

WIRELESS QUARTER

Issue 3, 2022

FINDING FAUNA:
USING TECH TO SAVE
ENDANGERED SPECIES

MAKING THE GRADE:
DIGITAL EDUCATION FOR
TOMORROW'S ENGINEERS

THREAD TOGETHER:
BUILDING AUTOMATION
KEEPS THINGS COOL

Agriculture's Golden Age

Wireless tech helps farmers balance
increasing food demand with sustainability

NORDIC INTRODUCES
WI-FI 6 COMPANION IC

BRIGHTER YEAR AHEAD
FOR CHIP MAKERS

UNDER THE HOOD
OF DECT NR+



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Welcome

Svenn-Tore Larsen
CEO



Wi-Fi has played a foundational role in the emergence of the IoT. With the release of Wi-Fi 6, there is now a version of the tech that makes it even better suited to low power wireless – an area where Nordic has decades of experience.

Nordic's customers have been well aware of the significance of Wi-Fi for some time and, after becoming familiar with the ease-of-development and reliability of Nordic's leading [Bluetooth LE](#) solutions, regularly asked us for complementary [Wi-Fi](#) products. The chance for us to meet that customer requirement came with the [acquisition](#) of the Wi-Fi development team and the Wi-Fi IP tech assets of Imagination Technologies Group. The addition of this group and tech has made Nordic one of the very few chip vendors able to offer Bluetooth LE, Wi-Fi and [cellular IoT](#) solutions.

It is with immense pride that Nordic announces its entry into the Wi-Fi IoT market with the introduction of the nRF7002 Companion IC. (See pg10.) In addition to a Wi-Fi product that brings low power, advanced security and seamless coexistence to IoT applications, what has impressed me most about this entry is the knowledge, hard work and dedication that enabled Nordic's Wi-Fi engineers to introduce the nRF7002 Companion IC so quickly. This really is a remarkable achievement.

The Wi-Fi team has added something extra to our already excellent engineering team and, although I can't yet give any details, I can say some great Nordic Wi-Fi 6 products are in development to follow the nRF7002 Companion IC.

Together with Nordic's renowned low power wireless engineering, our expert technical support and mature development tools, the nRF7002 will make it easier for customers to get started on Wi-Fi IoT projects alongside their Bluetooth LE and cellular IoT applications.



Nordic is one of the very few chip vendors able to offer Bluetooth LE, Wi-Fi and cellular IoT solutions

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Acquisitions

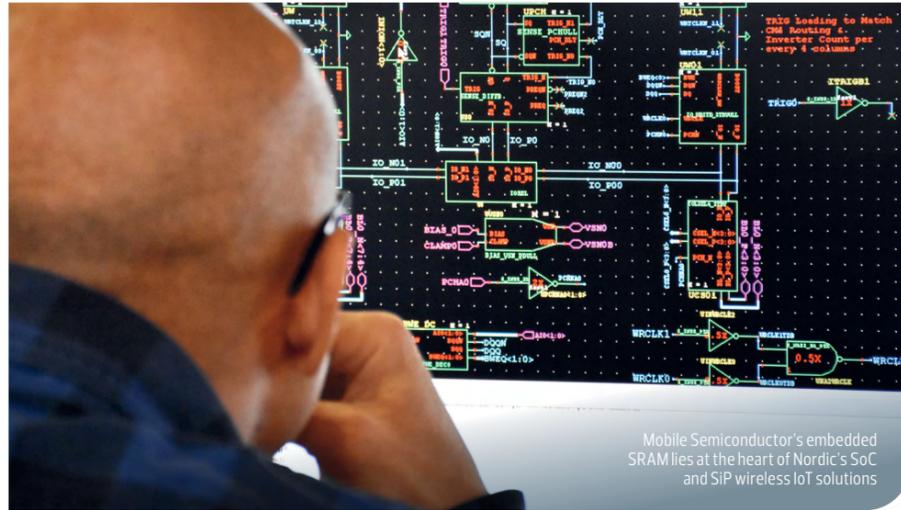
Nordic to acquire U.S. memory specialist Mobile Semiconductor

Nordic Semiconductor has entered into an agreement to acquire Mobile Semiconductor, a privately-held U.S. firm specializing in optimized embedded memory tech for silicon devices.

Mobile Semiconductor has a market-proven track record of delivering ultra low power-performance optimized, leading-edge static RAM (SRAM) for microcontrollers and SoCs. These include Nordic's nRF52 and nRF53 Series SoCs and nRF91 Series SiP wireless IoT solutions.

"We are very excited to bring on-board this world class team, recognized as an industry leader in optimized, low voltage embedded SRAM designs," says Nordic CTO/EVP R&D and Strategy, Svein-Egil Nielsen. "It's a team we know intimately from years of working together. And in terms of the tech, Mobile Semiconductor's SRAM has been a key differentiator in our Bluetooth and cellular IoT product ranges. When the opportunity to bring this critical expertise in-house arose, it was a 'no-brainer' to proceed and make this latest acquisition."

"As IoT applications continue to become ever more capable and high performance, memory has become an increasingly vital ingredient of the ultra low power



Mobile Semiconductor's embedded SRAM lies at the heart of Nordic's SoC and SiP wireless IoT solutions

mix," adds Kjetil Holstad, Nordic's EVP of Product Management. "Nordic has relied on Mobile Semiconductor's embedded SRAM technology for many years to [help keep power consumption down]. Bringing that expertise in-house will position us extremely well when it comes to developing highly optimized future products."

"As the technology becomes more advanced, customers benefit from the

resources larger companies have to continuously invest in R&D," says Cameron Fisher, CEO at Mobile Semiconductor.

"We believe Mobile Semiconductor has grown as far as it can as a private company and now needs a company like Nordic Semiconductor to take our memory architectures to the next level."

The acquisition is expected to close during Q3 2022 pending U.S. government approval.

Connected Health

Wearable helps keep Alzheimer's sufferers safe

Californian technology company Saluswear Corp. has released a wearable designed to track and monitor individuals suffering from Alzheimer's, dementia or autism. The SalusWear device reports the location of the wearer to family, friends or caregivers in the event they go missing, or if they have potentially been subject to a fall.

The miniaturized 25 by 38 by 13 mm waist-worn device is powered by Nordic's

nRF9160 SiP, a multimode cellular IoT device. SalusWear responds directly to SMS commands from preapproved phone numbers, without the need for a smartphone app. For instance, a caregiver can text "LOCATE" to the device to receive a map link to the wearer's location.

Location tracking is enabled via Wi-Fi and GNSS, using Wi-Fi where possible to extend battery life. The nRF9160's assisted

and predictive GNSS also saves power by speeding up 'time-to-first-fix'.

"We selected the nRF9160 because we needed a small and highly integrated SiP with low power consumption that was still powerful enough to provide all of the key features we required," says Chris Rotberg, President of Saluswear. "In addition, Nordic has a great sales and support team that has helped us enormously during development."



Smart Health

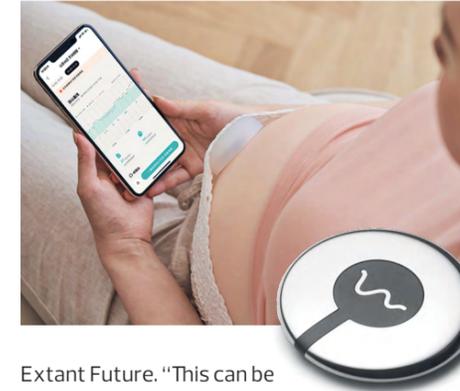
Fetus monitoring patch records and transmits intrauterine data

China-based company Extant Future has launched a fetal heart rate and movement detector for use in the final trimester of pregnancy. The Modoo patch is placed against the skin where it records the fetus heart rate using passive sonar technology, as opposed to the traditional ultrasound Doppler method.

Powered by Nordic's nRF52833 Bluetooth LE SoC, Modoo works using an audio sensor to detect any vibration on the wearer's skin. This signal is then amplified and the data filtered using the SoC's powerful 64 MHz Arm Cortex-M4 processor. The filtering uses algorithms that reduce background noise and track changes over time.

The results are then transmitted using Bluetooth LE to the user's smartphone, where the fetal movement and heart rate curve are analyzed, using several years' worth of reference data, to help identify any signs of intrauterine distress, such as hypoxia. The data can also be sent to the wearer's physician.

"In the last months of pregnancy, it is common for expectant mothers to be required to record up to three hours of fetal movement each day," says Jiliang Ma, Founder and CEO of



Extant Future. "This can be extremely time-consuming and inconvenient when at home or at work."

"Modoo aims to provide a convenient alternative for home use," explains Ma. "The user attaches the device to their stomach, pairs it with their smartphone, tests for as little as 20 minutes, and then submits the report for scoring."

"Due to the frequency of fetal reporting sessions, extended battery life was key. Thanks to the nRF52833 SoC, we ... can achieve up to 20 sessions on a single charge."

Smart Home

Bluetooth LE security device reports unauthorized door access

France-based startup Artefeel has launched an all-in-one, sensor based, machine learning (ML)-powered security device that can be installed on a door or window to monitor activity and discriminate authorized access from a lock-pick or break-in attempt.

The wireless Check'In solution is suited to monitoring isolated sites - for example, electrical transformers, mobile homes, boats, barns or any property without Wi-Fi or a power source.

Nordic's nRF5340 advanced multiprotocol SoC collects sensor data and runs the ML prediction model for Check'In.

Check'In's ML model uses multiple sensor inputs to determine whether an entry is legitimate or an attempted break-in.

The Bluetooth LE connectivity provided by

the Nordic SoC improves Check'In configuration and set-up, enables local troubleshooting and performs certain actions in the event a notification is received. Check'In also integrates cellular connectivity to report directly to the Cloud.

While most security alarm systems require the configuration of multiple components and pairing with a control panel for operation, Check'In does not require complex activation or deactivation codes.

"In order for our ML prediction model to run on the Nordic SoC, it was key to have both great processor and RAM performances while maintaining low power consumption," says Alain Staron, CEO of Artefeel.



In Brief

SMART CITIES BOOST FOR ESG



The United Nations (U.N.) has flagged smart city technology as the only way to combat the environmental impact of the mass migration of global populations from rural to urban areas. It said by 2050, around 70 percent of the world's population will have moved to large cities that were already responsible for nearly three quarters of greenhouse gas emissions. To counteract this, the U.N. says smart urban infrastructure will have to be built on a massive scale which could represent a \$30 trillion ESG investment opportunity. This could involve the building of climate-smart cities with flood defenses, electric transport and smart green buildings.

NEW LIFE FOR DISCARDED CDs



With millions of discarded CDs thrown out each year as the technology is steadily replaced by digital downloads, researchers from

Binghamton University, New York, are providing a sustainable alternative to landfill. The researchers are turning old CDs into flexible biosensors that are inexpensive and easy to manufacture. They said a gold CD's thin metallic layer can be separated from the rigid plastic and made into sensors to monitor electrical activity in hearts and muscles as well as lactose, glucose, pH and oxygen levels. The sensors can then wirelessly communicate with a smartphone. The fabrication is completed without releasing toxic chemicals or needing expensive kit.

