitoring solution for multi-franchise food service operations. The Tempgenie product assists with the early detection of food inventory spoilage, attaining regulatory compliance, and monitoring the temperature of all refrigeration equipment.

According to the company, it is the only comprehensive sensor-based product that supports both hot-holding and cold equipment units of food service operations.

The solution comprises temperature sensor beacons and a Bluetooth LE to Wi-Fi gateway both integrating Nordic's [nRF52840](#) advanced multiprotocol SoC. The [nRF52840](#) SoC-powered beacons measure the ambient and



surface temperature of front- and back-of-house equipment. The Nordic SoC enables the temperature data to be wirelessly relayed via Bluetooth 5 connectivity to the gateway.

In addition, the presence of the [nRF52840](#) SoC allows the gateway to scan the beacons to transmit the equipment temperature sensor data to Stratosfy's proprietary Cloud platform. From there, the associated Tempgenie app can provide a real-time snapshot of the equipment temperature for the restaurant operations team.

Stratosfy's web-based application provides analytics for food service companies seeking equipment temperature management.

By the Numbers

\$202.1 million in revenue

Nordic Semiconductor has [reported](#) Q3 2022 revenue of \$202.1 million, a year-on-year growth of 36 percent over Q2, 2021. Bluetooth LE revenue increased by 44 percent year-on-year despite delivery capacity remaining capped by wafer supply. Cellular IoT revenue meanwhile increased by 61 percent over the same period last year. The consumer end-product market dominated, accounting for over 60 percent of total revenue.

30.9 billion

IoT connections by 2025

The total installed base of IoT connected devices is projected to reach 30.9 billion units by 2025, up from the 13.8 billion connections in 2021, according to Statista. By comparison, non-IoT connected devices—for example smartphones and laptops—are expected to amount to just over 10 billion units by 2025. IoT connected devices overtook non-IoT connected devices for the first time in 2020, and are expected to outstrip them two-to-one as soon as next year, according to the research.

\$11.2 billion by 2028

The global IoT device management market is forecast to reach \$11.2 billion by 2026, according to Reports and Data. The analyst said the demand for intelligent sensors in combination with the growing trend of Cloud-based device management platforms will push growth. It said the market was particularly strong in the retail, health, utilities and logistics verticals.

Smart Home

Nordic Semiconductor joins Connectivity Standards Alliance Board of Directors

Promotion to the board of the 550-member tech grouping allows the company to guide the development of Matter, a key standard for the smart home

Nordic Semiconductor has been elevated to the Connectivity Standards Alliance Board of Directors and added as a Promoter Member, the highest level of membership. In addition to Nordic, the Alliance's board includes executives from Amazon, Apple, Google, Huawei, IKEA, LG Electronics, OPPO, Samsung Electronics, Schneider Electric and Somfy, among others.

The Alliance, formerly the Zigbee Alliance, was established in 2002, and boasts a membership of over 500 tech companies committed to bringing standardization and interoperability to the smart home.

Nordic takes an active role in the development and promotion of global standards for wireless connectivity such as Bluetooth LE, Wi-Fi, NB-IoT, LTE-M and DECT NR+. In 2019, the company backed Project CHIP (Connected Home over IP), an attempt to bring interoperability to smart home devices by introducing a standard application layer based on Internet Protocol (IP).

Project CHIP later became [Matter](#). Today, Nordic is a main contributor to the development of Matter and is one of only nine companies whose engineers can make changes to the standard's implementation on code repository GitHub.

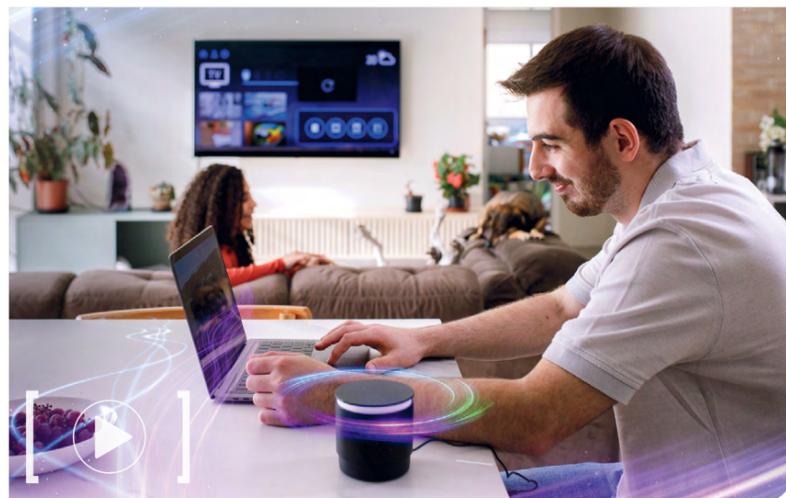
"Nordic is an enthusiastic advocate of open standards for the IoT and backs this with engineering resource to help push them into mainstream adoption," says Pär Håkansson, Nordic's Product Director – Short Range Wireless. "In the case of Matter, Nordic has played a major role in the initiative since the very beginning."

With the standard emerging as an important technology for smart home device interoperability, Nordic's promotion to the Alliance board will see the company even better positioned to play a significant role in the continued development of the standard and its promotion.

"Nordic joins the Alliance Board at a pivotal time in our twenty-year history," says Tobin Richardson, President and CEO of the Alliance. "[Nordic has] been an integral part of [Matter's] development and we look forward to [its] enhanced participation and leadership as we change the game from silicon to storefront for the entire IoT ecosystem."

Matter 1.0 officially released

In early October, the Matter 1.0 specification was officially unveiled and with it the opening of the Matter certification program. "Members now have a complete program for ... interoperable products that work across brands and platforms ... with greater privacy, security and simplicity



“Nordic has been an integral part of Matter's development and we look forward to its enhanced participation and leadership

for consumers," the Alliance said in a statement.

Since Matter 1.0's adoption things have moved quickly. The Alliance reports that 190 products have received Matter certification or are awaiting certification testing. And the Matter 1.0 specification has been downloaded 4,400 times since its release. The SDK has also been downloaded 2,500 times from GitHub.

The Matter certification program includes certification of hardware and software products, and can now be conducted in any of eight authorized test labs in 16 locations across nine countries. The labs can test not only Matter, but also the underlying network technologies Wi-Fi and Thread. Wi-Fi enables Matter devices to interact over a high-bandwidth local network and allows smart home devices to communicate with the Cloud. Thread provides an energy efficient and reliable mesh network within the home. Both the Wi-Fi Alliance and Thread Group partnered with the Alliance to launch Matter.

Matter is a connectivity standard that forms a common language to bring together disparate ecosystems and enables smart devices from different makers to work in harmony. Matter products are interoperable with the major smart home ecosystems like Apple's Siri, Google's Assistant, Amazon's Alexa and Samsung's SmartThings.

The standard works by building on top of the existing smart home wireless connectivity technologies Thread, Wi-Fi and the Ethernet wired protocol by providing a unifying application layer. Bluetooth LE is used for secure commissioning of new devices to the network.



Nordic ready for Matter 1.0

Matter was originally announced in 2019 as Project CHIP (Connected Home over IP). The first release of the standard was planned for late 2020 but was put back as many more companies became involved with the initiative. Following the August 2021 rebrand to Matter, version 1.0 of the standard was adopted in October 2022, and with it the Matter certification program was launched.

During the three years from Project CHIP's initiation to the Matter 1.0 launch, collaboration between the key contributors on the engineering specification continued unabated. Nordic Semiconductor and other major smart home companies continued to develop Matter hardware, software and development tools ahead of the official launch of the standard.

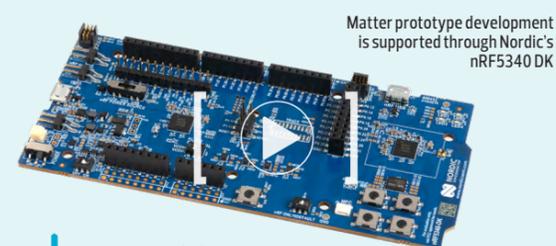
Because of this program of continuous development, Nordic's customers are already developing Matter-compliant devices using the company's [nRF52840](#) and [nRF5340](#) SoCs, which support Thread and Bluetooth LE. And with the company's recent expansion into Wi-Fi, products such as the [nRF7002](#) Wi-Fi 6 Companion IC as well as future Nordic Wi-Fi chips will also support Matter.

Nordic customer products using the [nRF52840](#) and [nRF5340](#) SoCs, and Nordic itself using its Thingy:53 prototyping platform to run the Matter Weather Station application, successfully completed the alliance's Matter Test Events and Matter Specification Validation Events (SVEs). This success proves Nordic Matter products' maturity and full compliance with the Matter 1.0 specification.

Matter prototype development is supported through the [nRF52840](#) and [nRF5340](#) DKs and the [nRF Connect SDK](#). nRF Connect SDK is Nordic's scalable and unified development tool for building products based on the company's SoCs, SiPs and [nRF7002](#) Wi-Fi 6 Companion IC.

The latest version of the SDK (2.2) includes full Matter over Thread and adds support for Matter over Wi-Fi for the [nRF5340](#) SoC in combination with the [nRF7002](#) Companion IC. The SDK includes fully integrated Matter support, and includes sample programs for a diverse range of applications that include weather stations, light bulbs, light switches and door locks.

The incorporation of Matter over Thread into the nRF Connect SDK comes after Nordic was the first company to earn a Thread 1.3 certification badge earlier this year. Thread 1.3 is a prerequisite for Matter over Thread and the certification can be inherited by Nordic customers for their own products.



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Internet of Things

Wireless connectivity set to 'transform the world by 2030'

The next decade will be defined by innovation across sustainability, smart cities, micromobility and connected care, according to telcom giant's latest research

New research predicts a connectivity and smart technology explosion throughout the next decade that will "fundamentally transform" our experience of the world. The conclusion follows analysis conducted by consultancy, The Future Laboratory, in partnership with Vodafone Smart Tech – the global telecom leader's innovative tech business. According to *The Connected Consumer 2030* report, by 2025 an average tech-savvy person anywhere in the world will interact with connected devices almost 4,800 times per day—about one interaction every 18 seconds.

The Vodafone report identifies five pillars around which consumers will seek to harness the power of connectivity through to 2030. Those pillars include [sustainability](#), smart cities and mobility, connected care, ethical connectivity and future technology. As these key trends play out, they are expected to help the world navigate the complex impacts of climate change, depleting natural resources and aging populations, while simultaneously addressing once-in-a-generation challenges such as geopolitical instability and [healthcare](#) crises.



Smarter sustainability, cities and mobility

As the Earth's natural resources continue to be depleted, Vodafone claims a new consumer mindset will see connectivity "harnessed to create a more resilient, circular, regenerative society". In turn, this growing demand will see the global green technology and sustainability market become worth \$48.36 billion by 2027, according to a forecast by Allied Market Research.

The Vodafone report pinpoints three main advances in connectivity for climate action that could be made by 2030: Connectivity enabling consumers to track the environmental impact of their actions in real time and optimize their behavior for a more sustainable future; connectivity helping the world shift away from linear consumption towards a [circular economy](#) built on resources being recycled, re-used and shared; and new innovations allowing nature itself to become connected.

Meanwhile, the report predicts connected transport could soon be the norm, enabling safer, more optimal journeys. For example, the global market for autonomous vehicles (AVs), including self-driving cars, is forecast to reach almost \$2 trillion by 2030, up from \$54 bn in 2019, according to analyst Research and Markets. Consultant McKinsey estimates the GDP impact of connectivity on mobility could reach \$280 bn by 2030.

But for AVs to thrive and transformative mobility

Need to Know

In the U.K., the average person currently owns 6.2 smart devices (Deloitte); MarTech Advisor forecasts by 2030 the number of connected devices globally will reach 125 billion – around 15 devices per person. Meanwhile, 62 percent of U.K. consumers are more likely to purchase a product with sustainable credentials

systems to be fully realized, cities themselves must first become smart, according to Vodafone. To this end, we can expect to witness the development of smart cities that respond seamlessly to the needs of citizens – including fully autonomous mobility systems. These new mobility systems will see vehicles go beyond means of transportation to drone delivery services, for example.

Smart city initiatives are already attracting massive investment. IDC estimates the value of spending on such schemes will reach \$158 bn in 2022, as cities harness the power of connectivity to improve traffic flow, lower pollution levels and enhance living conditions.

"Society is evolving faster than we think, and it's driving new, sustainable directions within the world of technology," says Alex Froment-Curtill, Chief Commercial Officer, Vodafone Group. "We need technology to optimize daily life so we can live more sustainably."

Connected care and ethical connectivity

Healthcare systems around the world are under strain, but the Vodafone report forecasts connectivity will provide a lifeline to an industry it describes as being near breaking point. An era of connected care will enable a generation of consumers who need assistance to take



The next decade will see connectivity become much more visible to customers, enabling new experiences which fundamentally transform both individual lives and society

"ownership" over their own health and live independently.

By 2030, homes will be equipped with an array of connected devices capable of proactively monitoring health and diagnosing conditions, or even detecting the early stages of degenerative diseases, Vodafone suggests. AI-powered smart speakers, for example, could automatically request the appropriate medical prescription when they detect a person coughing or sneezing.

And preventative healthcare models could save as much as \$45 bn per year in the U.S., according to the University of North Carolina. Moreover, connectivity will allow disparate aspects of the healthcare sector to come together, the Vodafone report asserts, creating efficient digital ecosystems that alleviates pressure on health services.

In addition, the report details the: "Emergence of new frameworks that embed integrity and ethical codes of conduct into new technologies". It is proposed that these will place people in greater control of their own data and allow them to demand hyper-personalized services and experiences in exchange for their information.

Finally, the report outlines how the rise of new, immersive technologies—driven by the power of human imagination—will extend our experience of the world and facilitate an entirely new way of engaging with products, as well as with each other.