BLUETOOTH KING IN BURIAL DISPUTE



King Harald 'Bluetooth' Gormsson of Denmark, whose nickname became synonymous with the wireless tech, is at the center of a dispute as to his burial site a 1,000 years after his death. It was believed the Viking king was buried in Roskilde in Denmark in the late 10th century, but now a Swedish archaeologist and a Polish researcher claim he is buried in an area of Poland that had ties to the Vikings. A second Swedish archaeologist has challenged the findings, asserting that Harald converted from paganism to Christianity and must therefore have received a more appropriate grave rather than beneath a pagan mound.

Smart Health

Bluetooth LE ECG devices enable heart monitoring at home

Chinese biomedical company Borsam Biomedical Instruments has launched its Wireless ECG Monitor Event Recorder and ECG Holter Recorder home echocardiograms (ECGs). The product enables individuals to easily monitor their heart health at home. The Event Recorder can be held to the wearer's chest to record their ECG data. The Holter is for longer-term wear, and is attached to the chest using stickers and three leads.

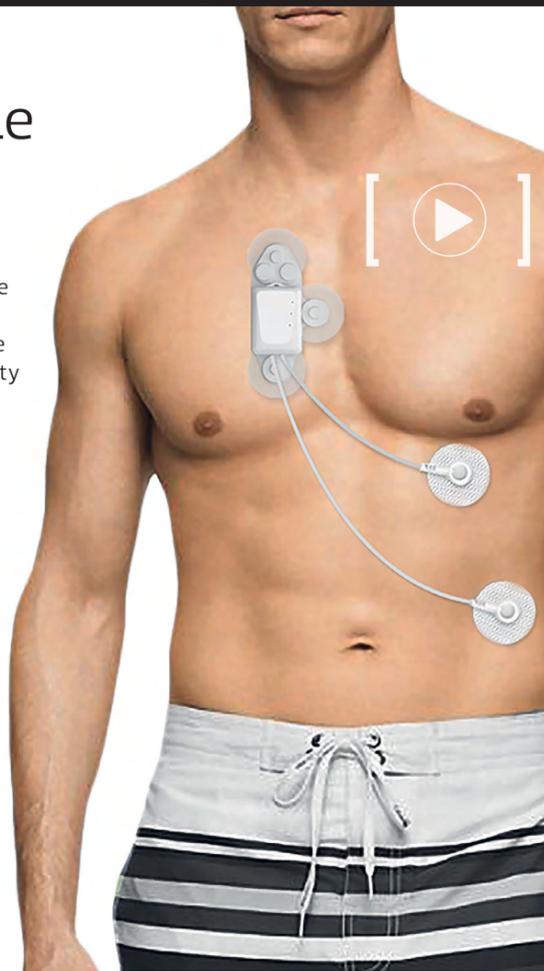
The Event Recorder is powered by Nordic's nRF52832 SoC. Its 64 MHz Arm Cortex-M4 processor with floating point unit (FPU) provides ample processing power for the device to continuously record ECG waveform data and detect arrhythmia in 'real time'. The data is then relayed to an app on the user's smartphone using Nordic Bluetooth LE connectivity. From the app the user can review their heart health information, while the data is also relayed to the Cloud where it can be analyzed by the individual's physician.

The ECG Holter Recorder meanwhile sends the ECG data to an ECG Workstation, which in turn acts as a gateway device to relay the data to the Cloud over a cellular network,

without the need for a smartphone. Both the ECG Holter Recorder and the ECG Workstation are also powered by Nordic's nRF52832 SoC to provide the [Bluetooth LE](#) wireless connectivity between the devices.

"It is imperative that an ECG device detects any arrhythmia and myocardial ischemia, but these are not always easily found during routine surface electrocardiogram examinations," says Yan Gao, Vice General Manager at Borsam Biomedical Instruments.

"To ensure our products were capable of sufficiently sophisticated detection, we adopted a high-precision ECG collection chip and a metal electrode sheet with excellent conductivity. The ECG signal is collected through contact with the patient's skin, using a high sampling rate to ensure that the waveform data is complete and free of distortion."



Industrial IoT

Cellular IoT provides remote monitoring

A wireless level-measurement solution and a motion and vibration detection device have been developed by Finland-based industrial IoT solutions company, iProtoxi, enabling a range of remote industrial monitoring applications. The company's Aistin suite of IoT devices have a multi-year field life, eliminating the need for personnel to perform on-site data analysis in hazardous environments.

The Aistin Level device integrates object distance, plus ambient temperature and orientation sensors to accurately measure any surface level and its important properties. Applications for Aistin Level include air, water, oil and gas distribution, waste and septic tank management, or level control in tanks, containers and silos. Typical use cases for the system include measuring

the fill level of fuel and water tanks, the temperature and level of foodstuffs, as well as the delivery of predictive alerts when containers need to be filled.

The Aistin Motion device measures motion and vibration, enabling the user to accurately monitor, for example, the true total usage time of an engine and the number of start-stop cycles. Use cases for Aistin Motion include detecting changes in device vibrations for electricity networks, operation time and predictive maintenance for cranes, pumped volume for sewage pumps and the engine condition of various motors.

Sensor data gathered by Aistin Level and Aistin Motion is relayed from the devices to the Cloud via an LTE-M/NB-IoT cellular IoT network using Nordic's [nRF9160 SiP](#), without recourse to a separate gateway.



Sustainability

Nordic recognized as high-growth tech leader

Nordic has been chosen among a select group of companies to participate in the Euronext Tech Leaders initiative. The initiative is organized by Euronext N.V.

"Nordic is delighted to have been recognized by Euronext as a high-growth and tech leader," says Ståle "Steel" Ytterdal, SVP IR with Nordic Semiconductor. "We know our wireless tech is among the best in the world ... but to have that recognized by Euronext, a respected and independent European financial organization, underscores the hard work of Nordic's people."

Euronext N.V. bourse (stock exchange) is the largest group in Europe. It was originally created via the mergers of the Amsterdam, Paris and Brussels stock exchanges in 2000.

Toys & Gaming

Connected board game offers immersive interactive gameplay

Italian company Xplored has launched its Teburu board game console, integrating wireless connectivity to transform the traditional board game into an immersive, multimedia gaming experience. The 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 runs on a mobile device or PC to enhance gameplay.

The board and its embedded sensors are powered by Nordic's 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 board via a hardware connection. The connected dice integrate Nordic's nRF52805 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 the nRF52805 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.

"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, in order to help them learn the rules, keep some key information away from other players and to manage enemies."

Patent Licensing

Huawei and Nordic agree cellular IoT licensing deal

Nordic Semiconductor has entered into a patent license agreement with Huawei Technologies Co., Ltd. The agreement grants a fair, reasonable and non-discriminatory (FRAND) royalty bearing, component level license of Huawei's LPWAN [cellular IoT](#) standard essential patents (SEPs) to Nordic, and its customers.

The agreement follows a similar deal (see [WQ Issue 1, 2022 pg5](#)) between Nordic and Nokia that provided customers purchasing IoT hardware from Nordic with the opportunity to acquire licenses to Nokia's portfolio of cellular patents. With the Huawei agreement, Nordic can bring its cellular IoT customers comprehensive legal protection, and a

practical way to access and implement Huawei's standardized cellular IoT technology. As such, the agreement brings greater commercial and legal certainty to the industry.

"Huawei owns a leading portfolio of LPWAN SEPs for LTE-M and NB-IoT ... which creates great value for IoT," says Huawei's Head of European IPR Department, Zhang Xiaowu. "Huawei is pleased to reach this license agreement with Nordic, which will enable ... a large-scale deployment of ... cellular IoT."

"Licensing in cellular IoT is a comparatively new practice, calling for flexible solutions," explains Marianne Frydenlund, SVP Legal & Compliance at Nordic. "This agreement with Huawei is a big step towards harmonizing the cellular IoT industry with FRAND SEP licensing practices employed throughout the global semiconductor industry."



In Brief

CELLULAR IoT CONNECTIONS SOAR



The volume of data generated by roaming IoT connections is set to soar by over 1,000 percent in the next five years, according to Juniper

Research. It said this growth will be chiefly driven by the shutdown of 3G networks and the adoption of low power cellular networks that provide an alternative to 4G and 5G networks. It said only use cases dependent on low latency and high speed data downloads, such as autonomous vehicles and connected factories, will justify enterprise investment in 5G connectivity. The U.S. will account for 26 percent of the total global roaming connections by 2027, generating 277 petabytes of data, the report claimed.

CAR SEAT MONITOR KEEPS KIDS SAFE



Holmbergs has launched a Bluetooth LE-powered child car seat safety system for children in vehicles. The Holmbergs DigitalSafety system

features a wired connection between the eBuckle and the battery-powered proprietary Connectivity Hub embedded in the child seat. Once paired to a user's smartphone using Nordic [Bluetooth LE](#) wireless connectivity, the Connectivity Hub can issue safety alarms via a smartphone app if a child unbuckles themselves, or if the child is left buckled but unattended in a parked vehicle. If the child is still not attended to following an anti-abandon alert, a text message with a GPS location is sent to an emergency contact.

LUGGAGE TRACKER POPULARITY SPIKES



The desire to resume travel has seen a significant uptick in consumer interest in Bluetooth LE suitcase tracking devices. New

Zealand-based PriceSpy said as people turn back to international travel, interest in new suitcases had risen a whopping 580 percent year-on-year, while the popularity of Bluetooth LE tracking devices had also skyrocketed, jumping 380 percent year-on-year, and over 150 percent in July alone. With many airports still running skeleton baggage handling crews following COVID-19 layoffs, PriceSpy said people were taking extra precautions to prevent luggage loss.

Smart City

Manhole cover monitor keeps scrap metal thieves in check

Jian-IOT has launched a smart utility access cover that can detect when the cover has been opened or closed, records water level and temperature data, identifies any damage, and includes an anti-theft system that tracks the current location of the device. The Integrated Intelligent Manhole Cover employs Nordic's [nRF52832](#) SoC to both act as the main processor for the device and to provide Bluetooth LE wireless connectivity between the device and a smartphone app operated by service personnel.

The device integrates a range of sensors to monitor what happens to the access cover as well as environmental data. This data can be used to monitor authorized maintenance by service technicians, as well as any unauthorized tampering or attempted theft of the cover.

Utility access covers are prized targets for



some thieves who sell them for their scrap metal value.

The sensors are supervised by the Nordic SoC's Arm Cortex-M4 processor and the data is in turn relayed to Jian-IoT's HAIMAO Cloud-based data platform using cellular connectivity. The [Bluetooth LE](#) wireless connectivity provided by the [nRF52832](#) SoC also enables service personnel to directly retrieve data via the Jian-IoT Android smartphone app from the utility access cover when in attendance.

"Because utility access covers are such important assets to a city, it's key that they're not lost or stolen," explains ShuangJiang Zhang, Hardware Development Manager at Jian-IOT. "However, due to often complex urban management conditions, it's almost impossible to keep track of them all. By including Nordic Bluetooth LE connectivity, we have been able to achieve interactive positioning among devices. As a result, these smart covers have helped digitize city-wide assets and increase traceability."

Connected Health

AI-based earbud system detects ear infections

Researchers from the University of Buffalo, New York, have developed an experimental earbud device they claim allows them to potentially detect conditions that can afflict the inner ear and the ear canal. The findings could lead to commercial earbuds not only playing music into their owner's ears but also detecting common ear infections and other ailments such as ear wax blockage and ruptured eardrums.

The system, dubbed EarHealth, pairs earbuds with a smartphone that's equipped with a deep learning platform. It works by sending a chirp through the earbuds of a healthy user. It records how the chirp reverberates throughout the ear canals, creating a profile of each user's inner ear.



Subsequent chirps—for example, a user might set the system for once daily testing—monitor each ear for three conditions that alter the ear canal's geometry. These conditions are earwax blockage, ruptured ear drums and otitis media, a common ear infection. Each condition has a unique audio signature that the deep learning system can detect with fairly accurate results.

"Because EarHealth has the potential to detect [inner ear problems] conditions very early, it could greatly improve health outcomes for many people," says Zhanpeng Jin, Associate Professor in the Department of Computer Science.

Logistics & Transport

Tracker monitors goods in storage

China-based company Aovx has developed a suite of devices designed for tracking and monitoring goods, for example, fresh food and medicine storage or cold chain [transportation](#) applications.

The Aovx G Series tracker devices integrate multiple sensors—including a three-axis accelerometer, light sensor, and temperature and humidity sensor—for monitoring the movement, vibration status, tampering, delay, temperature and humidity of goods in storage or transit.

The integrated Nordic [nRF9160](#) low power SiP provides the Aovx G Series tracker devices with either LTE-M or NB-IoT cellular IoT network connectivity to relay goods tracking data to the Cloud. The G Series devices also feature [Wi-Fi](#) and [Bluetooth LE](#) connectivity.

Sustainability

Smart connectivity 'will transform world by 2030'

Smart technology and connectivity solutions will fundamentally transform our experience of the world in the next decade, a new report from Vodafone claims. The *Connected Consumer 2030* report claims there are five pillars around which consumers will seek to harness the power of connectivity during the next 10 years – sustainability, smart cities and mobility, connected care, ethical connectivity and 'next tech'. It said that by 2025, an average connected person anywhere in the world will interact with connected devices nearly 4,800 times per day, equivalent to one interaction every 18 seconds.

"Smart technology and sensors will collect data and then shape people's behavior to ensure their actions are facilitating a sustainable future," says Vinod Kumar, CEO, Vodafone Business.

"In future, consumers will place much more emphasis on reusability," Kumar adds. "In response, we need to focus on recyclability, multi-purpose design, begin considering what happens to devices once no longer in use and start viewing the supply chain as a circular economy."



Other findings from the report included that connectivity would enable the creation of fully autonomous mobility systems that will redefine how urban citizens get from A to B; that a wave of digital solutions will empower people to take ownership of their own health, live independently for longer and alleviate pressure on healthcare; and that new tools will extend our experience of the world.

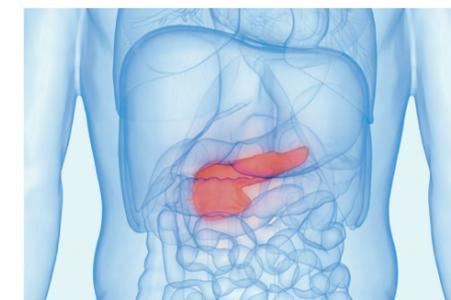
"Soon we'll have new ways of engaging with technology as it becomes more immersive," says Ruth Ruppen, Head of Strategy, Vodafone Smart Tech. "Voice activation and gestural design will become integral, while we may no longer need screens."

Smart Health

Diabetes monitor detects glucose levels using breath

A next-generation diabetes monitor that analyzes breath might soon mean no more needle pricks to check blood sugar levels, researchers claim. The device uses gas sensors to measure breath instantly, then links via [Bluetooth LE](#) with a program on a user's smartphone to provide a readout. Distinct biomarkers in exhaled breath carry a subtle signature that the device picks up before the app uses a deep learning algorithm to produce rapid individual results.

Nathalia Nascimento, a postdoctoral researcher at the University of Waterloo, Canada, and a team of researchers and health professionals are developing the new health-tech. "It's about the size of a mobile phone and also has a detachable mouthpiece," says



Nascimento. "We've developed a series of prototypes and are set for clinical trials."

The researchers had initially investigated the use of gas sensors to identify various diseases through breath before being encouraged to focus on diabetes specifically since there is nothing of the kind in the field.

"There are many possible uses for the same technology," says Nascimento. "So many people are living with diabetes and have to go through an uncomfortable daily routine. Our product is hopefully going to make things a little easier."

By the Numbers

\$200.2 million in revenue

Nordic Semiconductor has [reported](#) Q2 2022 revenue of \$200.2 million, corresponding to year-on-year growth of 36 percent over Q2, 2021. [Bluetooth LE](#) accounted for 84 percent of total revenue in the quarter, although revenue remains capped by wafer supply constraints. The company recorded a market share of 39 percent of new Bluetooth LE design certifications during the period, according to FCC and Bluetooth SIG data.

\$2.1 billion cellular IoT connections

A new report from market research firm Berg Insight says the global number of [cellular IoT](#) subscribers increased by 22 percent during 2021 to reach 2.1 billion. The major regional markets China, Western Europe and North America grew similarly as the world recovered from the COVID-19 pandemic. By 2026, the analyst projects that there will be 4.3 billion IoT devices connected to cellular networks worldwide. China Mobile is the world's largest provider of cellular IoT connectivity services.

\$415.12 billion by 2029

The global wearable technologies market is expected to reach \$415.12 billion by 2029 according to Meticulous Research. The firm claims the surge in adoption is driven by the uptake of [wearables](#) across multiple application areas. It said by value and volume the smartwatches segment is expected to account for the largest share of the wearables market, thanks to increasing demand for fitness and sports devices.

Wi-Fi

Nordic introduces low power Wi-Fi 6 companion IC for IoT applications

The company's first Wi-Fi solution fills the gap between short range wireless and cellular IoT to offer wireless connectivity for all IoT applications

Wi-Fi 6 promises to secure the popular wireless protocol's place as a foundation technology for the IoT alongside short range wireless solutions such as Bluetooth LE, Thread and Zigbee, and LPWANs such as LTE-M and NB-IoT. Wi-Fi 6's throughput and spectral efficiency ensures fast response from smart devices while also allowing for more network connections. Further technical improvements promise up to 80 percent lower power consumption in like-for-like applications, boosting IoT device battery lifetime. (See [WQ Issue 2, 2022 pg36](#).)

Describing it as "the number one missing capability requested by customers," Nordic Semiconductor is strengthening its wireless IoT solutions portfolio by complementing its short range wireless and cellular IoT product ranges with Wi-Fi 6 products. The company acquired U.K.-based Imagination Technologies' Wi-Fi development team and associated IP assets at the end of 2020. (See [WQ Issue 4, 2020 pg7](#).) Now the company has launched its first Wi-Fi 6 product, the [nRF7002](#), an ultra-low power, dual-band Wi-Fi 6 companion IC.

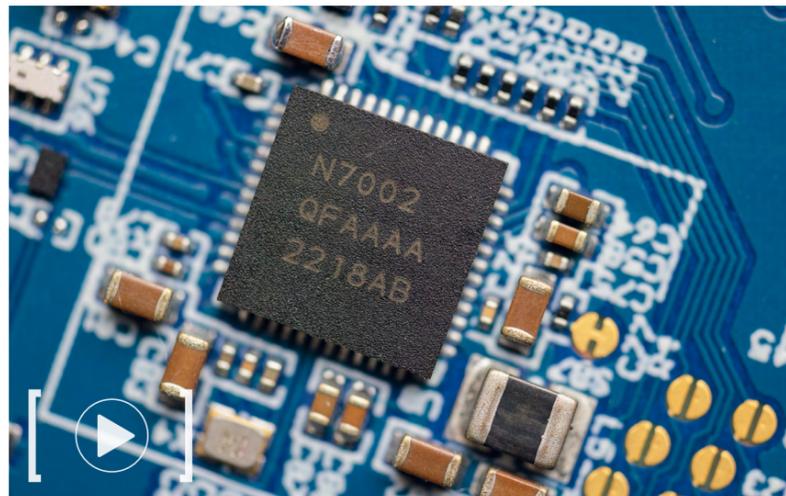
"We were able to bring our first Wi-Fi IC to market very quickly as a result of acquiring an extremely capable Wi-Fi team alongside a portfolio of Wi-Fi assets that team had already developed," says Nordic CTO/EVP of R&D and Strategy, Svein-Egil Nielsen.

"The new Wi-Fi team's relentless hard work to enable Nordic to launch its first Wi-Fi product so soon deserves huge recognition," adds Mike Davis, Nordic's Wi-Fi Systems & Software Director.

Designed for low power consumption

With the nRF7002, Nordic Semiconductor brings decades of ultra low power wireless IoT and silicon design expertise to Wi-Fi 6, bringing even more efficiency gains to a standard that already supports long battery-life wireless IoT operation. With the launch of the Wi-Fi companion IC, Nordic becomes one of the few companies in the world to offer all three of the most popular wireless IoT technologies: Bluetooth, Wi-Fi and cellular IoT.

The nRF7002 is a Wi-Fi 6 Station (STA) IC network device and is compliant with 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). The companion IC operates as a complementary device providing seamless Wi-Fi connectivity and locationing (service set identifier (SSID) sniffing of local Wi-Fi hubs) when used alongside Nordic's existing products such as the nRF52 and nRF53 Series multiprotocol SoCs and



Tech Check

The nRF7002 is a Wi-Fi 6 STA IC operating in the 2.4 GHz and 5 GHz bands. The chip offers good coexistence with Bluetooth LE devices and offers one Spatial Stream (SS), 20 MHz channel bandwidth and 86 Mbps PHY throughput

nRF91 Series cellular IoT SiP. The nRF7002 can also be used as a companion IC in applications hosted by non-Nordic products.

Product development will be supported through Nordic's [nRF Connect SDK](#), a unified software development kit for building applications based on the company's wireless products. The SDK includes all the software and firmware needed to develop Bluetooth LE, Thread, Zigbee, Wi-Fi and cellular IoT products.

"The nRF7002 is a great starting point and we are already well ahead in terms of building a portfolio of unique Wi-Fi products that will combine seamlessly with Nordic's existing ultra low power wireless technologies," says Kjetil Holstad, Nordic's EVP Product Management.

Wi-Fi's key advantages for the IoT are its native IP interoperability, enabling sensors to connect to the Cloud without having to pay additional data subscriptions, and, because access points are ubiquitous, eliminating the need for new infrastructure. The technology's higher throughput compared to other short range wireless tech enables new use-cases like wireless security cameras and high-quality video doorbells.

Wi-Fi forms an integral part of the Matter protocol. By adding Wi-Fi to its range Nordic now supports all three protocols used in Matter - Bluetooth LE for commissioning, Thread for low power mesh networking and Wi-Fi for high-speed wireless applications. (See [WQ Issue 1, 2022 pg14](#).) Those advantages will see the technology playing an increasing role in the nascent IoT.

What next for Wi-Fi?

Wi-Fi has evolved through six generations in the near quarter century since its initial launch and commercialization. The addition of an Internet Protocol (IP) suite to the IEEE802.11 PHY and MAC underpinned Wi-Fi's expansion. The IEEE802.11n and ac versions ('Wi-Fi 4' and 'Wi-Fi 5'), introduced in 2009 and 2013 respectively, then cemented the protocol as the 'go-to' technology for high-speed consumer wireless connectivity. (See [WQ Issue 2, 2021 pg28](#).)