Bjørn "Bob" Brandal
VP Sales & Marketing APAC



IoT implementation made simpler

Building connected products is never easy, but Nordic aims to make it as straightforward as possible

Developing IoT products is challenging. Engineers say their biggest problems come from dealing with the multiple protocols that form the wireless sensor networks and LPWANs making up the IoT. Other engineering problems stem from making sure firmware and software is compatible and interoperable for systems based on more than one wireless technology. These challenges are made even harder because open standards allow third parties to create their own software

Nordic offers highly optimized hardware and software stacks

stacks to run on vendors' silicon.

Worse yet, some companies put off adopting cellular IoT because of the engineering difficulties presented by chipsets based on stripped down mobile handset technology. Because these chipsets weren't designed specifically for cellular IoT, they offer poor battery life and unreliable connectivity. And they tend to be supplied by large smartphone chipset companies who aren't set up to support lots of small and medium firms that have little or no cellular experience.

The problem is made worse when the hardware is packaged into modules from a second vendor and use firmware from a third. The customer is confused as to where to turn for engineering tools and technical support for their cellular IoT development.

Here at Nordic, we understand the challenges our customers face.

That's why the company has spent many years and millions of dollars setting up to support any customer that wants to build applications for the IoT. Nordic has based its technologies on international standards—which ensures interoperability—and it is one of very few global firms that can support all the mainstream IoT technologies including Bluetooth LE, [Bluetooth mesh](#), [Matter](#), [Thread](#), [Zigbee](#), [Wi-Fi 6](#), [NB-IoT](#), [LTE-M](#) and [DECT NR+](#).

And for each technology, Nordic offers highly optimized hardware and software stacks built with Nordic's decades of low power consumption expertise, easy-to-use and constantly updated development kits, the [nRF Connect SDK](#) a scalable and unified software development kit, and comprehensive technical documentation.

Nordic also hosts [DevZone](#), an online development community, which features tens of thousands of technical queries and answers from Nordic employees and others about Nordic's technologies.

By partnering with Nordic, developers can get everything they need to build leading commercial end products for the IoT from a single company.





Sensory Perception

Without data, the IoT would be useless. Billions of sensors gather the real-world information the digital network needs to go about its work

In Short

The IoT uses sensors to obtain data, and these are just as important to its distributed digital intelligence as sight and hearing are to humans

Engineers' ingenuity has resulted in some highly-specialized sensors such as air-quality measurement devices

While there are dozens of sensors available, many IoT applications rely on relatively few mainstream types. For instance, temperature, humidity, air-quality and -pressure sensors are common

Prototyping kits like the Thingy:53 help to short-circuit the challenges of sensor selection by incorporating carefully selected and matched measurement devices for typical IoT applications

The human brain is, as far as we yet know, the most complex construction in the Universe. In comparison, planets, stars and even exotic heavenly bodies such as pulsars and black holes, are mere collections of atomic particles bending to the randomized whims of quantum mechanics.

Within its average 1.4 kilogram weight, the brain is a highly-interconnected, -organized and -efficient construction of 86 billion neurons (and the same number again of supporting cells). Such is the power of this organic computer it can produce the symphonies of Mozart, the theories of Einstein, the novels of Toni Morrison, and so much more.

But the brain can't perform these tasks without perception. The human senses of sight, hearing, touch, taste and smell provide every bit of data the cerebral matter uses to interact with the outside world - as well as calculate, analyze, have fun and form lifelong memories. Without senses, our lump of gray and white matter would be utterly isolated and, according to some experts, even lacking basic consciousness.

And so it is with the Internet of Things. "There is many billion times more information in the world than people could possibly type in through a keyboard or scan with a barcode," Kevin Ashton, the RFID expert who coined the phrase 'Internet of Things' told *Smithsonian Magazine*. "In the twenty-first century, because of the IoT, computers can sense things for themselves."

The IoT uses electromechanical and electronic sensors to collect information, and these 'senses' are just as important to its distributed digital brains as sight and hearing are to human organic ones. The sensors of the IoT form the critical interface between the real world and its Cloud-based digital twin. And the accuracy of the digital twin and how it develops is largely dictated by the frequency and precision of the data gathered.

However, unlike human sensors, limited as they are to relatively narrow ranges of stimuli such as light between 380 and 700 nanometers, and sound between 20 hertz and 20 kilohertz, engineers can use the IoT's sensors to detect almost anything: from low frequency vibration

to high humidity, or low light intensity to high carbon monoxide concentration. This wide range of sensors allows for the measurement of many different variables. That in turn enables engineers to pick and choose exactly what sensors they need for their IoT application.

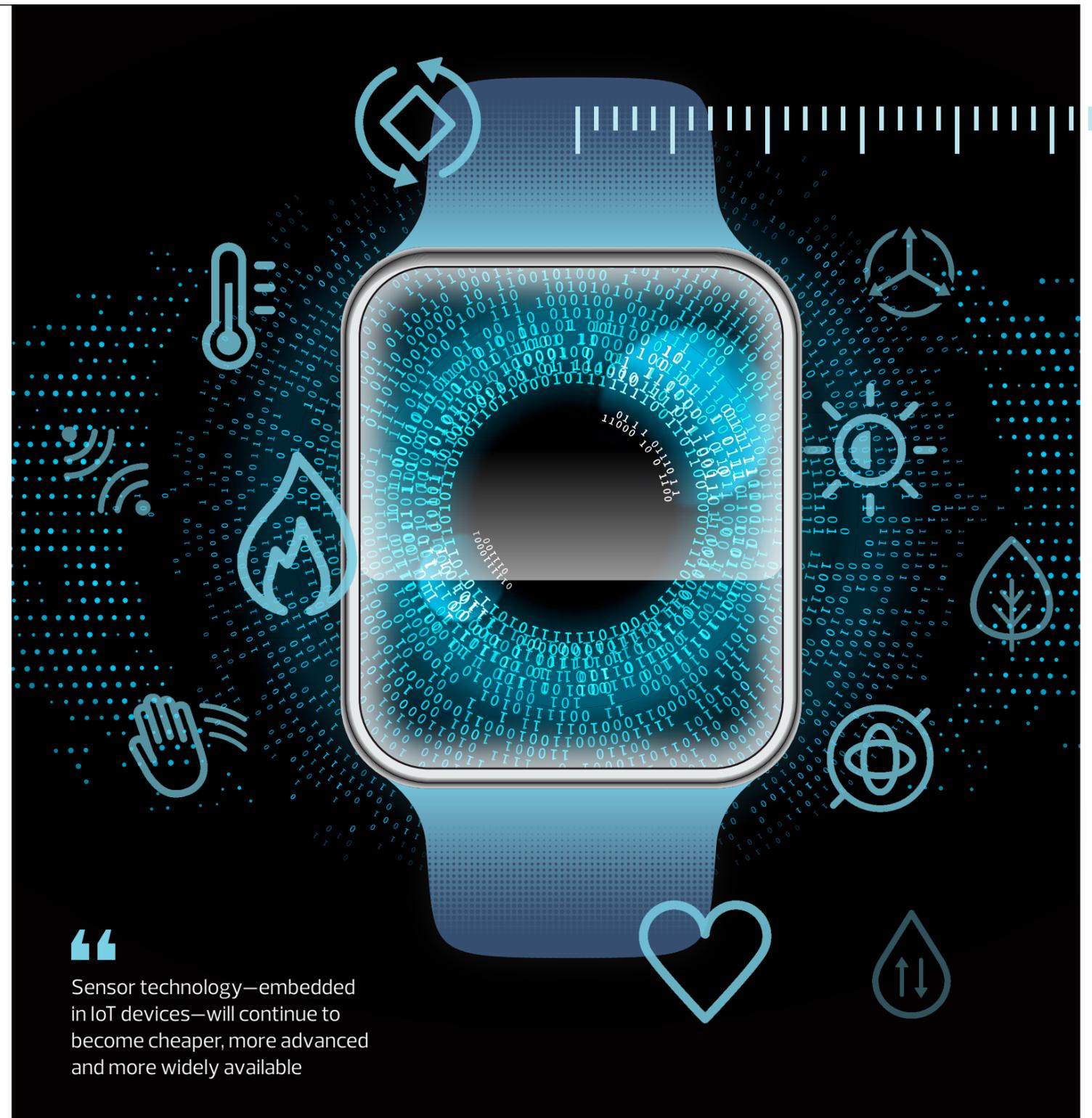
And, according to analyst McKinsey, this is just the beginning. "Sensor technology—embedded in IoT devices—will continue to become cheaper, more advanced, and more widely available," the company stated in a recent article. "In turn, this availability and cost-effectiveness will make new sensor applications possible, including large-scale monitoring and detection."

FROM ANALOG TO DIGITAL

Humans live in an analog world while computers inhabit a digital one. For us, light, heat and sound vary continuously, and our biological sensors allow us to resolve even the tiniest differences in color (for example, the eye can determine hundreds of shades of gray), temperature or frequency. But the IoT's distributed intelligence is different; its computers need discrete values for the data it uses for calculations - and its sensors must be adapted to suit. To achieve this, engineers use analog-to-digital converters (ADCs) to transform the continuous signals of things such as pressure, voltage or distance into discrete digital representations.

The ADC samples the incident analog waveform at regular intervals and assigns a digital value to represent the magnitude at that point. Because there are only a finite number of digital values to represent a continuous waveform, the magnitude representation will increase or decrease in discrete, uniform steps, effectively "quantizing" the original waveform. The greater the sample rate and smaller the quantization the more accurately the digital signal will map the analog one.

There is a lower limit for the sampling rate before errors occur; sampling theory states that the sampling frequency must be at least double the signal frequency to prevent 'aliasing' - a phenomenon whereby spurious signals appear. So, for example, a signal with a maximum



Sensor technology—embedded in IoT devices—will continue to become cheaper, more advanced and more widely available

By the Numbers

8.4 million

Global sensor patents

Source: IDTechEx

\$24.8 billion

Wireless sensor market value 2032

Source: Future Market Insights

14%

Wireless sensor network CAGR 2016 to 2022

Source: Market Research Future

73.1 zettabytes

Of data generated annually by IoT devices by 2025

Source: IDC

frequency of 20 kHz would need to be sampled 40,000 times a second (40 kHz) or more.

Sensors can either directly incorporate ADCs, such that they measure an analog signal and output a digital one, or they can output an analog signal proportional to the analog input for later conversion to a digital representation by a downstream ADC in the computing device.

KEEPING A CHECK ON AIR QUALITY

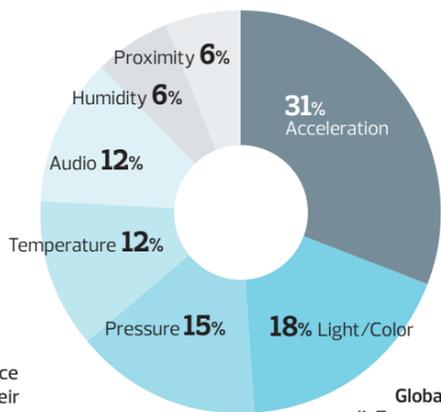
Nature's primary sensors—the eye, ear and nose—are highly-refined examples of biological engineering. The human eye, for example, has been under development for 550 million years. It comprises two million parts yet weighs-in at just 30 grams and uses one million nerve fibers to send messages to the brain. Even then it's not as good as an eagle's. (See sidebar pg 19 *Lessons from Mother Nature*.) While not yet on a par with nature, engineers' ingenuity has allowed us to create some impressive sensors of our own.

For example, we have developed sensors that can accurately measure air quality by, for example, checking the level of volatile organic components (VOCs) in the air. A popular type uses a semiconductor sensor which is periodically heated to several hundred degrees Celsius. Once at the desired temperature, the sensor absorbs the target VOC which causes its resistivity or conductivity to change. This change is proportional to the amount of

State of Play

Keeping the machines humming

The **Industrial IoT (IIoT)** has embraced sensors like no other sector. Strategically placed wireless devices allow factory managers to keep tabs on everything from worker location, factory ambient conditions, energy use and even if the canteen vending machine is stocked. But it's their use in preventative maintenance that has seen sensors really earn their keep. According to a U.S. Department of Energy report published in 2020, a robust predictive maintenance program can lead to a 70 percent reduction in breakdowns, 45 percent reduction in downtime and 30 percent reduction in maintenance-related costs. Top of the sensor list for predictive maintenance are the accelerometers that feel for the unusual vibrations that could indicate machinery is due for an overhaul, but all the mainstream sensors play an important role in ensuing production runs smoothly.



Tech Check

The Nordic Thingy:53 IoT prototyping platform incorporates a wide range of key sensors for the IoT. Thingy:53 also features support for embedded machine learning (ML). That makes it ideal for building advanced prototypes with ML capabilities on short development schedules



VOC absorbed. Absorption is affected by temperature and humidity, so the air quality sensors are often teamed with appropriate sensors such that readings can be made more accurate by compensating for atmospheric conditions.