Now Wi-Fi 6 adds key technical features that make the protocol better suited to consumers and the IoT alike. For example, the latest version includes a feature called uplink MU-MIMO (multiuser - multiple input, multiple output) which meets the growing demand for improving Wi-Fi access for multiple devices. And to save battery life in IoT applications, a power-saving feature called Target Wake Time (TWT) enables 'careful' scheduling of traffic exchanges. This in turn enables a connected device to save energy by entering a low power idle mode between communication sessions.

Although Wi-Fi 6 was introduced as recently as 2019, there is already a complementary version, called Wi-Fi 6E, and advanced plans for the introduction of a new, improved version of Wi-Fi, called Wi-Fi 7. Wi-Fi 6E was introduced in early 2020 and is an extension of Wi-Fi 6 that uses RF spectrum centered on 6 GHz. Regulatory authorities are making portions of the 6 GHz spectrum available for unlicensed use. Sitting next to the popular 5 GHz Wi-Fi allocation, 6 GHz is ideal for modified Wi-Fi operation and allows Wi-Fi traffic to move away from the congested 2.4 GHz and the increasingly busy 5 GHz allocations.

Wi-Fi 7 builds on current technology but will bring faster speeds, markedly improved responsiveness and greater reliability for consumer applications, the IoT and Industry 4.0.

Compared to Wi-Fi 6's theoretical maximum access point (AP) raw data throughput of 9.6 Gbps, Wi-Fi 7 offers a theoretical maximum of 36 Gbps from the AP. And a feature called multi-link operation ensures high-priority data is transmitted without delay. This will allow engineers to assign data throughput based on application requirements - ensuring very low latency for real-time control for things such as critical industrial IoT processes.

The [Wi-Fi Alliance](#), the trade body promoting the technology, is working towards adoption of Wi-Fi 7 by 2024.



Wi-Fi 7 will bring faster speeds and greater reliability to Industry 4.0 applications

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Brighter year ahead for chip makers

A report by KPMG and the Global Semiconductor Alliance reveals semiconductor industry leaders are bullish about their prospects for 2022 and beyond

The semiconductor industry has faced its fair share of [challenges](#) in recent times – from rising global inflation and shifting reporting regulations, to an industry talent shortage and fears of further supply chain disruptions.

Despite these and other challenges, many industry insiders are anticipating a bright medium-term outlook for the sector. Financial and operational confidence is evidently surging. A clear reflection of the industry's strength is the KPMG Semiconductor Industry Confidence Index.

This report is based on companies' revenue, workforce growth, capital spending, R&D spending, as well operating profitability for the industry. The conclusion is that operating profitability has increased considerably year-over-year to reach an all-time high. For example, for 2022, the confidence index rose from 61 to 74.

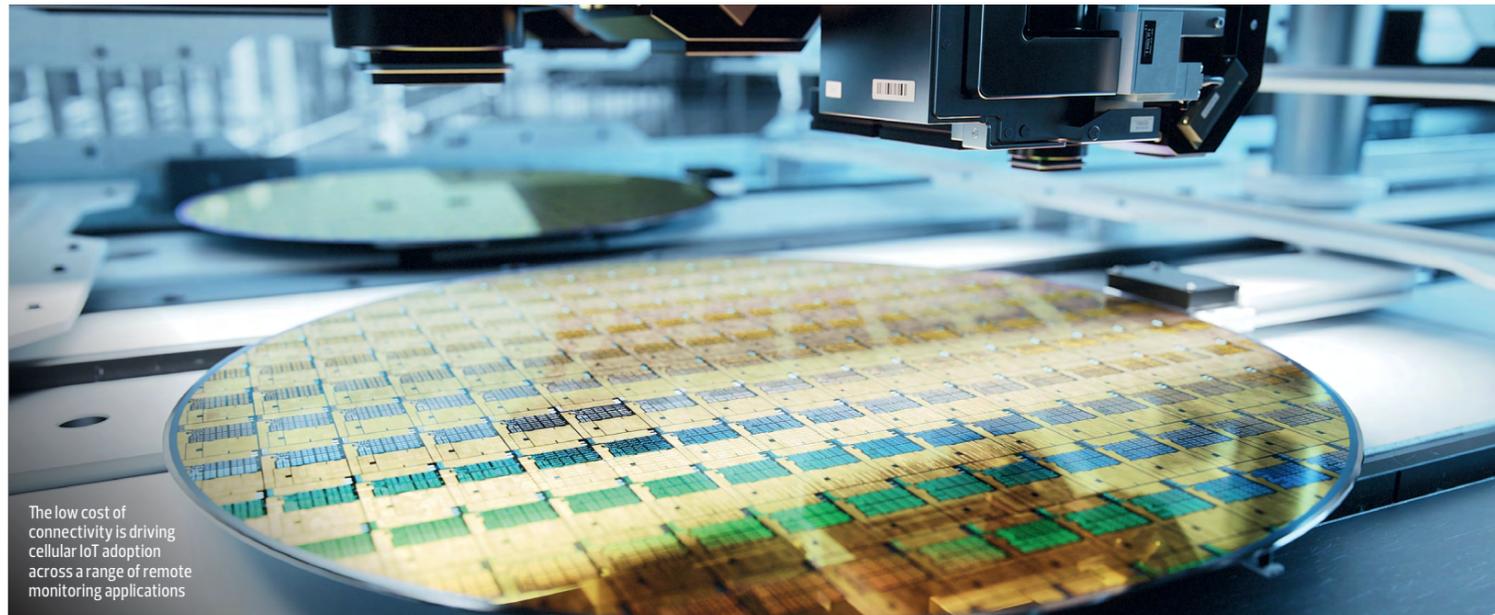
This leap in optimism reflects the key findings from the [Global Semiconductor Industry Outlook 2022](#)—a survey of 152 semiconductor professionals from across the globe, conducted in the fourth quarter of 2021 by KPMG, a professional services company, and the [Global Semiconductor Alliance](#) (GSA)—suggesting "the future of the industry appears as positive as it's ever been on virtually every level".

According to Jodi Shelton, CEO, Global Semiconductor Alliance: "The acceleration to digital in all areas of our personal and professional lives is driving the semiconductor industry to new heights in growth and innovation. There has never been a more exciting time to be a part of this essential industry."

Financial optimism abounds

Buoyed by record demand in all key end-markets, most semiconductor executives (95 percent) expect both company revenue and industry revenue (97 percent), as well as industry operating profitability (91 percent), to increase over the next year, according to the KPMG/GSA report. More than one-third (34 percent) of survey respondents expect their company's revenue to grow more than 20 percent, highlighting the bullish outlook of industry leaders on their financial prospects for 2022.

This optimism should not be overly surprising, the report claims, given the strong demand for chips within numerous industries – from communications and automotive to healthcare and consumer electronics. Driven by a combination of factors, including the rollout of 5G infrastructure, the increased use of AI and the



The low cost of connectivity is driving cellular IoT adoption across a range of remote monitoring applications

rising demand for chips for IoT applications, global semiconductor sales are expected to exceed \$600 billion in 2022, according to data provided by the [Semiconductor Industry Association](#) (SIA).

Investment is also high on the agenda, indicating chip firms are keen to focus on innovation as well as improve efficiencies. A significant majority of respondents (88 percent) expect capital expenditures, including both equipment and software, as well as research and development (84 percent) spending to increase on an absolute level over the year ahead. TSMC, Samsung and Intel all announced plans for major increases in capital expenditures in 2022.

From an operational expectations perspective, 53 percent of representatives from semiconductor firms agree their organizational structure has moved toward being more oriented towards end markets and solutions (such as automotive, communications or consumer electronics), rather than products. Only 18 percent disagreed with this position.

Interestingly, 64 percent of large companies said they are realigning business toward end markets, compared to 38 percent of smaller firms.

This data suggest semiconductor companies are prioritizing the specific needs of customers who use



The acceleration to digital in all areas of our personal and professional lives is driving the semiconductor industry to new heights in growth and innovation



Need to Know

The Global Semiconductor Alliance (GSA) brings together the entire semiconductor ecosystem to represent and promote industry-wide interests. In 2021, Nordic Semiconductor won the 'Outstanding EMEA Semiconductor Company' GSA Award, considered one of the most prestigious awards within the global semiconductor industry

Svein-Egil Nielsen

CTO/EVP R&D and Strategy, Nordic Semiconductor



Five ways the IoT is supporting sustainability

Wireless technology is vital for solving global challenges

During the pandemic, the IoT proved pivotal in keeping countless businesses and organizations functional in a locked-down world. And before the arrival of vaccines, the [IoT was vital](#) in helping the world survive COVID-19.

Today, from helping protect billions from the dangers of COVID, the IoT is set for its next big job – helping build a sustainable global economy. The IoT will do that in a trillion small ways ... and some very large ones too. Let's look at four examples.

The IoT is set for its next big job – helping build a sustainable global economy

Here in Oslo, we have smart refuse bins. That means the bins can be emptied when they're full or left when they're empty. That avoids unnecessary maintenance trips with their associated carbon emissions, not to mention wasted staff time. Granted this example may be a little prosaic, but it's often the commonplace uses of the IoT that have the biggest impact.

My second example is on a bigger scale.

Domestic water heaters are estimated to be responsible for up to 20 percent of home power in the U.S. By using a Nordic-powered cellular IoT wireless controller the [water heaters](#) can be selectively switched on and off during the day to ensure

hot water when needed while smoothing out peaks in electricity demand. Such peaks often require firing-up additional fossil fuel powered generating capacity. By heating up the water at times of low demand, the utility is effectively finding a productive use for excess generation that would otherwise be wasted.

In a third example, the IoT is having a huge positive impact on human health and wellbeing. For example, according to the World Health Organization (WHO), diabetes is the world's ninth biggest killer and costs around \$827 billion in 2016 alone. However, millions of diabetics are already avoiding the severest complications of the disease by using wireless technology. Continuous glucose monitors (CGM) [use Bluetooth LE](#) tech to send blood glucose readings to patients and carers while also ensuring reaction to level changes in a timely fashion.

My final example concerns biodiversity. It's a worrying fact that unless we do something quickly, elephants in Africa are under threat of extinction. Now, thanks to the efforts of Hackster.io, and pro-conservation organization Smart Parks, a competition resulted in the world's most advanced wildlife

tracker for elephants. The tech allows rangers to monitor the risk of poaching and gives them the tools they need to protect elephants over vast areas ([see pg20 this issue](#)).

The pandemic was just one emergency the world faces. The IoT is coming of age not a minute too soon as we have never needed its help more than now.



Agriculture's Golden Age

Connected technologies could help farmers meet growing global demand for food and become more sustainable

In Short

Farmers face a raft of challenges including changing dietary preferences, rising labor and energy costs and changes in the environment

Smart farming, involving the use of data and connectivity, can help farmers make better and more precise decisions, allowing them to generate maximum yield with minimum resources

These techniques are already improving outcomes for farmers, and for the entire agricultural sector, where they could add \$500 billion in value to global GDP by 2030

For more than a hundred thousand years, humans subsisted by foraging, scavenging and hunting for food. About 12,000 years ago, formerly nomadic societies largely ceased moving, opting instead to settle down alongside the crops and animals they had recently learned to cultivate and domesticate.

Theories abound on what triggered this transition from hunting and gathering to farming. Some say it was driven by a desire for a more efficient way to obtain food. Some theorize it was a necessary adaptation to climate changes. Others suggest it may have been a fortunate accident.

Regardless of the reasons, the shift to farming was immensely significant to the human project. Domestication of plants and animals enabled our ancestors to quit nomadic life and build the first villages and towns, creating the earliest versions of the lives we recognize and enjoy today. With a more reliable food supply, populations also burgeoned, with small clans turning into villages and ultimately kingdoms and empires.

While these first farmers clearly changed the course of history, today's crop of farmers are pivotal to safeguarding the future. As we contend with global hunger, population growth and climate change, a technology-led and data-driven revolution in farming methods is taking shape to take on the formidable challenges farming faces.

More people than ever will soon come to depend on the agricultural sector to provide sustenance. As the world's population surges towards 9.7 billion by 2050, 60 percent more food will need to be produced according to the Food and Agriculture Organization of the United Nations (FAO). Yet the FAO says food production is already insufficient, with nearly 690 million people globally going hungry.

AIMING FOR ZERO HUNGER

This is precisely why the UN has established a Sustainability Development Goal (SDG) of 'Zero Hunger', to end all forms of hunger and malnutrition by 2030 and ensure all people—especially children—have sufficient and nutritious food all year. The UN says "increasing agricultural productivity and sustainable food production are crucial" to meeting this goal.



As the world's population surges towards 9.7 billion by 2050, more people than ever will come to depend on the agricultural sector to provide sustenance

Easier said than done. Farmers today face a dizzying array of challenges even to maintain the status quo. These include rapidly changing dietary preferences, rising labor and energy costs, and changes in the environment. The last of these is arguably the most impactful, with agriculture proving extremely vulnerable to climate change. "Climate change's negative impacts are already being felt, in the form of increasing temperatures, weather variability, shifting agroecosystem boundaries, invasive crops and pests, and more frequent extreme weather events," says the World Bank in a 2021 report. "On farms, climate change is reducing crop yields, the nutritional quality of major cereals and lowering livestock productivity."

By 2050, 70 percent of crops produced in sub-Saharan Africa will be grown in areas experiencing "extreme" heat stress, according to the Bill & Melinda Gates Foundation. And about one quarter of arable land is also degraded and will need significant restoration before it can again sustain crops at scale, says consulting firm McKinsey.

Global demographic shifts compound these pressures. For instance, demand in China for meat and dairy products will double by 2050. Evolving consumer expectations also put farmers under pressure to adopt more ethical and sustainable farm practices—such as improved animal welfare and reduced chemical and water use—even as they

try to radically increase production. In short, the average farmer is facing a squeeze.

The effects of the environment on farming also flow in reverse. The agricultural sector is an outsized contributor to climate change, responsible for up to a third of total greenhouse gas (GHG) emissions, according to the World Bank. Farming practices have impacted the land, with 52 percent of agricultural area moderately or severely degraded. With the agriculture sector now being asked to ramp up farm production to address future hunger needs, José Graziano da Silva, Director-General of the FAO sounds a warning: "Doing that with a farming-as-usual approach would take too heavy a toll on our natural resources."

THE NEXT WAVE OF TRANSFORMATION

A disruption to current agricultural techniques is clearly necessary. Fortunately, agriculture is no stranger to innovation, having gone through multiple waves of transformation since the first farmers began tending crops all those millennia ago. The first farming revolution—in the 17th and 18th centuries—was mechanical, introducing machinery such as tractors to expand the scale, speed and productivity of farms. In the aftermath of World War Two came the second revolution—the introduction of genetic

modification of seeds, fertilizers and pesticides, as well as improved irrigation.

While these innovations have improved farming yields historically, experts contend they won't resolve today's challenge to meet growing demand as farming conditions deteriorate. The catchcry is to find a way to "produce more with less".

Thankfully, the next revolution already has a name and shape—smart agriculture. "A smart farm is one that can operate in an optimal way—generating maximum yield with minimum resources—with little or no human interaction," says Clay Hine, a Business Development Manager at Nordic Semiconductor. "At the heart of smart farming is the use of data and connectivity, supported by AI and analytics, to help farmers make better and more precise decisions." Nordic is a global provider of wireless IoT solutions, and as a [UN Global Compact signatory](#) and active supporter of the [UN's Sustainable Development Goals](#) (SDGs), is exploring how these solutions can solve problems like global hunger.

So-called 'precision farming' will likely be one of the cornerstones of smart agriculture. Using a combination of connectivity solutions, sensors, autonomous machines, drones and data analytics, farmers will get a granular picture of the demands of their crops and livestock and can respond with exactly what they need. According to the

By the Numbers

100,000
cows milked daily on the world's largest farm, the Mudanjiang City Mega Farm in China

Source: AgronaMag

1.94 billion
metric tons Annual sugar cane production

Source: Statista

1.53 billion
hectares on earth covered with crops

Source: National Geographic

70%
of all fresh water is used in agriculture production

Source: World Development Indicators

570 million
Number of farms worldwide

Source: Food and Agriculture Organization of the United Nations

World Economic Forum, the benefits of precision farming "range from improved productivity and crop quality to more efficient operations, reduced input usage and costs, lower environmental impact and adaptation to climate change".

Consider an irrigation system. Connected humidity sensors placed among crops could communicate with water sprinklers to deliver the exact amount of water to the plants when they need it, improving yields while minimizing precious water use.

Austrian firm voestalpine's leova SMART vineyard post is an example of this in action. The product uses a cellular IoT solution in combination with connected sensors and AI to capture and analyze microclimatic conditions and provide viticulturalists with accurate insights—such as frost warning and precipitation predictions—so they can better manage their vineyards. As well as boosting yields, tools like the leova SMART also help farmers reduce their ecological footprint. The product's leaf wetness sensors support reduced use of water, while its ability to detect fungal diseases allows for minimized or site-specific application of fertilizers and pesticides, reducing GHG emissions. While designed for viticulture, IoT solutions like the leova SMART could be extended to a range of crop monitoring scenarios.

Vertical farming is another smart farming innovation also making its mark on food production challenges. An increasingly popular method for growing small plants such as leafy greens and strawberries, vertical farms are indoor



Tech Check

Nordic's nRF9160 is a compact, highly integrated SiP that makes low-power LTE technology and advanced processing and security accessible. The integrated modem supports both LTE-M and NB-IoT wireless connectivity



installations where plants are stacked vertically on shelves in a completely enclosed and controlled environment. LED lights replace sunlight, closed-loop recycled water is used, and because it's a protected environment, there's no need for pesticides. According to *Science Focus* magazine, vertical farming allows 10 times the yield for a given land area. Other estimates indicate it uses 95 percent less water. More innovative vertical farm installations also use sensor networks and connected solutions to automate control and monitor key indicators including humidity, fertilization, temperature, and light intensity and color for maximum yield.

Connected technologies also help keep farm machinery

running reliably, by using sensors combined with data processing to monitor the state of critical equipment such as machinery, water tanks, pumps and even fences and gates, thus supporting farmers to intervene accordingly. This predictive approach not only reduces overall maintenance costs, it can also increase yields given the considerable impact of critical machinery breaking down or functioning poorly during planting and harvest periods. Autonomous farming machinery such as combine harvesters aided by GPS, computer vision and sensors are another area of great promise. These machines not only liberate farmers from manual activities, but often deliver greater precision than when humans operate the same machines, leading to more complete harvesting.



Using a combination of connectivity solutions, sensors, autonomous machines, drones and data analytics, farmers will get a granular picture of the needs of their crops and livestock



only enables them to maximize the value of their farming efforts but is a far more sustainable approach given one third of all food produced is lost or wasted. Surveys also show 70 percent of consumers would be willing to pay a premium for brands that provide traceability and for organic ingredients. Harnessing data enables farmers to demonstrate this traceability and benefit from such lucrative opportunities. Richer farming data is also likely to create more insurance offerings, to ease a notably risky and difficult livelihood.

Investors are also expected to find attractive the substantial upside in smart farming. "It's a sleeping IoT giant and the growth potential is immense," says Nordic's Hine. "In 2020, the world's 525 million farms had two billion connected devices, up from zero in 2000. But by 2035, we expect there to be 20 billion devices across these farms, which will mean countless new use cases and applications built on the data being generated."

Estimates indicate that the smart agriculture market in Europe alone will experience a 10.6 percent compound annual growth rate from 2018 to 2028. Global bodies like the World Bank are actively supporting the trend, with so-called Climate-Smart Agriculture Investment Plans in place in countries including Bangladesh, Zimbabwe, Zambia, Lesotho, Mali, Burkina Faso, Ghana, Cote D'Ivoire, Morocco and The Republic of Congo.

Of course, there are potential barriers to the uptake of smart farming. Connectivity is clearly a key enabler of this technology, and some regions currently lack the necessary infrastructure. However, McKinsey notes that: "By 2030, we expect advanced connectivity infrastructure of some type to cover roughly 80 percent of the world's rural areas". Additionally, many precision farming applications such as crop and livestock monitoring are increasingly designed to run on cellular IoT networks, which are increasingly ubiquitous in the world.

Perhaps a more intriguing question centers on the capabilities of farmers to operate the solutions, tools

Farms, facts and the silver screen

Farming today attracts a lot of attention from filmmakers. Growing interest in the environment, sustainability and in the ethical food movement in recent years has seen a spate of documentaries focused on agriculture.

Many of the more popular films narrow in on so-called 'factory farming'. For many, this might create an image of modern-day farming as predominantly one of highly intensive, mechanized and mass-scale operations, run mostly by global multinationals.

In truth, the world's farming population is far more diverse, and farms themselves are more varied in size and composition. According to the World Economic Forum, 84 percent of the world's 570 million farms cultivate less than two hectares of agricultural land. The world's smallholder farmers also produce around a third of the world's food, according to the Food and Agriculture Organization

of the United Nations (FAO). Other bodies have claimed the output from small-scale farms could even be as high as 70 percent.

Misconceptions about farm sizes also run the other way. While many farms are often understood to be 'family owned', so-called 'family farms'—which occupy up to 80 percent of the world's farmland—are not always small.

"It is imperative that we avoid the use of the terms family farms and small farms interchangeably; the majority of family farms are small, but some are larger and even very large," says Marco Sánchez, Deputy Director of FAO's Agrifood Economics Division. So large are some of the bigger farms that the largest one percent of farms in the world account for 70 percent of the world's farmland. No wonder books with titles like *The Myth Of The Family Farm*, which highlight



growing corporate penetration, have been written as far back as the 1980s.

At the smaller end though, farming continues to be very much associated with hard toil. Consistent yields are difficult, and rarely achieved without lots of grueling human effort. Owners of the smallest farms are also among the world's poorest people, and often go hungry.

More efficient farming practices can support improved livelihood for these communities, while meeting global food needs.



Autonomous robots fitted with cameras and sensors can be deployed in fields to monitor crops for any sign of disease or pest infestation

and technologies associated with smart farming. The *Proceedings of the National Academy of Sciences* (PNAS), a US-based science journal, observes that: "Limited knowledge and skills can be significant adoption hurdles [to smart farming] especially in developing countries." Others fear the introduction of robots and autonomous systems might devalue and undermine respect for the traditional role of the farmer.

Yet even here there appears to be a silver lining. The British National Farmers' Union argues introducing new technologies into farming could be just what the profession needs, by overhauling stereotypes about farming as solely back breaking and laborious work. Instead, the industry's push into tech could attract younger and more technically skilled entrants to an aging workforce. A survey by consulting firm Cap Gemini also listed "farmers are not ready for digital" as one of 10 digital myths in agriculture.