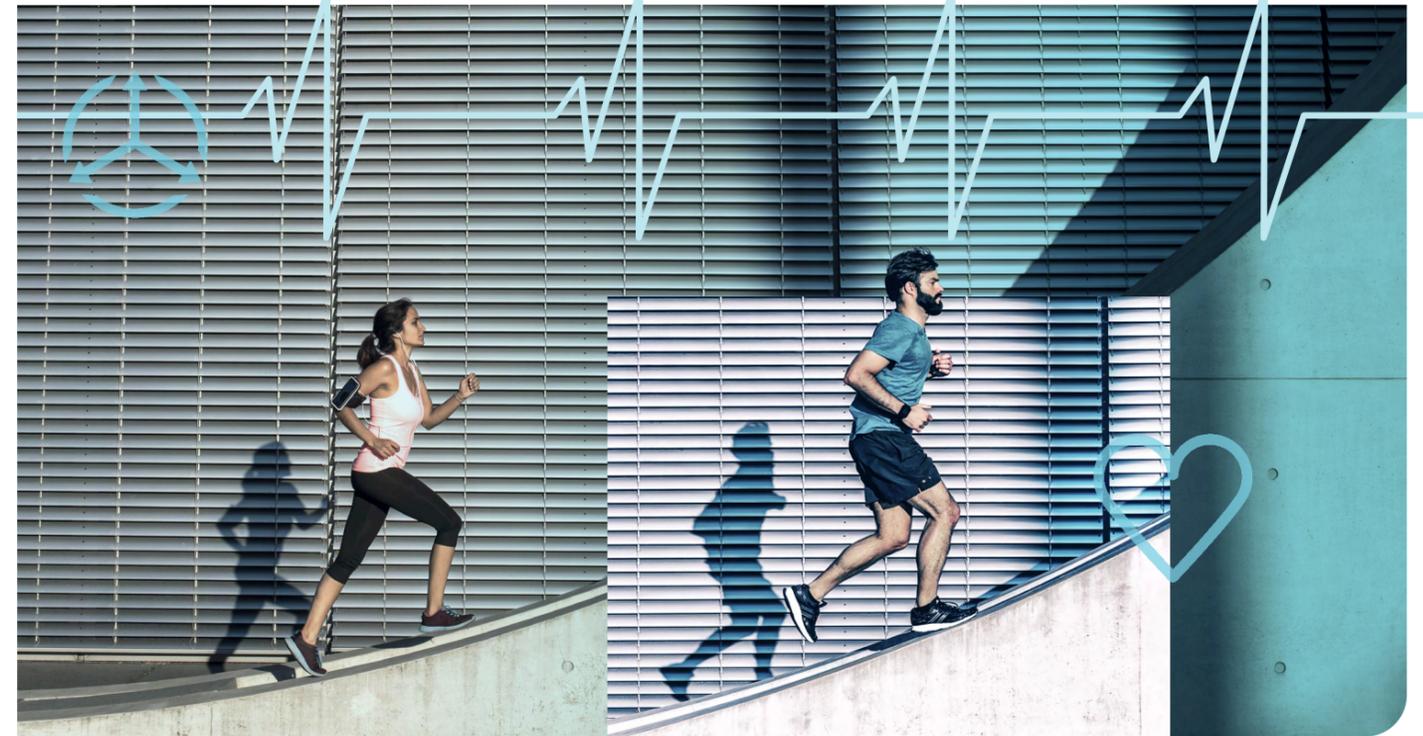
An example of a popular air quality sensor for compact IoT applications is Bosch Sensortec's BME680. The BME680 combines air quality, humidity, pressure and temperature into a package with a footprint of 3.0 by 2.0 by 0.93 mm. The Bosch sensor is incorporated into Nordic Semiconductor's [Nordic Thingy:91](#) rapid cellular IoT prototyping platform. A similar sensor is in the [Thingy:53](#).

"With air quality monitoring markets expanding rapidly, users are looking for wireless trackers of temperature, pressure, humidity, and volatile organic compounds [VOCs] to assist them in taking action to provide real time asset tracking in the field," says Dr. Peter Weigand, Vice President of Marketing at Bosch Sensortec.

In part because it features a built in air quality sensor, together with color and light sensors, and accelerometers, a prime application for the Thingy:91 is asset tracking. It ships with the latest version of Nordic's asset-tracking application. "Not only is it easy for non-experts to get an asset tracking proof-of-concept (PoC) up and running very quickly, but it also makes turning that PoC into a commercial product straightforward, right down to using the same code and development environment," says Petter Myhre, Product Marketing Director with Nordic.

TAKING THE MEASURE

While there are dozens of sensors available, many IoT applications rely on relatively few mainstream types. (See State of Play (left): *Keeping the machines humming*.) For instance, the temperature, humidity, air-quality and



–pressure type are commonly employed to enable IoT devices to determine ambient conditions.

Seguro 120 from sensified.io, for example, is a Nordic-powered IoT device that uses its built-in temperature sensor to record temperature fluctuations in critical cold chain shipping applications. And Druid Technology's DEBUT ULTRA 5G, an IoT device used in the field of wildlife scientific research, uses temperature and air pressure sensors to determine the microclimate around an animal in flight.

Light sensors are another common type used to, for example, determine if your living room lights need to be switched on because it's getting dark, or alternatively to detect movement through a change in light intensity caused by a shadow. Color sensors are more sophisticated than white light detectors because they also detect the frequency of incident illumination. Such capability is useful in an IoT device such as a wearable which, for example, shines green light into the skin and measures the light's absorption to detect blood flow. The [E2 smartwatch](#) from August International, for example, uses a color sensor to check the oxygen level of the wearer's blood and then reports the result to the Cloud using Nordic's cellular IoT technology.

Tech Check

[iProtoxi's](#) Aistin Motion device measures acceleration and vibration, enabling accurate monitoring, for example, of device vibrations in electricity networks, operation time and predictive maintenance for cranes, and the condition of electric motors. Sensor data gathered is relayed to the Cloud via Nordic's nRF9160 low power SiP



The [Seguro 120](#) from sensified.io has is used for the transport of valuable perishables with a critical temperature tolerance range, such as pharmaceuticals. The device can be easily added to most cold chain packaging types, while the smartphone app assigns temperature thresholds, start delay and other monitoring parameters



[DEBUT ULTRA 5G](#) is a wearable used for wildlife research. It uses sensors to assess the environment around birds and can also monitor and record latitude and longitude, altitude, speed and acceleration. It can also be used in any application with weight limitations



“While there are dozens of sensors available, many IoT applications rely on relatively few mainstream types

that move in three dimensions for a range of applications including gaming or indoor navigation.

Sensor Maestros uses Nordic's Bluetooth LE tech for the wireless connectivity of its [Sensor Fusion Module](#), a wearable IMU. It incorporates a three-axis gyroscope, three-axis accelerometer, and three-axis magnetometer and is aimed at human motion applications such as gait analysis, sports motion, impact analysis and aiding in the diagnosis of disorders such as dizziness and vertigo.

Level sensing of fluids, particles or powders meanwhile, is becoming increasingly popular to reduce maintenance visits to tanks and silos - in addition to limiting staff exposure to hazardous substances or environments. There are several methods in use to ascertain the level to which a container is filled, but the most popular non-invasive types use ultrasonics or microwaves. The sensor emits the signal and the time until the 'echo' is received provides an indication of the distance from the material surface being measured to the known position of the sensor.

Finland-based iProtoxi uses level sensors in its Aistin Level device, an industrial IoT product which uses Nordic technology. Aistin Level can accurately measure any surface level and typical use cases include ascertaining the level in fuel or water tanks, and the fill rate of waste bins.

THE FUTURE OF SENSORS

For the inexperienced, the sheer number of IoT sensor types can be overwhelming. And even when the list has been whittled down to those needed for the application, choosing the precise model that suits the size, battery and



budget of the end-device is not a simple exercise.

Prototyping kits like the Thingy:91 and Nordic's latest 'Thingy', the Thingy:53, help to short-circuit the challenges of sensor selection by providing platforms that include carefully chosen and matched measurement devices for typical IoT applications. Thingy:53 boasts a suite of sensors, including a built-in IMU, a low power accelerometer, temperature, humidity, air-quality and -pressure sensors, a digital MEMS microphone, and color and light sensors.

For the Thingy:53, Nordic has collaborated with Edge Impulse, a U.S.-based machine learning (ML) specialist, to



include ML firmware with the prototyping platform. The firmware enables developers to rapidly collect sensor data and test embedded ML models on the Thingy:53. (See Case Study pg 18, *Nordic, hackster.io and Thingy:53 inspire sustainable innovation.*)

Thingy:53 points to a future where sensors provide a continuous stream of data to feed ML algorithms. ML enables IoT systems to learn from collected data, identify patterns and make informed decisions with minimal intervention from humans.

There are examples of the power of sensor-fed ML in action. According to tech publication *ZDNET* a pioneer is Siemens. The company has embedded sensors in rolling stock and rails and then used the data to train ML models to spot when tracks or trains may be wearing out and target maintenance ahead of failure. On the back of this technology, Siemens sells a service which guarantees that nearly all trains will arrive on time.

Meanwhile, Thyssenkrupp, an engineering firm which runs over a million elevators worldwide has been feeding data from wireless sensors throughout its elevators into ML models for several years. These models provide real time updates on the status of elevators and predict which are likely to fail, allowing the company to plan preventative maintenance.

Building such advanced applications with today's and tomorrow's sensors will be vital if we are to maximize the potential that IoT pioneer Kevin Ashton foresees the IoT providing. "What the [network] is really about is information technology that can gather its own information," he told *Diginomica*. "Often what it does with that information is not tell a human being something, it [just] does something." That final action helps to automate and optimize everything to make the world a better place.

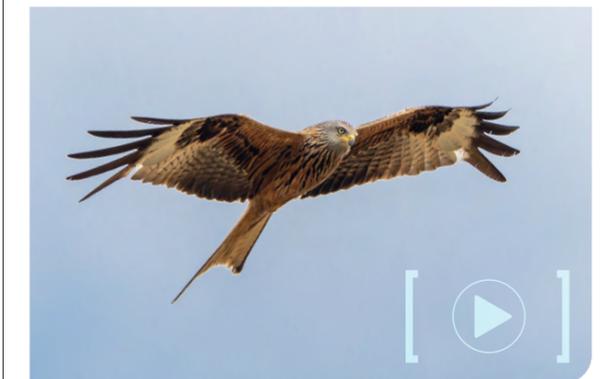
Lessons from Mother Nature

If engineers need inspiration on how to build the best sensors, they would do well to look to Mother Nature for inspiration. She has been researching and developing organic tech for a few billion years - and it shows.

Few animals have better eyes than an eagle and according to *Livescience*, if we were similarly equipped, we'd spot an ant crawling across the ground from atop a ten-story building. Not only that but looking directly at things would show them magnified and colors would be super vivid and in a much wider array of shades than we can see. Two tricks help the eagle's vision; the first is a retina densely coated with cones to resolve fine detail and the second is a deep fovea, a pit at the back of the eye that acts like a telephoto lens.

Bats are noted for their hearing. And it is indeed impressive; even young humans struggle to hear sound at 20 kilohertz and yet at this frequency the flying mammals are only just getting warmed up. For them, the highest audible frequency is nearer 200 kilohertz. Such high frequencies help them with the echolocation they use to navigate in dark caves. But the finest-tuned hearing in the animal world belongs to the Greater Wax Moth. Its relatively simple ear structure can handle frequencies as high as 300 kilohertz. The moth uses its impressive hearing to listen for the calls of its greatest predator ... the bat.

When it comes to smell, man's best friend is high on the list. The ability to detect smells relies on the number of olfactory receptor genes. Humans have around 400 while dogs boast over a thousand. But our furry friends are out sniffed by rats who have 1300 receptor genes. According to *New Scientist* magazine, the rodents are clever enough to smell in stereo; within just 50 milliseconds of an odor entering either nostril the rat can tell if the whiff came from the left or the right. This proves handy in avoiding predators and being first to food. Yet the king of noses—perhaps not surprisingly—belongs to the African Elephant. According to the *New York Times*, the mammal's long trunk houses 2000 receptor genes. That's enough to sniff out food from several kilometers away.



Thingy:53 points to a future where sensors provide a continuous stream of data to feed machine learning

Case Study: Nordic, hackster.io and Thingy:53 inspire sustainable innovation

The [Smarter Sustainable World Challenge](#) with Nordic Semiconductor—launched in conjunction with hardware education community, [hackster.io](#) (an Avnet company)—called upon young people to design solutions to aid global sustainability.

The Nordic Thingy:53 prototyping platform was offered as the foundation for participants in the challenge to come up with innovations to help reduce humanity's ecological footprint.

The Nordic Thingy:53's integrated range of sensors make it the perfect platform for building Proofs-of-Concept (PoCs) and developing new

prototypes in a very short timeframe without building custom hardware.

Over the course of the four-month contest period, 468 participants from 63 representative countries joined the contest, with 50 final qualified submissions. The overall winner was Elijah Maluleke from South Africa, who used the Thingy:53 as the basis of a smart faucet leak controller.

When the Thingy:53's sensors detect an abnormal flow of water through the faucet, Maluleke's invention automatically closes a valve to prevent waste of precious resources. In addition to shutting the faucet down in cases of unusual flow, the IoT prototyping platform monitors daily water usage and sends aggregated water usage information to the faucet supervisor's smartphone using the Thingy:53's built-in nRF5340 SoC's Bluetooth LE connectivity. Maluleke showcased the invention at a local farm.



The jury, which comprised Nordic and Edge Impulse staff members, were impressed with Maluleke's hardware and software, particularly with the limited resources available in a rural context. The simple prototype has great commercialization and impact potential, the judges said, as it is applicable to all faucets globally. Moreover, it was noted that the affordable solution could be implemented in under-developed regions.

"We congratulate the winner and participants of the challenge for their dedication to sustainability innovation and their impressive ability to take advantage of the Thingy:53 prototyping platform," says Nordic's Bjorn Spockelli, a Senior Project Manager and a member of the challenge expert jury.

In the Line of Fire

The IoT promises quicker detection of wildfires and can support more effective response and recovery efforts

In Short

Researchers and scientists are looking for a better way to limit the damage wildfires cause

As well as immense destruction, wildfires are compounding climate change through the release of carbon

IoT sensors can provide authorities with accurate early warning signs of a fire by detecting gases

Sensors are also contributing to new research findings and insights about the overall behavior of wildfires, to support improved future response strategies

Of such intensity were the blazes of Australia's devastating "Black Summer" wildfires of 2019–20, that locals evoked paranormal and mythological language to describe them. Beneath a "mountainous curtain of smoke" emanated an "intense, pulsing orange and yellow furnace-like glow" that ran the entire length of a cliff, recalled one property owner. A reporter recounted how fierce winds "like dragon's breath" propelled the fire forward at terrifying pace, scorching in a few hours huge swathes of terrain that should have taken days to cover. It was like an "atomic bomb" had gone off, with plants and animals "vaporized," recalled another local.