A MORAL CASE

Yet perhaps the strongest case for introducing smart farming is a moral one. About 40 percent of the world's population works in agriculture, while farmers make up 65 percent of the world's poorest people. In sub-Saharan Africa, women form most of the small-holder farmers.

These impoverished custodians of the land face a daily challenge to survive, and climate change is making their existence that much harder. "The agricultural platform can lift millions of people out of poverty ... that platform is burning right now as we speak," says Enwock Chikava, interim director of agricultural development at the Gates Foundation. On top of this predicament, the world now expects farmers to carry the burden of resolving long-standing global challenges – to feed a growing global population while increasing environmental sustainability, even as these aims may come into conflict with each other.

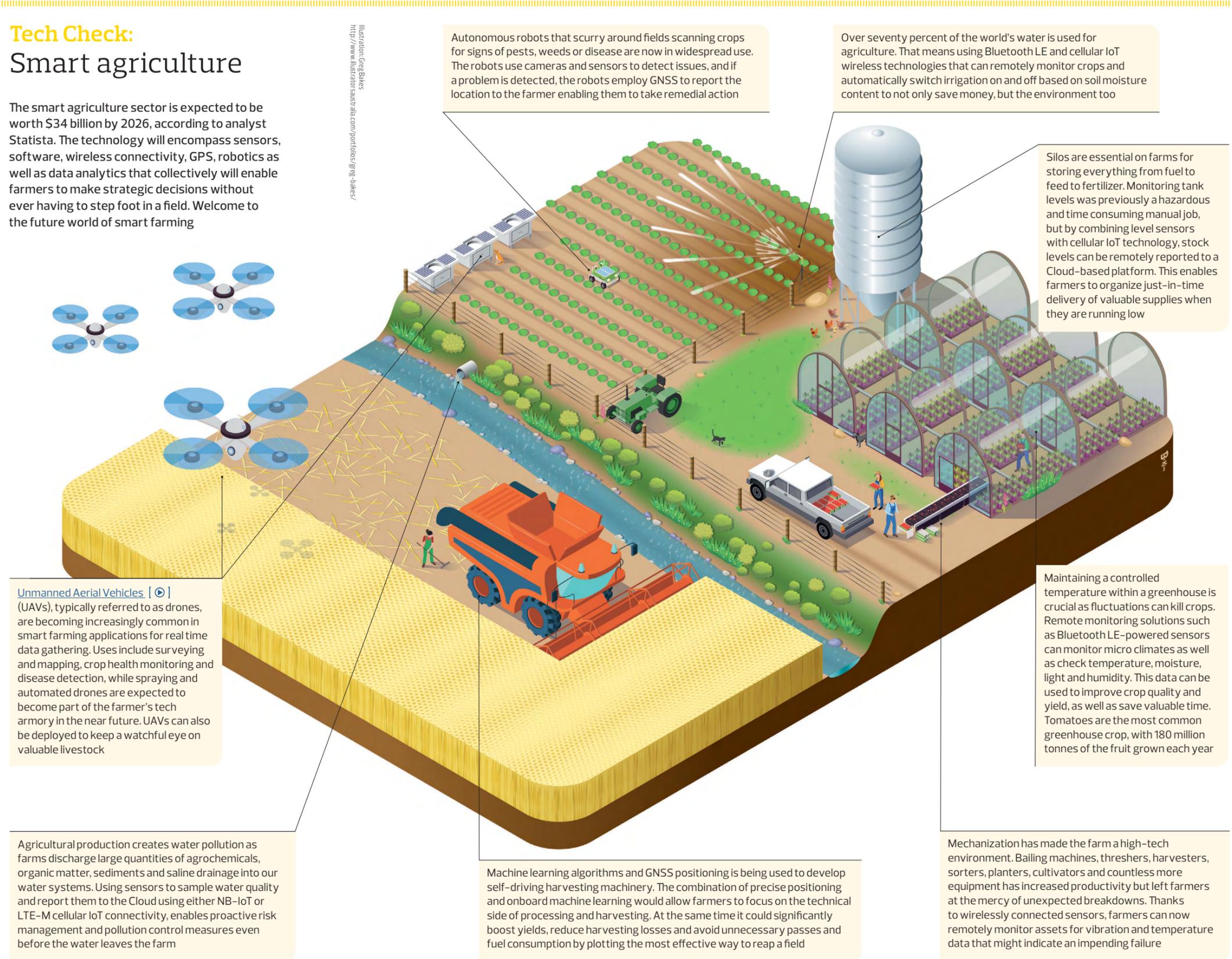
The time is ripe to ease this burden by introducing connected technologies based on the IoT into agriculture, so farmers can implement and then enjoy the fruits of these innovations.

“ The time is ripe to ease the burden of sustainably feeding a growing population by introducing connected IoT technologies to agriculture

Tech Check:
Smart agriculture

The smart agriculture sector is expected to be worth \$34 billion by 2026, according to analyst Statista. The technology will encompass sensors, software, wireless connectivity, GPS, robotics as well as data analytics that collectively will enable farmers to make strategic decisions without ever having to step foot in a field. Welcome to the future world of smart farming

Illustration: Greg Bikes
<https://www.illustratorsofaustralia.com/portfolios/greg-bikes/>



Autonomous robots that scurry around fields scanning crops for signs of pests, weeds or disease are now in widespread use. The robots use cameras and sensors to detect issues, and if a problem is detected, the robots employ GNSS to report the location to the farmer enabling them to take remedial action

Over seventy percent of the world's water is used for agriculture. That means using Bluetooth LE and cellular IoT wireless technologies that can remotely monitor crops and automatically switch irrigation on and off based on soil moisture content to not only save money, but the environment too

Silos are essential on farms for storing everything from fuel to feed to fertilizer. Monitoring tank levels was previously a hazardous and time consuming manual job, but by combining level sensors with cellular IoT technology, stock levels can be remotely reported to a Cloud-based platform. This enables farmers to organize just-in-time delivery of valuable supplies when they are running low

Maintaining a controlled temperature within a greenhouse is crucial as fluctuations can kill crops. Remote monitoring solutions such as Bluetooth LE-powered sensors can monitor micro climates as well as check temperature, moisture, light and humidity. This data can be used to improve crop quality and yield, as well as save valuable time. Tomatoes are the most common greenhouse crop, with 180 million tonnes of the fruit grown each year

Unmanned Aerial Vehicles (UAVs), typically referred to as drones, are becoming increasingly common in smart farming applications for real time data gathering. Uses include surveying and mapping, crop health monitoring and disease detection, while spraying and automated drones are expected to become part of the farmer's tech armory in the near future. UAVs can also be deployed to keep a watchful eye on valuable livestock

Agricultural production creates water pollution as farms discharge large quantities of agrochemicals, organic matter, sediments and saline drainage into our water systems. Using sensors to sample water quality and report them to the Cloud using either NB-IoT or LTE-M cellular IoT connectivity, enables proactive risk management and pollution control measures even before the water leaves the farm

Machine learning algorithms and GNSS positioning is being used to develop self-driving harvesting machinery. The combination of precise positioning and onboard machine learning would allow farmers to focus on the technical side of processing and harvesting. At the same time it could significantly boost yields, reduce harvesting losses and avoid unnecessary passes and fuel consumption by plotting the most effective way to reap a field

Mechanization has made the farm a high-tech environment. Baling machines, threshers, harvesters, sorters, planters, cultivators and countless more equipment has increased productivity but left farmers at the mercy of unexpected breakdowns. Thanks to wirelessly connected sensors, farmers can now remotely monitor assets for vibration and temperature data that might indicate an impending failure

Finding Fauna

According to the endangered species list, over a quarter of all mammals are in danger of extinction. Wireless tech has a role to play in reversing that statistic

In Short

Humans are in large part to blame for the growing number of endangered species due to habitat loss, climate change, poaching and conflict with indigenous communities

In anti-poaching measures, Bluetooth LE collars equipped with motion, audio and vision sensors have been deployed to protect African elephants from the illegal ivory trade. Cellular IoT and GNSS technology can be harnessed to lock the fuel pump of heavy machinery and shut it down if it moves into geofenced or protected territory

Those that have been fortunate enough to see a snow leopard in the wild can count themselves among the lucky few. Wildlife photographer Saurabh Desai spent almost three years in search of the wild cat before he finally snapped one. Biologist Rodney Jackson was only marginally more successful. He spent the early 1980s in Nepal aiming to fit radio collars to snow leopards, four years later he returned home having only tagged five animals.

Tracking snow leopards is challenging. There are believed to be fewer than 7,000 of the cats remaining in the wild, across a habitat that extends for nearly two million square kilometers over inhospitable mountainous regions from Uzbekistan to Mongolia. Seventy percent of this habitat remains almost entirely unexplored according to the World Wildlife Fund (WWF), which is why their estimated population is little more than an educated guess. Unnervingly, so good is their natural camouflage you probably wouldn't realize you were looking at a snow leopard even if you were. As Jackson says: "Way more snow leopards see people than people see snow leopards." (see sidebar pg23, *Hiding in plain sight*.)

Like so many other animals that can be elusive to locate in the wild, humans are in large part to blame as increased habitat loss and degradation, climate change, poaching and conflict with indigenous communities has seen populations dwindle. The good news is that thanks to more recent

conservation efforts, snow leopards are now listed as 'vulnerable' rather than 'endangered' on the International Union for Conservation of Nature (IUCN) Red List, but their future is far from secure.

Supporting technology has also moved on from the rudimentary radio collars Rodney Jackson was using 40 years ago. The collars he used in the early 1980s were in effect VHF transmitters, emitting a radio signal which was picked up by a handheld receiver connected to an antenna. They had a range of around 12-to-15 kilometers if the weather was good and you had direct line-of-sight. The problem of course is snow leopards live in the mountains, where you can't rely on the weather, nor maintaining line-of-sight with an animal that can move over 100 kilometers in a few days. Today's technology is rather more sophisticated, and has as important a role to play in the conservation of animals as humans do.

THE TROUBLE WITH HUMANS

While Earth is home to millions of species, one dominates. And we humans are both self destructive and inconsiderate citizens. As our global population charges towards eight billion and beyond, our increasing use of land—for agriculture, cities, roads and mining—and the pollution we generate in the process, is putting humans in direct conflict with the animals that occupied this habitat well before us.

"Demand for land for food is going to triple—at least—by the end of this century," said British computational scientist, Stephen Emmott, writing in *The Observer* newspaper. "This means pressure to clear many of the world's remaining tropical rainforests ... is going to intensify, because this is predominantly the only available land that is left for expanding agriculture at scale." As land is cleared to meet rising food demands, the accompanying CO₂ emissions will be measured in gigatonnes, and the resulting climate change will be devastating for animals — us included. Therein lies an irony. As the best-known living natural historian David Attenborough says: "It's not about saving the planet, it's about saving ourselves."

And then of course there are our more deliberate and wanton acts of wildlife destruction, poaching and trophy hunting for example. According to the International



Wildlife Defense Foundation (IWDF), the illegal hunting and harvesting of animals is the second biggest direct threat to species after habitat destruction. And the loss of one species can have a chain reaction, leading to the loss of other animals or the collapse of their ecosystem. In anti-poaching efforts, technology is proving itself a significant ally of conservationists, but the poachers are often more resilient than the animals they hunt.

TECHNOLOGY TO THE RESCUE

One animal being rapidly driven to the brink of extinction is the African elephant, with the most recent reliable estimate putting the continental population at 415,000 according to the IUCN. If that number seems large for an at-risk species, consider that their population stood at 10 million less than 100 years ago. Decades of poaching for ivory, human-elephant conflict, and habitat loss due to human population expansion has the two sub species—the African savanna elephant and the African forest elephant—listed as endangered and critically endangered respectively.

Supplementing conservation efforts is a technology-based initiative, the [ElephantEdge challenge](#), which aims to replace traditional and manual methods of elephant monitoring with a connected alternative. A joint enterprise

of Avnet community, Hackster.io and pro-conservation organization Smart Parks in combination with leading technology partners including [Nordic Semiconductor](#), the design competition asked developers to create machine learning (ML) models that could be installed onto wirelessly connected collars integrating vision, audio and motion sensors, as well as Web-based dashboards that could help park rangers use the data to track, monitor and receive on-demand alerts about the elephants.

The top ten winning entries will be deployed on production-grade collars manufactured by Institute IRNAS and used to monitor poaching risk, human conflict and elephant activity, for example. According to Svein-Egil Nielsen, CTO and EVP R&D and Strategy at Nordic, the initiative is clear evidence of the role technology can play in reversing the harm humans inflict on the natural world.

"There are still elephants, but they and other endangered animals are under constant pressure and it's looking pretty bad," Nielsen told the recent GSA 2022 European Executive Forum. "But what if we could solve the poaching problem with a tiny piece of electronics?"

"Without the IoT I think elephants would be extinct within a few years. [Which is why] I believe the IoT is instrumental to the wellbeing of this planet in fact I believe it is an absolute necessity to save the world."

“
The IoT is instrumental to the wellbeing of this planet. In fact it is an absolute necessity to save the world



Illegal hunting of animals is the second biggest direct threat to species after habitat destruction

TAG AND TRACE

It's not only the poster animals that need saving with the help of technology. Vultures may not hold the same fondness in human consciousness as elephants, but they are no less vulnerable. Vultures perform important ecosystem functions as they clean the landscape by eating carcasses, limiting the spread of wildlife diseases. Yet, vulture populations in Africa are rapidly declining, mainly owing to intentional and unintentional poisoning.

The difficulty is vultures have vast home ranges that can stretch for up to 75,000 square kilometers, so tracking the birds and their behavior is impossible without the assistance of technology. One project aiming to do just that is being piloted by the Leibniz Institute for Zoo and Wildlife Research (Leibniz-IZW) in Berlin, Germany. The researchers are developing tags that combine motion sensors, GPS tracking and a camera, while on-board ML algorithms are used to decode data and images of the movements and behavior of individual vultures, enabling relevant data to be uploaded to a satellite network in near real time for study and analysis by researchers.

Additionally, the project will develop decentralized, ML-based data analyses on various tags on vultures and lions to unravel the movements and behaviors within bird flocks, and the carnivore and scavenger communities. "The high-tech approach will facilitate new insights," says Dr Jörg Melzheimer, head of the project at the Leibniz-IZW. "We will not only better understand vultures ... we will also learn about it faster. Our project will link human, animal and AI for watching the ecosystem in real time."

PINCHING THE POACHERS

South African-based IoT solutions company [iSiTech](#) is also pioneering the use of wireless tags to track both wildlife and livestock at risk of poaching and theft, at the same time monitoring the animals' health and behavior. The devices are easily applied to the ears of livestock and wildlife and are equipped with temperature and movement sensors as well as GNSS.

Once attached to the animal's ear, the tag employs Nordic's [nRF52840](#) SoC to not only supervise the on-board sensors but also to relay the data using [Bluetooth LE](#) wireless connectivity to a gateway, which in turn transfers the data to the Cloud where farmers or conservation agencies can review the data, set-up geofencing of feeding areas with go and no-go zones, as well as review captured sensor data. For example, low movement could indicate animal illness, or if it is outside of the set boundary, the animal may be lost or have been stolen.

To overcome the problem of grazing animals and wildlife that may roam outside of conventional Bluetooth LE wireless range, the tags also integrate Nordic's [nRF21540](#) RF Front End Module (FEM), a power amplifier/low noise

By the Numbers

99% of endangered species are caused by humans

Source: World Animal Foundation

Animals are going extinct between **1,000 & 10,000** times faster than the natural rate

Source: Tufts Now

125,000 animals are hunted as trophies every year

Source: World Animal Protection

The African elephant population has decreased by **95%** in the last 90 years

Source: Thompson Safari

7,079 species of animals are critically endangered

Source: Britannica.com



amplifier (PA/LNA) solution enabling the device to relay data from the tag to a gateway over a line-of-sight distance of up to three kilometers.

ACROSS THE FROZEN TUNDRA

For animal tracking applications over longer distances cellular connectivity is being successfully deployed in a growing number of use cases, including tracking reindeer across the arctic tundra. The semi-domesticated animals are an important source of nutrition, clothing and income for polar indigenous communities, and as such arctic peoples in Norway, Sweden, Finland, Russia, Mongolia and China herd some 2.5 million of the animals across four million square kilometers.

To keep track of the health and whereabouts of reindeer, farmers can now use light weight ear tags offering an integrated LTE-M/NB-IoT modem and GNSS, application processor, antenna, as well as motion and thermal sensors. The tags autonomously measure reindeer activity using the onboard sensors, and report every hour any significant changes that indicate either illness, injury or predator attack, as well as the animal's location - enabling rapid rescue and treatment. (See [WQ Issue 2, 2019 pg10.](#))

"The commercial challenge for herding livestock farmers is that they have to manage hundreds or thousands of animals and the loss of even a few can significantly [affect] slim profit margins," says Geir Langeland, Nordic's EVP Sales and Marketing. "This makes IoT-enabled herding ... particularly attractive to them as a way to protect profits and minimize any illness or injury of their animals."

HABITAT PRESERVATION

If using wireless technology to track every single valuable or endangered animal isn't yet quite a reality, then using it to halt the progress of people and their equipment of mass habitat destruction is another alternative. An initiative

launched in 2019 called [Code of Conscience](#) hopes to convince organizations around the world to monitor and restrict the use of heavy-duty vehicles on protected land. Open source software uses mapping data together with GPS installed in construction vehicles to autonomously restrict crews from entering protected zones.

The software is linked to the fuel pumps of the machinery, enabling automatic shutdown if the equipment moves into a restricted area. The Proof-of-Concept (PoC) design uses the [Nordic Thingy:91](#) multi-sensor cellular IoT prototyping platform to enable notifications and audits of the machinery's position during normal operation.

The PoC and a pilot project in the Amazon rainforest proved the feasibility of the technology, but implementation at a global scale will require a willingness among big business to collaborate. Two years ago an invitation was sent to the CEOs of the world's top 10 manufacturers of heavy machinery to adopt the code - none yet have. (See [WQ Issue 3, 2020 pg10.](#))

"The sociopolitical challenges of implementing this at scale are the most urgent to solve," says Tim Devine, Executive Creative Director at AKQA, the agency behind the initiative. "Many of the regions where the Code of Conscience will be useful have complex sociopolitical conditions ... [but we are] looking to build key partnerships that will help the transition from PoC to adoption."

Whether it's using wireless tech to save the Amazon rainforest and its inhabitants, elephants in Africa, or the elusive snow leopard, the stakes could not be higher. Every year between 200 and 100,000 extinctions occur. The inaccuracy of the prediction is because scientists have no idea how many species exist, and thus how many are lost before they are even discovered. Nevertheless this extinction rate is up to 10,000 times higher than it should be, and one mammal is the reason why. Us.

But human tech could give hope to other species. It may be too late for the Dodo, the West African Black Rhinoceros and the Woolly Mammoth, but it's not too late for us.

Hiding in plain sight

It might be inconvenient for conservationists trying to track and monitor animals, but if you aren't an apex predator, camouflage can be an important weapon in your bid for survival. If you are a predator, it is handy for sneaking up on your prey. Also known as cryptic coloration, animals use camouflage to mask their location, identity and movement, usually to blend in with their background and surroundings.

Animal species are able to camouflage themselves through two primary mechanisms - pigments and physical structures. Some animals have natural, microscopic pigments-known as biochromes-which absorb certain wavelengths of light and reflect others. Other species have physical structures that act like prisms, reflecting and scattering light to produce a color that is different from their normal skin tone.

The most famous exponent of camouflage in the animal kingdom is the chameleon, but rather than change its skin color so that it can't be seen, the iconic lizard does the opposite. When a chameleon is threatened, it changes its color in order to communicate to other chameleons and warn them of the presence of danger.

Zebras on the other hand prefer to hide in plain sight. It might seem an evolutionary mistake to adopt black and white stripes against a background of golden yellow-brown savanna, but in fact their coloring makes it nearly impossible for a predator to tell one zebra from another, making it difficult for them to stalk an individual animal. Also lions-the main predator of the zebra-are color blind, so zebras have no need to match the color of their environment.

As for humans, we didn't cotton on to the benefits of camouflage until the 17th century. Before then, military uniforms were brightly colored in order to intimidate the enemy (a trick some animal species also employ). It wasn't until the 1850s that British Army officers dyed their bright white uniforms a dull sandy tan to blend in with their desert surroundings in India. They called the uniforms khakis, a Hindi word for dust.



Tech Check

The [nRF21540](#) RF Front End Module (FEM) is Nordic's power amplifier/low noise amplifier (PA/LNA) solution for applications demanding extended range, such as tracking wildlife over wide areas. The addition of the FEM offers a highly adjustable TX power boost up to +21 dBm, with the LNA providing +13 dB RX gain for solutions powered by Nordic's nRF52 and nRF53 Series multiprotocol SoCs



Making the Grade

Wireless educational devices like the BBC micro:bit can help the engineers of tomorrow learn the digital skills they'll need to address diverse global challenges

In Short

Education will need to play a critical role in supporting sustainability and development. Governments, industries, companies, STEAM educators and technology developers must work together to address inequalities in digital education. Global initiatives supported by Nordic Semiconductor are providing digital education opportunities for the coders of the future.

Almost two-thirds of the children that entered first grade in 2016 will work in jobs that did not exist at the time, according to the World Economic Forum. And by 2029, when many of those students will move into higher education or the workforce, the U.S. Bureau of Labor Statistics projects there will be 3.6 million computing-related job openings in that country alone.

While we may not yet have a clear picture of the industries that will thrive and help us survive, or exactly what future jobs will entail, we do know one thing – hardware and software engineers will be the lifeblood of tomorrow's connected world. And as such they're going to carry enormous responsibilities.

That's because global challenges are diverse and will be difficult to overcome. Society will need coders capable of leveraging advanced technologies to their full potential if innovation is to be relied upon to solve these problems. To tackle climate change, the impact of aging populations and endemic diseases, let alone sustainability, we must build a pipeline supplying skilled engineering practitioners and make sure it flows continuously.

But to make that happen we first need to address global education shortcomings. In a message to the fourth United Nations' International Day of Education, Audrey Azoulay, UNESCO Director-General, pointed to the essential role of education for global peace, sustainability and development. "Glaring inequalities, a damaged planet, growing



polarization and the devastating impact of the pandemic present us with a generational choice: continue on an unsustainable path or radically change course," asserted Azoulay. "In these exceptional times, business as usual is no longer an option. If we are to transform the future, if we are to change course, we must rethink education."