Once a conflagration like this got going, there was almost nothing that could hold it back. It's common wisdom in emergency management circles that quelling a wildfire within the first hour offers the best chance of containment. But it would take a day before this fire was even detected, having been ignited by lightning in a remote forest.

That was much too late. The blaze would grow into one of the fiercest of the summer, burning for 74 days, destroying 1.2 million acres, more than 300 homes and causing untold environmental, health and psychological scarring.

Now, as wildfires intensify all around the world—propelled by the forces of climate change—authorities, researchers and scientists are looking for a better way to limit the damage. Many are turning to technology, specifically IoT solutions that draw together sensors, wireless connectivity and AI. These deployments are promising not only quicker detection of fires, but improvements right across the wildfire management lifecycle from prevention through to response and recovery.

Such an intervention is long overdue. Though more intense today, wildfires have plagued the globe for as long as humans can remember, and likely well before that. Using charred fossils, scientists date the earliest evidence of wildfires to approximately 420 million years ago, at a location near Wales in the U.K.

That first fire too was likely caused by lightning. Today, natural effects remain a common cause of wildfires, though human activity has raced up the ladder.

Almost 85 percent of U.S. wildfires are now caused by

“Experts predict extreme wildfires will become more intense and frequent, with wildfire events increasing by 50 percent by the end of the century

humans, says the U.S. National Parks Service, citing factors including unattended campfires, camping equipment malfunctions, discarded cigarettes and, worst of all, arson.

AN UNVIRTUOUS CYCLE

Wildfires and the climate share something of an unhealthy relationship, each bringing out the worst in the other. Climate change, through its effects of longer drought periods and higher temperatures, is dramatically increasing the risk of wildfires. In drier conditions, trees and vegetation become more flammable, increasing the likelihood of ignition and the rate at which fires spread. "U.S. a giant tinderbox as megadrought and wildfires combine," proclaimed an ominous but typical headline in U.S. magazine *Newsweek* earlier this year.

Yet, just as the climate increases the prevalence of wildfires, each wildfire makes climate change worse. In 2021, wildfires released 1.76 billion tonnes of carbon, according to the EU's Copernicus Atmosphere Monitoring Service—a record amount that was more than double Germany's total annual CO₂ emissions. Forests, instead of acting as a carbon sink, can become a net carbon source.

The destructive impact of wildfires is perhaps most

starkly seen in the devastating effects on flora, fauna and the human population. The previously mentioned Black Summer bushfires—as wildfires are known in Australia—saw 186,200 square kilometers burned, 3,500 homes lost and more than one billion animals perishing.

Worryingly, there's little good news on the horizon. Experts predict extreme wildfires will become more intense and frequent, with wildfire events increasing by 50 percent by the end of the century. Even the Arctic now faces rising wildfire risk, says a recent UN report.

This deteriorating situation impedes progress towards several [UN Sustainable Development Goals](#) (SDGs), an urgent call for action focused on 17 priority areas. Wildfires obviously impact goals relating to sustainable forest management and protection of ecosystems, but they also have secondary impacts on health, inequality and water quality. Wildfires "disproportionately affect the world's poorest nations," says the UN.

AWAY WITH OLD WAYS

Fire has light-heartedly been described man's greatest "invention". But now the management and mitigation of wildfires is in desperate need of human inventiveness to

address the escalating scale and impact of the blazes.

"Current government responses to wildfires are often putting money in the wrong place," says Inger Andersen, Executive Director of the UN's Environment Programme. "Those emergency service workers and firefighters on the frontlines who are risking their lives to fight forest wildfires need to be supported."

Among her prescriptions, Andersen argues for more focus on reducing the risk of extreme wildfires, including through better understanding of how they behave.

Thousands of years ago it seems we were better at managing wildfires and today, Australia's indigenous peoples are lending their generations of knowledge to modern firefighters. (See sidebar pg 22: *Elders teach how to control wildfires*.) Conventional strategies to reduce the impact of wildfires haven't always worked so well. The earliest approaches relied on watchtowers, but these were not efficient as they relied on human observations, says *Nature* magazine. More recent detection solutions use cameras mounted on poles, satellite imagery and aircraft to detect plumes of smoke. Though an improvement on having a human in a tower, these options too are limited by being optically based. The task of spotting smoke from a new fire can be hindered by the height of tree canopies,



By the Numbers

6,872 wildfire incidents in California in 2019

Source: Center for Disaster Philanthropy

1.76 billion tonnes of carbon released in 2021 wildfires

Source: EU Copernicus Atmosphere Monitoring Service

50% increase in wildfire events by the end of the century

Source: UN

\$67 billion tangible economic cost of 2019–20 Australian wildfires

Source: University of Queensland

cloud cover and, ironically, smoke haze, resulting in potential detection delays of several hours. Detecting fires in the so-called smoldering phase, or within the first hour, is critical to having a chance to prevent their uncontrollable spread and the resulting damage.



Tech Check

Nordic's nRF9160 is a compact, highly integrated SiP with a modem that supports both LTE-M and NB-IoT cellular IoT, plus GNSS. The device's low power consumption enables IoT sensors with long battery life



SENSING A NEW PATH

In the wake of Australia's devastating Black Summer, an official inquiry reached a powerful conclusion about the country's response efforts. Yes, the fires "were unlike anything seen ... before", but technology had been under-utilized, it said. The inquiry urged authorities "to push our technological and our research capabilities much harder". It specifically highlighted "remote sensing technology," which it said could make a marked difference to so-called "big fire-risk seasons" through "enhanced capability for early detection of new ignitions, real-time tracking of the fire edge progression and intensity as it spreads, and better understanding of vegetation and fuel load issues before the fires start". Since then, the UN too has advocated for remote sensing and real-time alarm systems to be deployed to monitor, detect and control fires.

Happily, IoT solutions are now finding their place in wildfire management to support this need. For instance, IoT sensors placed on trees in forests susceptible to wildfires can provide authorities with accurate early warning signs of a fire, by detecting the gases emitted during the smoldering

phase. Systems that can also integrate these sensors with long-range connectivity and dedicated GNSS—such as Nordic's nRF9160 SiP—can aid fire crews even further by pinpointing the precise location of the fire.

As well as detecting gases like carbon dioxide and oxygen, sensors could also be deployed to detect environmental indicators such as humidity and temperature. This is where [IoT edge devices with embedded machine learning \(ML\)](#) capabilities bring significant value, says Thomas Söderholm, Director of Business Development at Nordic Semiconductor. "By not only collecting the data from sensors about air quality and other variables such as

humidity, temperature and wind conditions, but also analyzing that data using ML capabilities, tomorrow's IoT edge-computing devices will be able send back to emergency management teams valuable insights and predictions. They will make available information about things like the chances of fire breaking out and how quickly, and where, an outbreak is likely to spread," he says. As a signatory to the UN's SDGs, Nordic is particularly excited about the beneficial impact its solutions could have on the challenges posed by wildfires, Söderholm added.

Other similar solutions are also being seen. Following catastrophic wildfires in 2021, Vodafone deployed a network of sensors into what it dubbed a "smart forest" in Sardinia, Italy. The sensors were networked to communicate both with each other, and back to a gateway at the edge of the forest, where data about the fires could be sent to a Cloud-based center.

Another promising Australian IoT deployment resulting from the recent bushfires proposes to deploy "sensor node pairs", in which temperature, humidity, plant stem water content and wind data is collected from tree-mounted sensors and combined with soil moisture data collected from ground sensors to assess fire risk. The sensor nodes use Bluetooth LE to communicate to each other, first responders' smartphones and Cloud gateways.

The value of these solutions extends beyond detection. A critical challenge for authorities during wildfires is the need to rapidly identify residents in danger and evacuate them – a task complicated by the spread of the fire itself, which can render properties inaccessible. Using IoT deployments, fire services can better pinpoint the location and trajectory of burning blazes and broadcast emergency alerts via text message to individuals within a certain radius. Safety for firefighters can also be enhanced. In Australia, technologists are exploring the use of wearable sensors for firefighters, which could improve safety outcomes by improving firefighters' real-time awareness of factors such as air quality and their colleagues' whereabouts.



IoT sensors placed on trees in forests susceptible to wildfires can provide authorities with accurate early warning signs of a fire

A common experience for industries that deploy IoT is realizing the opportunity to access valuable insights that go beyond the discrete problem the IoT was first introduced to solve, because of the wealth of data these solutions generate. Along these lines, temperature sensors deployed in forests are not only helping with prevention but are now fueling new research findings and insights about the overall behavior of wildfires that can be observed when these forests undergo controlled "hazard reduction" burns. These insights illuminate how natural fires move and shift and how they are impacted by factors such as wind and ground vegetation – invaluable inputs for formulating strategies for preventing and responding to wildfires. And data produced by sensors after a fire passes also helps conservation agencies monitor forest recovery, animal migration and disease spread, supporting more focused restoration efforts.

HOT CHALLENGES

Nascent deployments of IoT into forests have illuminated several of the key challenges and considerations. Due to the vastness and natural remoteness of many forests, sensors need to be placed in hard-to-reach areas for extended periods. This makes solutions that support extended battery life critical. Given the task they are performing, sensors must also be heat and weather resistant, and need to be positioned in ways that minimize the chance of being dislodged by curious wildlife.

Physically deploying sensors is also made tricky by the sprawl and density of most forests. Scientists have been exploring how to aerially drop low-cost sensors over vast forest areas, after which they can be remotely configured into a network. Using the same methods, once deployed, a network could be reconfigured should any sensors fail.

Connectivity is another key challenge. Where cellular connectivity is available, it's an effective and robust solution. Technologies such as [NB-IoT](#) are ideal, as they are



Elders teach how to control wildfires

As the world looks to modern technologies like the IoT to help quell an increase in extreme wildfires across the globe, at least some authorities also hope answers lie in the ways of a culture more than 50,000 years old.

Interest in the cultural fire management practices of Australia's indigenous population has surged in recent years, after the country's devastating bushfires in 2019–20. Aboriginal people for thousands of years have successfully carried out traditional fire management activities to reduce the risks of wildfires. Many of these practices were halted after colonization, resulting in more large and uncontrolled wildfires with destructive impacts for ecosystems, infrastructure and pastoral animals.

Now, Aboriginal communities say they are experiencing an upswing in interest in their fire management ways. The interest is coming from landowners, fire protection services, government

officials and schools, to name just a few. To assist these groups, indigenous cultural burning experts and elders from Aboriginal communities run so-called fire workshops in which they share their longstanding wisdom and practical knowledge of cultural burning practices.

Broadly speaking, indigenous fire management involves lighting so-called cool fires in certain areas early in the dry season. The fires burn slowly, reducing fuel loads and creating natural fire breaks. The result of the burns is a so-called fine grained mosaic of burnt and unburnt country. This result has the effect of hindering the spread of fires and reducing the risk of large and intense wildfires.

The pattern was also believed to benefit biodiversity by supporting varied stages of vegetation growth and habitats that in turn supported different species – for instance, grasslands for kangaroos to flourish amid harvests



of yam and grains, adjacent to forested areas that abound with fruits and possums.

Some indigenous cultural burning experts hope cultural fire management will again be the default practice across Australia. Others have larger dreams. They hope that the revived interest in indigenous fire management practices might be a spark for a broader reinvigoration of the place of indigenous knowledge and indigenous people in community leadership and decision-making in Australia.



optimized for solutions involving robust, compact battery-powered sensors that must run for long periods and need to send small data volumes across many kilometers – the precise scenario for most wildfire deployments.

When cellular IoT isn't an option due to lack of infrastructure in remote regions, other IoT connectivity alternatives such as [DECT NR+](#) private mesh networks, LoRaWan or satellite IoT are options.

A WORTHY INVESTMENT

After Australia's Black Summer fires, its official inquiry pointedly concluded that "investment in disaster prevention is more cost-effective than the huge cost of emergency response and rebuilding". Put simply, prevention is better than cure – a slogan that resonates loudly for wildfire management as it does any realm of risk management.

On this basis alone, the business case for introducing IoT solutions into the forest stacks up. Even more so, after analysis by Switzerland-based Distrelec Group revealed the cost of fully deploying sensors to cover the forest density of Spain and garner their preventative benefits was just 0.0083 percent of the amount of money spent tackling forest fires. The group drew similar conclusions for a range of European nations.

With compelling figures like these and beneficial use cases like those outlined earlier, the IoT is now also being considered for an even wider set of emergency scenarios. As it promises for wildfires, solutions involving sensors, wireless connectivity data analytics and AI might improve preparedness and response outcomes for a range of natural disasters including hurricanes, earthquakes, floods, tsunamis and monsoons.

Sadly, like wildfires, many of these events are set to increase in prevalence in the years ahead due to humans' impact on the climate. But with careful deployment of IoT technology and analysis of the data it will provide, perhaps at least we can have greater warning of occurrence. Seeing the dragon cross the horizon is still scary but much better than feeling the heat of its breath.



Prevention is better than cure – a slogan that resonates loudly for wildfire management as it does any realm of risk management

Tech Check: Battling blazes

Fires are a natural part of nature's cycle, cleaning up dead vegetation and opening up the forest for renewal. But humanity's impact on the environment is making blazes more frequent and intense. Wireless tech is helping fire fighters tackle these fiercer flames

Illustration: Greg Bakes
<http://www.illustratorsofaustralia.com/portfolios/greg-bakes/>

Observation platforms play a vital role in detecting fire outbreaks and are also useful as an elevated platform for wind, smoke and temperature sensors above the canopy. Conditions on the forest floor can be significantly different to those higher up, so mounting sensors up here helps authorities form a more comprehensive picture of the conditions that drive the likelihood of fire and its intensity. And, unlike human observers, the sensors are ever-vigilant

Not all creatures turn from fire—fire beetles need burnt wood for their larvae to thrive so seek out the flames—but for most animals survival instincts kick in and they run. This helps humans because animals detect problems before we can. Snakes, for example, can sense smoke from long distances and also host an infrared sensor which picks up changes in temperature. By tracking animal movements with cameras and sensors, humans can gain extra data about the speed and direction of a firefront

Wildfires can burn for months. And fire tenders can only carry relatively small volumes of water. That makes lakes and rivers critical sources for when trucks run dry. Firefighters will even resort to seawater if that's all they can find. But dry conditions can cause standing water to evaporate and rivers to turn into a trickle. IoT water level and flow sensors can be placed at known water sources so firefighters know what the reserves are before venturing to a remote location

The fire truck is the central resource for fighting remote blazes. And they are increasingly forming a tech hub to protect firemen. For example, Australian trucks have now been fitted with mobile data terminals that allow crews to share weather forecasts, fire behavior and safety warnings. The terminals will also help to keep track of fellow crews and their trucks

Fires are far more likely when temperatures are high, humidity low and the wind is blowing. And factors such as soil moisture and leaf litter can have a significant impact on the intensity of outbreaks. IoT sensors tracking these parameters and equipped with machine learning capabilities can give authorities advanced warning of the probability of ignition. This information allows firefighters to conduct targeted and controlled hazard reduction burns well ahead of dangerous outbreaks

Helicopters can cover long distances quickly to form an overview of a large firefront. But they are expensive and relatively few in number. The machines are increasingly being supplemented by inexpensive drones. Elevated locally to wirelessly send live data from onboard cameras and sensors, commanders can use the information to more precisely direct firefighting operations

Firefighting is inherently dangerous. [▶] The U.S. Bureau of Statistics reveals that 206 U.S. firemen died between 2013 and 2018. Part of the problem is that crews lose track of personnel who then get hurt by flames or falling branches. But now, helmet-mounted wireless tech allows the position of each crew member to be constantly tracked by commanders. The tech also issues alerts to others if the helmet wearer is struck or falls

Toy Stories

Wireless technology is helping smart toy manufacturers create innovative products to engage and educate children

In Short

In addition to joy and entertainment, play provides important developmental benefits for children

Toys and games that inspire mindful play and nurture imagination are fundamental to the development of a child

Smart toys employ wireless connectivity to provide interactive and immersive experiences

Nordic technology is powering many connected solutions in the global toy market

When 20th-century political and spiritual leader Mahatma Gandhi made the first attempt to develop an indigenous scheme of education in British India, he noted: "Literacy is not the end of education nor even the beginning ... I would begin the child's education by teaching it a useful handicraft and enabling it to produce from the moment it begins its training." While Gandhi may not have been referring specifically to the educational benefits of playing with toys, he advocated the power of a holistic education to help a child develop their capacities and become a more complete human being, as well as a productive future citizen.

And there is scientific research to back Gandhi's beliefs. One study looking at brain scans of participants over the course of two decades, conducted by the Center for Neuroscience and Society at the University of Pennsylvania, demonstrated that cognitive stimulation from parents in early childhood—using tools such as educational toys and children's books—has a positive effect on brain development later in life.

A child's play means much more than fun and games alone; it is also universally recognized as a critical element of learning and development from an early age through to young adulthood. Play helps children reach important developmental milestones related to their physical, social,

cognitive and emotional health, along the way providing them with the skills they need to interact positively with others, manage their own emotions and understand the world in which they live.

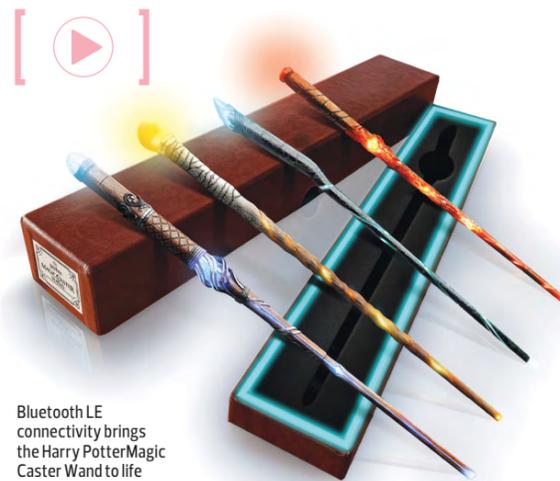
In fact, being able to engage in play and recreational activity appropriate to the age of the child is so essential to human development that the UN High Commission for Human Rights recognizes it as the right of every child.

DEVELOPING MINDS

There is no more fundamental or invaluable ingredient to play than toys and games, according to researchers from the Center for Early Childhood Education at Eastern Connecticut State University. From 2010–2019, the researchers conducted the TIMPANI (Toys that Inspire Mindful Play And Nurture Imagination) Toy Study, an empirical study of toys for preschool children. "Nearly all meaningful play includes toys – a single, engaging toy can transform a child's play from simple to symbolic, from repetitive to inventive, from solitary to social," the study found.

Even the most basic toys come with lessons to learn. By holding and manipulating a toy to make it do something, a child is practicing important motor skills and strengthening their hand-eye coordination. When a child builds a tower with blocks, then eventually knocks it over, they are learning valuable concepts of physics like gravity, momentum and inertia. In time they will start considering solutions to prevent the tower falling in the first place.

Educational toys and games are not new, of course. In different forms they have been sparking curiosity and building knowledge for thousands of years. The earliest form of the game which developed into chess originated in 6th-century India during the Gupta dynasty. Another board game of enduring popularity, snakes and ladders, also originated in ancient India before being introduced to Great Britain towards the end of the 19th century. This game of 'vice' (the snakes) and 'virtues' (the ladders) was used to teach values to children. In more recent times, Scalextric, a brand of slot car racing sets which first appeared in the late 1950s, has enthralled children while simultaneously encouraging an interest in design and engineering.



Bluetooth LE connectivity brings the Harry Potter Magic Caster Wand to life



Toys reflect the times and cultures in which they are created. Contemporary toy manufacturers are meeting their responsibility to keep pace with the rapidly changing world by creating wirelessly connected products that not only challenge young people's creativity and imagination, but also develop their senses, spatial awareness, self-esteem, observation, memory, concentration, critical thinking and problem solving skills. Moreover, tech built-in to modern toys is helping teach kids invaluable motor skills – particularly fine motor skills, the coordination of small muscles in the movement of the eyes, hand, fingers and thumbs for completing everyday tasks like handwriting.

CONNECTED GAMEPLAY

A recent example of the advance in toy technology is a wireless smart wand from Warner Bros. Home Entertainment that enables an interactive experience for child wizard Harry Potter fans. Created in partnership with design firm New Peak Interactive, the [Harry Potter: Magic Caster Wand](#) uses Nordic-enabled Bluetooth LE wireless connectivity to relay touch/motion sensor 'spell' data to an associated smartphone app. From there, the user can review their unique user profile—for example levels and experience attained—as well as a spell book

“ Nearly all meaningful play includes toys – a single, engaging toy can transform a child's play from simple to symbolic, from repetitive to inventive, from solitary to social

with over 50 spells and multiplayer duels. The collectible platform comprises the Nordic [nRF52832](#) SoC-powered Smart Wand device and the [nRF52810](#) SoC-powered Wand Box hub. According to the makers, the product is the only smart wand on the market able to recognize multiple spell gestures and connect to smart home devices for rich lighting animations and unrivaled depth of play.

By integrating touch sensors and a motion sensor, the smart wand can determine which spell the user wants to cast. Through the app the user can then create a multimedia, multisensory spell casting experience by controlling Bluetooth enabled stereo/speakers, compatible smart home lighting, and even compatible smart TVs.

Elsewhere, a Nordic-powered connected board game console integrates wireless connectivity to transform the traditional board game into an immersive, multimedia gaming experience. Launched by Italian company Xplored, the [Teburu](#) system comprises a connected board, connected dice and game pieces, and an AV feedback device—the LED Ring—that relays gameplay information to the players in near real time. It also includes software that can run on a smartphone, tablet or PC to digitally enhance gameplay. Teburu employs Nordic's [nRF52833](#) and [nRF52805](#) SoCs to track dice rolls, character movements and player decisions.

"The Teburu platform is designed to offer a digitally enhanced gaming experience, but with a still very analog basis," explains Enrico Garofalo, Hardware Director of Xplored. "The gaming board, dice and minis [game pieces] are very similar to those used in standard tabletop games, but the 'hidden' electronics track user actions and make the app aware of users' moves, to help them learn the rules, keep some key information hidden, and to manage enemies."

Each game includes a unique smartphone app that can be used as a 'master' to manage the gameplay and rules, and/or as a 'controller' to allow each player to control their character's actions. The app will also respond to dice rolls and figurine movements on the board, and automatically show the player their available gameplay options.

In a similar game sector, Israel-based Particula's [GoDice](#) solution—a set of smart dice—also employs an nRF52 Series SoC, enabling interactive digital gameplay for a virtual library of classic and popular family games. GoDice uses the Nordic SoC to connect the six smart dice to a tablet for hybrid physical/digital gameplay using Bluetooth LE connectivity. Integrated games include Yatzy, Ludo and Backgammon, as well as a growing number of newer games focused on STEAM (Science, Technology, Engineering, the Arts and Mathematics) education.

The results of a player's dice roll are relayed to the tablet where the outcomes inform the next move of any game being played through a companion app.

LED lights on each dice face will also illuminate to facilitate gameplay and in response to feedback from the app. Each game available through the app features a different interactive game board that appears on the tablet screen when selected.

In addition to providing the wireless connectivity, the nRF52 Series SoC's Arm Cortex-M4 processor analyzes



The Teburu connected board game transforms the traditional board game into an immersive, multimedia experience

By the Numbers

90% of preschool children's play in the U.S. involves a toy of some sort

Source: The National Association for the Education of Young Children (NAEYC)

31% of toys bought by U.S. parents are electronic toys

Source: Premium Joy

\$104 billion

Total revenue of the world toy market recorded in 2021

Source: Statista



GoDice offer users hybrid physical and digital gameplay

the sensor-based movement and positioning data of the dice to not only calculate the numbers rolled, but also determine whether the dice are moved, rolled, tilting, in free fall or are being tapped.

Meanwhile in the metaverse—a virtual reality (VR) space in which users can interact with a computer generated environment as well as other users—technology is changing the game for older children and adults alike. One Nordic-powered VR solution, for example, offers an immersive gaming, fitness and virtual cinema experience in the world of extended reality. Developed by Iqiyi Smart and employing Nordic's [nRF52833](#) and [nRF52832](#) SoC for reliable, low latency Bluetooth LE connectivity between its handheld controllers and headset, the six-degrees-of-freedom [Iqiyi Dream VR](#) is able to not only track the direction of the user's head movements, but also their location in physical space.

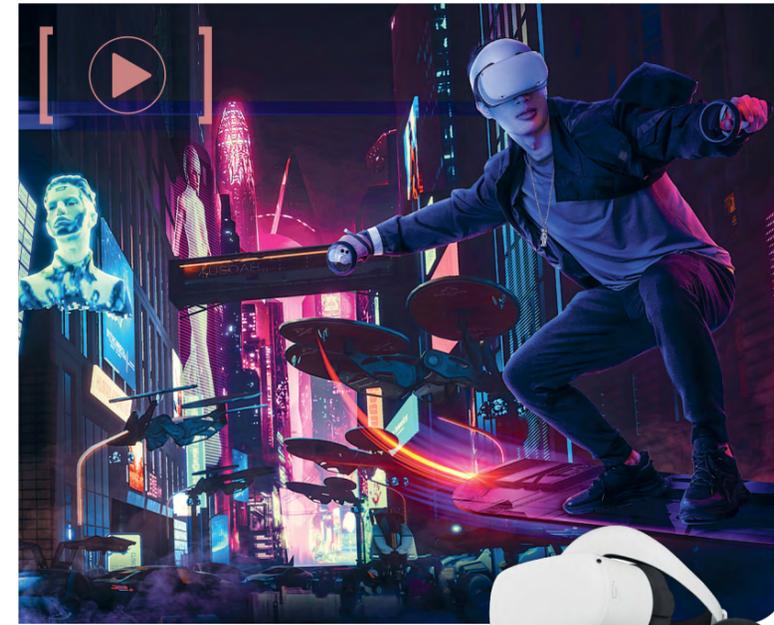
POWERED BY NORDIC

Central to the design and functionality of many smart toys is the integration of hardware and software that provide the required processing power, robust connectivity and low power consumption – all in a compact form factor to meet the size constraints of handheld products.

"The Wafer Level Chip Scale Package [WL-CSP] version of the nRF52832 SoC with M4 processor combined with our proprietary RF layout provided the necessary processing power, memory allocation and PCB footprint to create the desired system functionality within the ultra compact space required to stay true to prop replica dimensions," explains Mike Goslin, CEO at New Peak Interactive.

Both the wand and the box comprising the Harry Potter: Magic Caster Wand, for example, integrate Nordic nPM1100 dedicated power management IC (PMIC) with a highly efficient dual-mode configurable buck regulator and integrated battery charger, ensuring reliable power delivery and stable operation whilst at the same time maximizing battery life.

The Teburu connected board game console developed by Xplored features the board and embedded sensors both powered by the nRF52833 multiprotocol SoC. The sensors track the RFID-enabled game pieces as they are moved, and relay this data to the Nordic SoC in the



Iqiyi Dream VR enables its users to interact with the metaverse

board via a hardware connection. The connected dice integrate a Nordic SoC and an inertial measurement unit (IMU) to acquire orientation information that is transmitted to the game board using Nordic's 2.4 GHz proprietary low-power, low-latency Enhanced ShockBurst (ESB) protocol.

The LED Ring is also powered by an nRF52805 SoC and connected to the board using the ESB protocol. The nRF52833 in the board in turn relays this data to an app on the player's smartphone using Bluetooth LE wireless connectivity.

Both the connected dice and LED Ring are powered by small Li-ion power cells. As the small form factor 16 mm cube dice have to integrate the Nordic SoC, the IMU, a wireless charging antenna, and the battery, the inclusion of an ultra low power consumption SoC such as the Nordic chip was considered essential.

Ultra low power consumption was also paramount to the operation of Particula's GoDice, which employs supercapacitor technology for ultra fast (as little as 10 seconds), battery-free charging to power the dice for around two hours of continuous gameplay. The battery-powered charging station exists as part of the supplied dice sleeve.

Nordic's technology is allowing developers to take advantage of a lucrative and expanding sector. U.S. parents buy about 10 toys on average for their child each year, with the annual spending on toys per child around \$329 on average, according to a 2021 Premium Joy study of 1000 parents with kids aged 3–12 years.

And the global toy market has grown by over 13 percent since 2018 (data by Statista). While there will always be a place for traditional toys and games, low power wireless connectivity is opening up a whole new toy box filled with potential to better engage children and aid their learning and development. And educated children are what the world needs to solve its problems.



Tech Check

Nordic's [nRF52805](#) SoC has been engineered to minimize power consumption with features such as the 2.4 GHz radio's 4.6 mA peak RX/TX (at 0 dBm output) currents and a fully automatic power management system. That allows for extended battery life in toys and games

A world of weird and wonderful toys



In a competitive industry, the endless search for new toy ideas can lead to the creation of unusual or downright bizarre products. Not all wacky concepts hit the mark, but many weird and wonderful toys have turned into surprise best sellers – at least until the shortlived craze went flat.

Take for example Big Loo (1963). This shiny toy robot from Louis Marx and Company was almost a meter tall and featured a sight scope with crosshairs, flashing battery-powered red eyes, a hand-cranked mechanical voice box, a compass, and a Morse code clicker with chart. It also fired darts from its nipples, shot plastic balls from its arm, squirted water from its navel, and launched rockets from its spring-powered foot. Big Loo was a toy with all the bells and whistles, and included a bell and a whistle.

How does a rock in a box appeal to your inner child? The Pet Rock from 1975 was little more than a pebble in a box with breathing holes. The product did at least come with a tongue-in-cheek manual about caring for and training your pet stone. Toy stores sold millions before the fad ran its course.

Playmobil German-produced figurines and playsets exist in all sorts of unusual themes, but few make less sense than the Hazardous Materials Team set from 2002. The idea was that children could recreate a nuclear waste clean-up or post-apocalyptic pandemic. The set includes a small crew of two workers wearing head-to-toe protective hazmat suits outfitted with respirators, along with industrial vacuum cleaners and a container oozing a 'toxic' substance.

Step aside superheroes, Mega Plumber Action Hero—released in 2007 by plumbing fixtures manufacturer, American Standard—could save the world one faulty pipe at a time. It came complete with tools and a toilet to be fixed.

Made of "velveteen flesh and super soft fleece fat," My First Bacon Talking Doll of 2010 was a soft toy shaped like a rasher of bacon – presumably to introduce children to the joys of the popular breakfast meat. When loaded with batteries and squeezed, the doll emitted a single phrase from its robotic lips: "I'm bacon!"

In 2012 Japanese toy manufacturer Tomy caused a stir by creating a baby doll called Yume-chan that cried its eyes out when injected with water through a syringe.

The name says it all – Poo-Dough launched by Skyrocket Toys in 2013 encouraged children to "make your own realistic poo," providing a dark brown modeling compound to create your own replica excrement.



Image courtesy theoldrobots.com

Connected Home

aspara Smart Grower

This Bluetooth LE-powered hydroponic smart grower provides optimal light and irrigation growing conditions in the home

The increasing adoption of smart devices is expected to propel the growth of the [smart home](#) market to \$205 billion by 2026, according to analyst TBRC. It said networked devices powered by ML and AI, and accessed via smartphones or home computers would revolutionize every area of the home from lighting control, security and HVAC through to entertainment, the smart kitchen, appliances and furniture



Hydroponics as we know it—growing plants without soil using water-based mineral nutrient solutions in aqueous solvents—was popularized in the last 20 years, however the earliest example of the practice is thought to date back to the Hanging Gardens of Babylon. The gardens were believed to be built in the 6th century, and relied exclusively on the Euphrates river as their source of irrigation. Without soil available in the arid desert, they may be the first example of successful hydroponics



The [aspara Smart Grower](#) uses a range of sensors to detect and monitor variables important for ideal growing conditions, including humidity, light intensity, water and nutrient levels. It employs a removable water tank to automatically irrigate the plants, while LED Grow Lights use variable light spectra and intensity to stimulate plant development at different stages of growth

You're never too young to start a career in agriculture, just ask [Kendall Rae Johnson](#),  who at 6 years of age has become the U.S. state of Georgia's youngest certified farmer. Kendall took up farming at 4, learning the tricks of the trade from her great grandmother. Two years later the diminutive green thumb is now running a small farming business from her own back garden, selling food basket subscriptions and hosting classes for other Atlanta residents

The smart growers help control microclimates, lighting and water flow. Using Nordic-powered [Bluetooth LE](#) wireless connectivity the planter can connect to a smartphone with the aspara app, which can in turn notify users when their water tank needs to be refilled, or when their plants need additional nutrients. Users can also access planting data, specific programs for each plant species, and be given tips to optimize plant health

The heaviest tomato on record was grown in the U.S. in 2020, and weighed just shy of a whopping 5 kg. It had a circumference of 84 cm thanks to a number of outgrowths on the fruit known as 'dingleberries,' a feature common to giant tomatoes. But even that oversized orb doesn't compare to the world's largest fruit produced by the Atlantic giant pumpkin. The largest specimen on record weighed an incredible 1190 kg, give or take the weight of a small family car



Tech Check

Nordic's [nRF52832](#) SoC powers the aspara Smart Grower's sensors, enabling the planter to dynamically calculate conditions and make any necessary changes to optimize growth. The ultra low power consumption of the Nordic SoC provides extended sensor battery life as the nRF52832 has been engineered to minimize power consumption with features such as the 2.4 GHz radio's 5.4/5.3 mA peak RX/TX (at 0 dBm output) currents

Asset Tracking

Indoor asset tracking platform monitors essential medical equipment in hospitals

The Nordic nRF52840 SoC-powered MediTrack system helps staff oversee the location of assets to save time and take advantage of available resources

The worldwide healthcare industry continues to face challenges on multiple fronts. Hospitals in the U.S., for example, each spend on average an extra \$2 million to replace lost or stolen equipment and supplies (according to VHA Inc). On a daily basis, each nurse can spend over 20 minutes per shift searching for misplaced medical assets, according to *Becker's Hospital Review*. In addition, most equipment and supplies have only a 50 percent utilization rate, says the *CHRISMED Journal of Health and Research*. One hospital in Hong Kong reports that seven out of ten major medical devices have a utilization rate of less than 60 percent.

These problems can also lead to accidental disposal or unnecessary replacement of items, costing millions of dollars, and making it more likely for any theft or misplacement to go undetected.

Medical staff numbers are also in decline – the *Global Burden of Disease* study 2019 estimated that 6.4 million more physicians are needed worldwide to keep up with global health coverage goals. The shortages in Hong Kong, for instance, are extreme, with only two doctors and seven nurses per 1000 people.

"The stark reality that there are simply not enough medical personnel ... greatly increasing the chances of delays in on-time diagnoses and treatment administration," explains Carl Hung, CEO of Season Group and SG Wireless, the company behind MediTrack, an indoor asset tracking solution designed to ease the burden on overloaded hospitals.

"Inevitably, when attention is rightly placed on the patients themselves, there are even less resources available to manage and keep track of required medical tools and equipment, further exacerbating the issue with providing on-time patient care."

Finding equipment on time

In response to these challenges, the Hong Kong Hospital Authority released its Strategic Plan 2022–2027 outlining the need to establish an IT platform that employs IoT devices to help track essential medical equipment. The MediTrack system has subsequently been deployed to help streamline this asset location process at one Hong Kong hospital, where specific triangular-shaped wards can otherwise cause issues with connectivity coverage.

MediTrack is a healthcare-tailored version of the SG Wireless [Indoor Asset Tracking Solution Kit](#) using the SGW8130C BLE Beacon Tags and SGW6011 Universal IoT Gateway, both of which are based on the proprietary



Need to Know

MediTrack's connectivity is enabled by the nRF52840's multiprotocol 2.4 GHz radio with full Bluetooth 5.3 support. This features flexible 8 dBm output power support and -95 dBm RX sensitivity (at 1Mbps in Bluetooth LE mode) for a link budget of 103 dBm, extending range and increasing coverage

precertified SGW1110 BLE Module powered by Nordic's advanced multiprotocol nRF52840 SoC.

"Nordic's readily mature and stable Bluetooth LE stack and its comprehensive application examples, has immensely sped up development of MediTrack," says Hung. "This has enabled engineering efforts to focus on application code development to optimize MediTrack operations."

MediTrack's long range [Bluetooth LE beacon tags](#) are placed on medical equipment and supplies—such as transportation trolleys, wheelchairs, infusion pumps, blood pressure monitors and defibrillators—to send out signals which are captured by the gateways. Each tag emits a unique Bluetooth LE data message every five seconds.

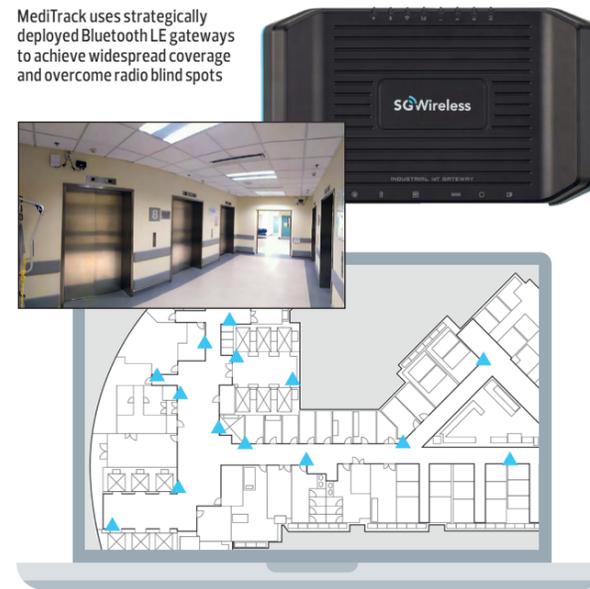
The data is then relayed from the gateway to a Cloud-based platform for real time location visibility. The beacons can even be placed on a patient's body, for instance a dementia patient, allowing staff to track their whereabouts throughout the hospital, with an alert sent whenever the patient leaves a certain zone.

"This system supports mesh networking with a 100-meter range and wall-penetrating abilities, so it can easily cover a 450 square-meter area, and can be deployed immediately to track assets with a proven accuracy within a three-meter radius," says Hung.



MediTrack enables nurses to easily look up if the required tools are available, then narrow down the search zone to their vicinity

MediTrack uses strategically deployed Bluetooth LE gateways to achieve widespread coverage and overcome radio blind spots



"Hospitals can customize their floor plan and set alerts to track when an asset leaves or enters a predefined area. MediTrack enables nurses to easily look up if the required tools are available, then narrow down the search zone to their vicinity, freeing up time that can then be redirected to treating patients."

An uninterrupted connection

The hospital in Hong Kong has specific requirements for independent networks with sensitive data, as well as assured uninterrupted stability. To allow for this, the MediTrack system runs on Nordic SoC-enabled Bluetooth LE, using a customized gateway with a separate transmission network to ensure secure, 'always-on' wireless connectivity.

"Dropped connections can occur should there be any unexpected disruptions in the transmission channel, and blind spots [happen]," says Hung. "While exasperating for any business, such disconnections are especially catastrophic in hospital settings, when ... interrupted signals can affect the quality of patient care."

To overcome this challenge, MediTrack uses Bluetooth LE gateways deployed as appropriate in main entrances, corridors, rooms and staircases at the hospital to achieve coverage extension and eliminate blind spots.

Diana Cezar
CEO, ISITECH



Wireless technology drives transition to smart farming

Tracking solutions take the fight to cattle thieves and transform an industry

The inspiration for our [ISITAG](#) livestock and wildlife tracking devices was actually born out of wanting a real time remote monitoring solution for my young child. During development it became clear such a solution had application beyond the home, and then on a visit to Natal in South Africa we were approached by farmers desperate to tackle cattle theft.

Cattle theft is a huge problem here in South Africa. According to reports it costs the economy 1.4 billion rand (\$80 million) a year. One problem is the technology farmers have traditionally employed to try and combat theft is old or inefficient – bulky devices attached to the

devices such as smartphones to extract information directly from the animal. It also resolves many of the issues posed by other tech like limited cellular network coverage or expensive LoRa receivers.

Of course, with innovation comes the inevitable question of how well the end client understands the technology and its benefits. Luckily for us when we first started, we encountered visionary, tech-savvy farmers. We listened carefully to their advice, used their knowledge of the animal to create a solution that can gather ample data about the animal and the farming ecosystem.

Tech-driven smart farming

These solutions can also facilitate a lot more than deterring cattle thieves. They are enabling the transition from traditional farming and livestock monitoring, towards tech driven integrated smart farming using wireless IoT technology and AI analysis. Farmers are able to make informed decisions for livestock management based on scientific findings rather than empirical assumptions.

Livestock identification and traceability, eco-certificates and certificates of origin are being implemented and requested by the beef industry worldwide, and wireless sensors allow for the collection of this data. For example, this 'big data' can be combined with mathematical models and interpreted into integrated applications that will allow for animal DNA prediction and assessment.

This ability to continuously assess the activity, behavior and health of individual animals in real time will provide huge benefits for the livestock industry worldwide.

“These wireless solutions are enabling the transition towards tech driven integrated smart farming

animal's neck, GSM trackers that rely on limited or non-existent network connectivity, as well as power hungry devices with a short battery life. That is now changing.

New cost effective wireless solutions are opening new horizons. [Bluetooth LE](#) is a good 'last mile' technology for animal tracking, although when I say last mile our solution can reach up to 6 km line of sight. Bluetooth LE also allows for more frequent transmission of data due to its low power consumption, and for direct connectivity to other

[Tech Zone]

An in-depth look at Nordic's wireless solutions

Power Management

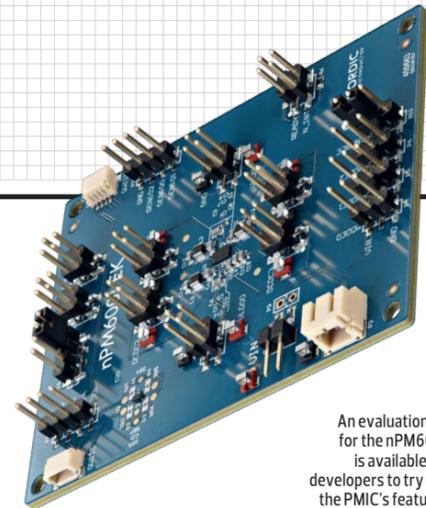
Nordic introduces nPM6001 PMIC to power complex IoT applications

Nordic Semiconductor has expanded its power management product range with the launch of the nPM6001 dedicated power management IC (PMIC). With six independently-controlled power rails, the nPM6001 is designed to supervise and supply the power requirements of complex IoT hardware incorporating multiple power domains that each require separate voltage regulation. The PMIC can also be used to independently power down each power domain to conserve energy and extend the battery life of the IoT device.

The nPM6001 can be used to power Nordic's nRF7002 ultra-low power, dual-band Wi-Fi

6 companion IC, and the nRF52 and nRF53 Series SoCs in systems with highly partitioned power architectures. Nordic's nPM1100 PMIC can be used as a complementary device to the nPM6001 to add battery charging to nPM6001-powered applications using smaller cells. Alternatively, the nPM6001 can be used to increase the number of regulated power rails in nPM1100 applications from one to seven.

The nPM6001 features four highly-efficient step-down (buck) regulators that can deliver 500, 200, 150 and 150 mA respectively at different selectable output voltage ranges from 0.7 to 3.3 V. In addition, two low dropout (LDO) regulators can supply up to 15 mA fixed



An evaluation kit for the nPM6001 is available for developers to try out the PMIC's features

at 1.8 V, and up to 30 mA selectable between 1.8 and 3.3 V respectively.

The PMIC also incorporates a watchdog timer (WDT) that can be set to time-out between 4 s and 776.7 days in 4 s increments. The WDT resets if not triggered before it times out. The WDT is also used to implement hibernate mode; in this mode, the whole PMIC system—except for a 2 kHz oscillator and a timer—is powered down. Power consumption in hibernate mode is 200 nA (typ).

Enterprise IoT

Edge gateway enables enterprise IoT mesh networking

Embedded systems and network solutions provider, SolidRun, has launched the latest gateway solution in its SolidSense family of enterprise IoT gateways. The SolidSense N8 Compact gateway is designed to service a local network of IoT devices to support asset tracking, smart office, smart city and lighting management applications.

The 150 by 85 by 40 mm SolidSense N8 Compact provides Cloud connectivity for networks of IoT devices based on Nordic nRF52833 SoC-powered Bluetooth mesh and Wirepas Massive – a decentralized large scale mesh networking solution. In addition to broad connectivity options, the gateway offers expansion add-on cards to support customer specific requirements, allowing users to create and manage infrastructure for various enterprise IoT applications.

The gateway provides the connectivity between low power field networks—including

Nordic nRF52833 multiprotocol SoC-enabled Bluetooth 5.3, Bluetooth LE, Bluetooth mesh and Wirepas Massive—and business applications in the Cloud with local processing capabilities.

The nRF52833 SoC supports the Wirepas Massive mesh connectivity software enabling cost effective, scalable IoT solutions with density, flexibility and reliability. For example, a network of anchor nodes and up to hundreds of thousands of end devices could be placed throughout a location and wirelessly linked using the Wirepas Massive connectivity integrated in the Nordic SoC-based modules. Collected sensor data and analytics could then be relayed via Wirepas Massive to the gateway which in turn sends the data to the Cloud using Wi-Fi, Ethernet and/or cellular IoT connectivity.



Modules

Bluetooth LE and LoRaWAN multiprotocol module launched

Indian company CWD Limited has launched its CBTLRM02 module which offers both high throughput Bluetooth LE and LoRaWAN connectivity for IoT applications. The module integrates Nordic's nRF52833 SoC to provide the Bluetooth LE connectivity for applications such as home automation, sensor networks and building automation.

The CBTLRM02 module has dual on-board antennas for Bluetooth LE and LoRaWAN, as well as three on-board crystals in a compact 21 by 30 by 3.4 mm package.

The module is powered by the Nordic SoC's 64 MHz, Arm Cortex M4 processor with floating point unit (FPU), with its generous 512 KB Flash and 128 KB RAM memory allocation.

CWD can provide open source application software development to users.

Reliability

Nordic and Memfault extend partnership

Nordic Semiconductor and IoT reliability platform developer Memfault are working together to provide developers building solutions with Nordic's nRF91, nRF53 and nRF52 Series SoCs easy access to Memfault's device reliability engineering capabilities.

The updated solution gives nRF91, nRF53 and nRF52 Series developers integration of the Memfault platform to accelerate product development and derisk product launches.

Memfault's IoT reliability platform helps capture relevant metrics and issue data remotely from devices operating in development or production, develop fixes or improvements, and monitor updates across hardware and software releases. Nordic's nRF Connect SDK enables rapid creation of a data pipeline for the nRF52 and nRF53 Series to the Cloud and device debugging and fault analysis capabilities. It includes Memfault SDK examples and template gateway applications for both Android and iOS developers. Registration is available at app.memfault.com/register-nordic.

Data Logging

Cellular IoT data logger enables long battery life flow monitoring applications

An IoT data logger designed for applications in the water industry has been developed by U.K. based Ashridge Engineering. Available in three different versions, CharIoT is suitable for a range of applications including flow monitoring, leak detection, pressure management, pressure relief value management, network modelling and commercial logging.

CharIoT can be configured and deployed in the field in under two minutes using the Android app, with settings transferred to the device via NFC. The device uses the computational power of the Nordic nRF9160 SiP's Arm Cortex-M33 application processor to oversee the sensors and collate data. The SiP's multimode LTE-M/NB-IoT modem with integrated RF Front End (RFFE) enables the data to be measured, logged and securely transmitted to the proprietary Cloud portal, Aquaguard, via MQTT on a cellular IoT network. An intuitive dashboard allows users to quickly identify issues.

The CharIoT device takes advantage of the

nRF9160 low power SiP to provide battery life in excess of 10 years even in challenging conditions, helping to reduce the number of single-use batteries used by water utilities. The solution enables these companies to understand flow and pressure in their networks in almost real time, but without the need for large single-use battery packs.

"In the past we have used a processor and modem in separate packages, but with Nordic's nRF9160 SiP we have all the components we need in a compact form factor, while the power consumption capabilities of the nRF9160 were also an important consideration," says Damien Lobb, Electronics Engineer, Ashridge Engineering. "We decided to use a Nordic solution because the company provides a lot of ... well-documented code and examples."



The ideal starting point for your LE Audio project



AVAILABLE NOW
nordicsemi.com/nRF5340-Audio-DK



Getting started on Matter projects using the nRF Connect SDK

Nordic's unified software development kit and hardware development kits make it easy to build Matter prototypes and experiment with the standard's multi-admin feature

Matter is gaining momentum. With the recent introduction of Matter 1.0 and an associated certification program (see *this issue pg10*), developers are busy building Matter products. Matter is an open standard for the application layer of smart home protocols. It brings interoperability by introducing an IP-based unifying application layer on top of the established smart home wireless protocols [Thread](#) and [Wi-Fi. Bluetooth LE](#) is used for commissioning new devices to the network. As a board member and promoter of the Connectivity Standards Alliance, the custodian of the Matter specification, Nordic has been heavily involved in developing the specification and the company's products and development tools are ready to build prototypes. Development is supported through the nRF52840, nRF5340 and nRF7002 DKs and the [nRF Connect SDK](#). nRF Connect SDK is Nordic's scalable and unified development kit for building products based on the company's SoCs, SiPs and the nRF7002 Wi-Fi 6 Companion IC.

Setting up a Matter prototype network

Prototyping with Nordic's [Matter](#) solutions relies on the nRF Connect SDK. The latest version of the SDK includes full Matter over Thread and adds support for Matter over Wi-Fi for the nRF5340 SoC in combination with the

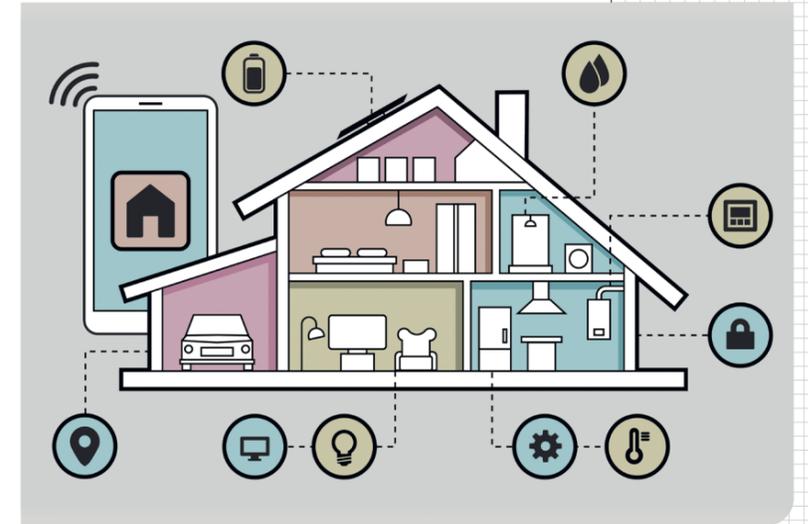
“ ” The interoperability that Matter brings allows the same accessory to be simultaneously controlled by two different consumer ecosystems

nRF7002 Companion IC. nRF Connect SDK is publicly hosted on GitHub. There is an extension pack for Visual Studio Code (nRF Connect for VS Code) which provides a self-sufficient IDE for application development. (The SDK can also be used with other IDEs.) An example of a Matter prototype network is shown in figure 1. A key part of the network is a Wi-Fi access point (AP) connected to the Internet. Another important part of the network is a Matter controller connected by Wi-Fi to the AP used to command smart home accessories. In the connected home, the controller would be a smartphone, smarthub, smart speaker or tablet running consumer smart home ecosystem software and used to control smart home accessories. For prototype work, a CHIP tool, a Matter controller implementation that enables commissioning of Matter devices onto the network and communication with them using Matter messages, is a good option. From figure 1, (pg 37) note the Matter light switch is a Thread device; that means it requires a Matter Border Router to connect to the Wi-Fi parts of the network. The light switch will be used to control another Thread device, a Matter light bulb. Initially, the Matter switch doesn't know which Matter light bulb it is supposed to control. The solution to this challenge is called Matter binding, a process through which the Matter controller configures the Matter switch to control a specific Matter light bulb.

Inside the nRF Connect SDK

The release of Matter 1.0 saw the delivery of the specification for the standard and the first implementation of the protocol stack. The specification is available from the Connectivity Standards Alliance and the stack source code is available from [Github](#). The latest version of Nordic's nRF Connect SDK includes the Matter 1.0 release and is fully compliant with the Matter specification. In the SDK, the Matter 1.0 firmware is deployed as one of the submodule repositories (with a dedicated fork). The user application and Matter stack is situated on top of the other firmware stacks in the SDK. The SDK also includes the Zephyr OS, certified support for Thread 1.3 and Bluetooth LE. The developer can download a precompiled library of the Thread and Bluetooth LE protocol stacks and use them safe in the knowledge they will carry the certification over to their end products. Nordic also offers Matter sample applications in the nRF Connect SDK such as window shade, smart lock and light switch. In addition to the SDK, Nordic customer products built using nRF5340 and nRF52840 SoCs, and the Matter Weather Station running on the Nordic Thingy:53, have successfully passed the Matter Specification Validation Event. This is further confirmation Nordic's SDK and Matter solution is fully compliant with the Matter specification.

- nRF Connect SDK
- Zephyr
- Nordic component
- Third-party
- Matter (built with GN)



For prototyping purposes, the consumer Matter controller is replaced with a Linux PC with CHIP tool. The Thread Border Router can be constructed from a Raspberry Pi 4, a low cost computer, running OpenThread using an nRF52840 Dongle as a Thread radio coprocessor. Nordic supplies a Matter light switch application in the nRF Connect SDK, and this application can run on an nRF5340 DK. An nRF52840 DK can be used as the 'smart light' with its LEDs illuminating to simulate the fixture. In addition to the nRF Connect SDK and the VS Code IDE with nRF Connect for VS Code extension pack, the developer will need nRF Command Line Tools. This is used for programming Nordic nRF devices. It is relatively straightforward to select and configure the Matter light bulb sample application using nRF Connect for VS Code running on the IDE. The same can then be done for the Matter light switch example. nRF Connect for VS Code can then be used to commission the Matter light bulb and Matter light switch to the network using the nRF5340 and nRF52840 DKs' Bluetooth LE connectivity. The final step is to configure the Matter binding so the Matter light switch knows which Matter light bulb to command. (For details of Matter configuration and commissioning using Nordic's development tools see the Nordic webinar referenced in the footnote. Setting up the Raspberry Pi 4-based Thread Border Router is explained in a previous Nordic webinar ([bit.ly/3Bq7XHo](#)).

The Matter multiple fabric feature

The interoperability that Matter brings allows the same Matter accessory to be simultaneously controlled by two different consumer ecosystems. For example, a Matter light bulb could be controlled by a smart speaker from one manufacturer and through a Matter light switch controlled from a smartphone from another. This multi-admin feature of the Matter specification has been included because different members of a household might each have their own preference of a consumer smart home ecosystem and want to use it without affecting others. The specification refers to the separate ecosystems as "fabrics". A Matter device can join multiple fabrics. Each fabric has its own controller, unrelated by any root of trust to other fabrics through which the Matter device might

be commanded. And each fabric handles a different set of encrypted communications and operates independently. Figure 2 shows a multi-fabric Matter network. In this case one Matter controller is an Android smartphone with the CHIP tool and the other is a Linux PC with the CHIP tool. In this example, the Matter device is the [Nordic Thingy:53](#) Matter Weather Station. The Thingy:53 Matter Weather Station application is also available in nRF Connect for VS Code where it can be configured and commissioned. In the example, the Thingy:53 is first commissioned to the fabric administered by the smartphone controller. Once done, the controller can be used to read, for example, the Thingy:53's temperature and humidity sensors. The process of configuration and commissioning can be repeated for the Linux PC with CHIP tool. Once that's done that controller can also be used to read the sensors of the Thingy:53 while it also remains part of the smartphone controller fabric. Nordic's [nRF5340](#) and [nRF52840](#) SoCs and the [nRF7002](#) Wi-Fi 6 Companion IC, the nRF Connect SDK and associated DKs provide everything the developer needs to take part in this significant moment for the connected home sector.

A Nordic webinar entitled [Developing Matter 1.0 products with nRF Connect SDK](#) is available from [bit.ly/3EP0bYn](#).

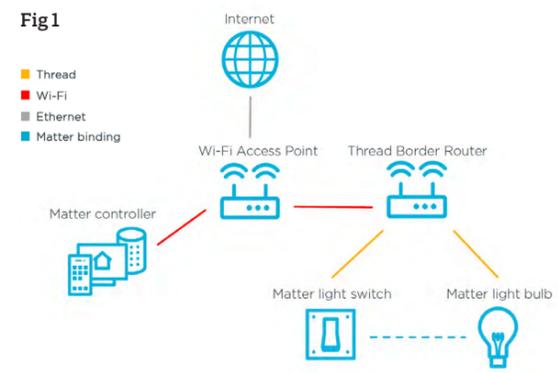


Fig 1 An example of a Matter prototype network

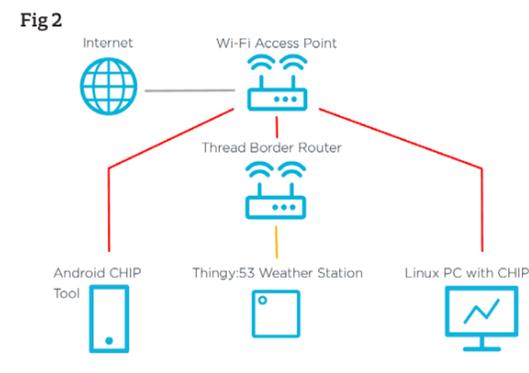
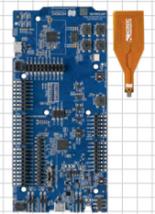


Fig 2 An example of a multi-fabric Matter network



Need to Know

Together with Thread, the nRF5340 DK supports Bluetooth mesh and Zigbee. The DK is based on the nRF5340, the world's first wireless SoC with two Arm Cortex-M33 processors. One processor is dedicated to the application while a low power network processor supervises wireless connectivity

Nordic Product Guide

This handy summary describes all of Nordic's IoT solutions



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

Nordic's RF SoCs and SiP

		nRF 41 SERIES	nRF 53 SERIES	nRF 52 SERIES						
		nRF9160	nRF5340	nRF52840	nRF52833	nRF52832	nRF52820	nRF52811	nRF52810	nRF52805
WIRELESS PROTOCOL	LTE-M	●								
	NB-IoT	●								
	GNSS	●								
	BLUETOOTH LOW ENERGY		●	●	●	●	●	●	●	●
	BLUETOOTH 5.3		●	●	●	●	●	●	●	●
	LE AUDIO		●							
	DIRECTION FINDING		●		●		●	●		
	2 Mbps		●	●	●	●	●	●	●	●
	LONG RANGE		●	●	●	●	●	●	●	●
	BLUETOOTH MESH		●	●	●	●	●	●	●	●
	THREAD		●	●	●	●	●	●	●	●
	MATTER		●	●	●	●	●	●	●	●
	ZIGBEE		●	●	●	●	●	●	●	●
	ANT		●	●	●	●	●	●	●	●
2.4 GHz PROPRIETARY		●	●	●	●	●	●	●	●	
NFC		●	●	●	●	●	●	●	●	
SYSTEM-ON-CHIP (SoC)		●	●	●	●	●	●	●	●	
SYSTEM-IN-PACKAGE (SiP)		●								
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
	FPU	●	●	●	●	●	●	●	●	●
	DSP INSTRUCTION SET	●	●	●	●	●	●	●	●	●
	CACHE	●	●	●	●	●	●	●	●	●
	MEMORY	1 MB Flash, 256 KB RAM	1 MB Flash, 512 KB RAM +256 KB Flash, 64 KB RAM	1 MB Flash, 256 KB RAM	512 KB Flash, 128 KB RAM	512 KB or 256 KB Flash, 64 KB or 32 KB RAM	256 KB Flash, 32 KB RAM	192 KB Flash, 24 KB RAM	192 KB Flash, 24 KB RAM	192 KB Flash, 24 KB RAM
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	
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
	MAXIMUM TX POWER	23 dBm	3 dBm	8 dBm	8 dBm	4 dBm	8 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)
ANTENNA INTERFACE	50 Ω single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	
PERIPHERALS	HIGH SPEED SPI	●	●	●	●	●	●	●	●	●
	TWI, SPI, UART	4xTWI/SPI/UART	4xTWI/SPI/UART +TWI/SPI/UART	2xTWI/SPI, SPI, 2xUART	2xTWI/SPI, SPI, 2xUART	2xTWI/SPI, SPI, UART	2xTWI/SPI, UART	TWI/SPI, SPI, UART	TWI, SPI, UART	TWI, SPI, UART
	QSPI		●	●						
	USB		●	●	●	●	●	●	●	●
	PWM	4	4	4	4	3		1	1	
	PDM	●	●	●	●	●	●	●	●	●
	I2S	●	●	●	●	●	●	●	●	●
	ADC, COMPARATOR	ADC	●	●	●	●	COMP	ADC, COMP	ADC, COMP	ADC
	TIMER, RTC	3, 2	3, 2 + 3, 2	5, 3	5, 3	5, 3	4, 2	3, 2	3, 2	3, 2
	TEMPERATURE SENSOR	●	●	●	●	●	●	●	●	●
CERTIFICATIONS	nordicsemi.com/9160cert	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	
SUPPLY VOLTAGE RANGE	3.0 to 5.5 V	1.7 to 5.5 V	1.7 to 5.5 V	1.7 to 5.5 V	1.7 to 3.6 V	1.7 to 5.5 V	1.7 to 3.6 V	1.7 to 3.6 V	1.7 to 3.6 V	
DEVELOPMENT KITS	nRF9160 DK, Nordic Thingy:91	nRF5340 DK, nRF5340 Audio DK, Nordic Thingy:53	nRF52840 DK, nRF52840 Dongle	nRF52833 DK	nRF52 DK, Nordic Thingy:52	nRF52833 DK	nRF52840 DK	nRF52 DK	nRF52 DK	
PACKAGES	10x16x1.04 mm LGA	7x7 mm aQFN94 (48 GPIOs), 4.4x4.0 mm WLCSP95 (48 GPIOs)	7x7 mm aQFN73 (48 GPIOs), 6x6 mm QFN48 (30 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), 2.53x2.53 mm WLC-SP44 (18 GPIOs)	6x6 mm QFN48 (32 GPIOs), 5x5 mm QFN32 (17 GPIOs), 2.48x2.46 mm WLC-SP33 (15 GPIOs)	6x6 mm QFN48 (32 GPIOs), 5x5 mm QFN32 (17 GPIOs), 2.48x2.46 mm WLC-SP33 (15 GPIOs)	2.48x2.46 mm WLC-SP28 (10 GPIOs)	

Wi-Fi 6 Companion IC

nRF7002



Description: The nRF7002 is a Wi-Fi 6 Companion IC for use in the 2.4 and 5 GHz bands. The product offers good coexistence with Bluetooth LE devices and features one Spatial Stream (SS), 20 MHz channel bandwidth, 64 QAM (MCS7), 86 Mbps PHY throughput and OFDMA (downlink and uplink).

Operation: The nRF7002 Wi-Fi 6 Companion IC is a low power and secure Wi-Fi device for IoT applications. It provides Wi-Fi connectivity and

Wi-Fi-based locationing (using SSID sniffing of local Wi-Fi hubs). The nRF7002 incorporates Wi-Fi 6's Target Wake Time (TWT), a power-saving feature allowing the IC to negotiate a wake-up schedule with the access point (AP) to which it is connected. The nRF7002 accompanies Nordic's nRF52 and nRF53 Series Bluetooth LE SoCs, and the nRF91 Series cellular IoT SiPs. The nRF7002 can also be used as a companion IC in applications hosted by non-Nordic products. Development is supported through Nordic's nRF Connect SDK, the unified software development kit for building applications based on Nordic's wireless products.

Tech Spec

Compliance
IEEE 802.11b (Wi-Fi 1)/a (Wi-Fi 2)/g (Wi-Fi 3)/n (Wi-Fi 4)/ac (Wi-Fi 5)/ax (Wi-Fi 6)

Package
6 by 6 mm QFN

Features
Low power, good coexistence with Bluetooth LE, TWT

Development tools
nRF7002 DK, nRF Connect SDK

Applications
Asset tracking, smart home, industrial

Range Extender

nRF21540



Description: The nRF21540 is an RF front-end module (FEM) that improves range and connection robustness for nRF52 and nRF53 Series SoCs. The nRF21540 is a complementary device operating as a 'plug-and-play' range extender with the addition of just a few external components. The nRF21540's 13 dB RX gain and low noise figure of 2.7 dB, coupled with up to +21 dBm TX output power, ensure a superior link budget boosting the range of supported SoCs by between 6.3 and

10x. In demanding RF environments, or where the application is operating close to the range limit, it can be more energy efficient to use the nRF21540 than continuously resend packets.

Operation: The nRF21540 supports Bluetooth LE, Bluetooth mesh, Thread, Zigbee and 2.4 GHz protocol applications. The RF FEM's TX output power is dynamically adjustable and can be set to comply across all geographical regions. The RF FEM can be used with Nordic's extended temperature-qualified nRF5340, nRF52833 and nRF52820 SoCs in industrial applications.

Tech Spec

Output power
Adjustable in small increments up to +21 dBm

Receive gain and noise figure ratings
13 dB receive gain, 2.7 dB noise figure

Input supply
1.7 to 3.6 V

Package
4 by 4 mm QFN16

Development bundle
nRF21540 DK and nRF21540 EK. The EK is a shield for use with nRF52 and nRF53 Series DKs

Applications
Asset tracking, smart home, industrial, toys, audio

Power Management

nPM1100



Description: The nPM1100 is a dedicated power management IC (PMIC) with dual-mode configurable buck regulator and integrated battery charger. It is designed to work with nRF52 and nRF53 Series SoCs. It offers reliable and stable power delivery, while maximizing battery life through high efficiency and low quiescent currents. The product can also be used as a generic PMIC for rechargeable applications. Its compact form factor makes it ideal for advanced, size

constrained devices. When optimized for size, PCB usage is around 23 mm² including passives. When optimized for performance, this increases to around 27 mm².

Operation: The dual-mode regulator operates at up to 92 percent efficiency, prolonging battery life of Nordic SoC-based applications. Hysteretic mode reduces current consumption for low loads, while PWM mode allows for cleaner power operation and better performance for higher loads. The regulator can deliver up to 150 mA, providing ample current for the SoCs plus any additional circuitry.

Tech Spec

Battery charger
JEITA compliant, 4.1 or 4.2 V selectable, 20 to 400 mA

Input regulator
Input 4.1 to 6.7 V, output 3.0 to 5.5 V (unregulated), USB current limit 100 or 500 mA

Buck regulator
Output 1.8, 2.1, 2.7 or 3.0 V, current limit 150 mA output

Package
2.075 by 2.075 mm WLCSP

Operating temperature
-40 to 85°C

Applications
Wearables, remote controls, medical devices, sensors

Cloud Services

nRF Cloud Services

Description: nRF Cloud Services are optimized for Nordic's ultra low power IoT Devices. nRF Cloud Services support Device-to-Cloud or Cloud-to-Cloud use cases. In the former, the device connects directly to nRF Cloud. In the latter, the device connects to a customer's Cloud that then connects to nRF Cloud's REST API.

Services: nRF Cloud Services are offered in nRF Cloud and include GPS and cell-based location

services. The product supplies accurate, rapid location data for IoT devices. The A-GPS service reduces time-to-first-fix. The result is lower latency and improved power consumption. P-GPS downloads predictive data, extending validity of assistance data. For Wi-Fi location services, the device scans two or more Wi-Fi access points and sends network information to nRF Cloud, where the location is calculated. Cell based services use base stations to predict location. If power saving is more important than location accuracy, cell services are a good option. Pricing for services can be found on nrflcloud.com.

Tech Spec

Location services
Assisted GPS (A-GPS), Predictive GPS (P-GPS), Single-Cell (SCELL), Multi-Cell (MCELL), Wi-Fi

Additional features
Supports Cloud-to-Cloud use cases for devices provisioned to a different Cloud provider

Supported products
nRF9160 SiP, nRF9160 DK, Nordic Thingy:91

Applications
Industrial, smart appliances, asset tracking, RTLS



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