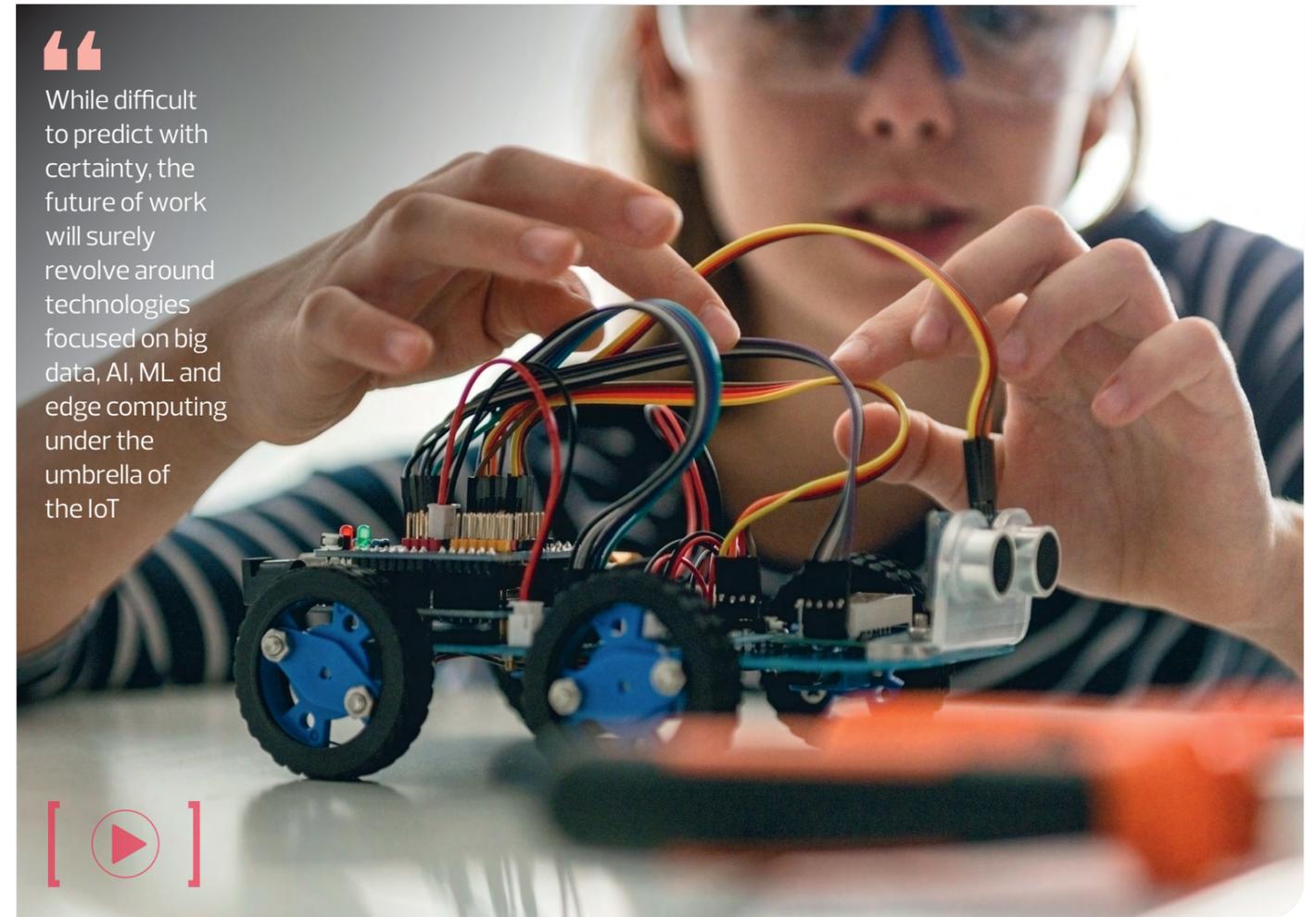
At the same time, urgent action is needed to protect the futures of young people and prevent a lost COVID-19 generation, says the former Director-General of the Confederation of British Industry (CBI), Dame Carolyn Fairbairn. Yet on a global scale the educational crisis is not new. Even before the pandemic caused disruptions, 268 million children were excluded from school (according to UNESCO). It's a confronting reality with wide-reaching impacts. As it stands, even as education systems try to keep pace with rapid change, there's often insufficient support to teach necessary digital skills.

SKILLS TO FILL

Employers are already finding it difficult to find the digital skills they require – and the problem is set to get worse. In the chip sector, for example, today's global skills shortage is a major concern. (See *this issue* pg12.)

"The shortage of tech talent is real and will not resolve itself," says Mark Gibson, National Sector Leader, Technology, Media & Telecommunications, KPMG in the U.S. "Semiconductor companies need to start creating a multifaceted talent pipeline, including apprenticeships and partnerships with secondary education that foster STEM [science, technology, engineering and math] interest in under-represented populations."

The unbalanced demographic of students is another factor that threatens to undermine the supply of engineers. This lack of diversity impacts skills and ideas, stifling technological innovation as well as future career prospects. For example, in 2017, women accounted for just 16 percent of engineers, according to the U.S.'s National Science Board. Meanwhile, women are significantly outnumbered in both school programs and the workforce. They receive only 21 percent of computer science bachelors degrees and hold only 25 percent of computing roles, says the country's National Center for Women & Information Technology.



While difficult to predict with certainty, the future of work will surely revolve around technologies focused on big data, AI, ML and edge computing under the umbrella of the IoT



There is a growing deficit in opportunity for young people, especially for girls and those from other under-represented groups, explains Gareth Stockdale, CEO of the [Micro:bit Educational Foundation](#), a not-for-profit founded in the U.K. in 2016. Even when the necessary digital skills are available to employers, there's a lack of diverse candidates, according to Stockdale, who says these issues are being felt globally and affect billions of young people. Finding a solution, he says, will hinge on revolutionizing how young people are taught, equipping them with the skills for the digital present and future (see sidebar pg27: *The rise of classroom tech: from the abacus to micro:bit*).

"Without these more diverse perspectives influencing the creation of technology, we will perpetuate—even deepen—social and economic inequity due to the pivotal role technology now plays in modern life," he concludes.

CREATING OPPORTUNITIES

Our current inability to support the digital education of young people is a massive problem that must be addressed. And the onus falls on governments, industries, companies and STEAM (science, technology, engineering, the arts and math) educators alike. Technology developers have a critical role to play too. When made easily accessible,



Need to Know

The BBC micro:bit is a transformative tool developed to inspire every child as they move towards the workforce. So far, micro:bits have benefitted more than 25 million young people across more than 60 countries worldwide. By 2025, the foundation aims to have 20 million of these devices helping 100 million young people learn about technology



new coding and computational thinking solutions can help build the digital skills of tomorrow's innovators. In turn, these digital skills will allow children and students everywhere to improve their life opportunities, while at the same time contribute to a more advanced society better prepared to tackle global challenges.

The good news is that change is already underway. One of the ways the Micro:bit Educational Foundation is addressing the challenge is through the new [micro:bit v2](#), a pocket-sized computer and user-friendly educational resource using a Nordic [nRF52833](#) SoC as the device's main microprocessor and connectivity device.

Moreover, the Foundation has teamed up with various initiatives to launch programs dedicated to digital literacy and high-quality technical education for all.

A Nordic Semiconductor grant is supporting a number of these project partners' activities. The Nordic-funded projects are targeting young people from low-income communities with very limited technical infrastructure, predominantly in Africa. For example, Nordic has supported '[Teens Can Code](#)', a registered social enterprise, to train 52 volunteers who have then carried out coding workshops focused on the 'do your :bit challenge'. The challenge encourages young people aged eight-to-18 across seven states in Nigeria to apply micro:bit and other technologies

towards tackling the United Nations (U.N.'s) Sustainable Development Goals (SDGs).

These workshops benefited over 1,200 students, of whom more than half were girls. Some had never coded before, and many did not know about the SDGs.

GLOBAL REACH

Entries for the 2022 do your :bit challenge closed in July. The expert judging panel has since been reviewing and assessing all project submissions ahead of short-listing potential winners. The diversity and ambition of the entries received has been impressive.

In Category 1 (idea only, 8 to 14-year-olds, Africa), an all-girl team from Tunisia, came up with a design for a solar-powered robot scarecrow that would detect birds with the micro:bit's accelerometer and move with the help of a line-following sensor and obstacle detector. This invention would solve a problem related to the UN's SDG number 7 (Affordable and Clean Energy), 9 (Industry, Innovation and Infrastructure) and 15 (Life on Land).

Another all-girl team from Colombia (Category 2 – design and code, 8 to 14-year-olds, Latin America), designed a prototype egg weigher to help improve the accuracy and efficiency of a task currently carried out by women in their community (SDG number 9).

A team from Lebanon (Category 2 – design and code, 8 to 14-year-olds, Middle East) created a device to help protect



In Nigeria, CS First Lagos has used Nordic funding to train teachers and students about coding and digital skills across four regions of the country



endangered sea turtle eggs. After learning that turtle eggs are often eaten by dogs or wolves in Lebanon, they used the micro:bit and a motion sensor to trigger a buzzer and light when something moves close to the eggs. Their device also monitors temperature and can raise an alarm in case of fire (SDG number 14 (Life Below Water)).

A team from Ireland (Category 3 – design and code, 15 to 18-year-olds, Europe), invented a micro:bit controlled device to capture CO₂ from the air and then feed it to algae and other sea plants that use CO₂ to photosynthesize and create oxygen. The boys hope their invention can help in the fight against climate change and were inspired by SDG number 13 (Climate Action).

One of the standout individual entries came from the U.S., with the design of a tool to record the amount of food and drink received by food banks, and to send an alert to volunteers when levels become low, so that they know when to start a food drive. The device was inspired by SDG number 2 (Zero Hunger).

"These examples and many others illustrate the wide geographical reach of do your :bit, and of course the ingenuity and imagination of the children who have entered," says Kjetil Holstad, EVP Product Management, Nordic Semiconductor, and a member of the do your :bit judging panel. "The challenge has once again ignited the creativity of young people around the world."

Meanwhile in Nigeria, CS First Lagos has used Nordic funding to train teachers and students about coding and digital skills across four regions of the country. An estimated 500 students attended a launch event broadcast on Silverbird TV, with students given the chance to win their own micro:bit. Ninety-five percent of the students taking part were learning coding for the first time.

In Uganda, Nordic funding has enabled Mindset Coders to carry out school workshops, teacher training and community-based training in slum areas, remote communities and refugee centers. Activities have focused in and around Kampala, with 158 girls having so

far participated in workshops. Girls from one school have also benefited from a pilot program, where visiting female role models inspired the students to consider careers in technology for women.

THE POWER TO EMPOWER

IoT wireless tech providers have a vested interest in the education of tomorrow's engineers. And some are taking action. As the world's leading [Bluetooth LE](#) chipmaker, Nordic Semiconductor is committed to providing [digital education](#) opportunities for the coders of the future. This commitment is demonstrated in part by Nordic's partnership with the Micro:bit Educational Foundation.

"At Nordic we're proud of our long-term partnership with the foundation and we support this educational computer to encourage and train the engineers who will build tomorrow's connected world," says Holstad. "From day one we have played a major role in the micro:bit's contribution to improving digital literacy across the globe, and we are delighted to be involved in the foundation's various initiatives working towards this goal."

"While difficult to predict with certainty, the future of work will surely revolve around technologies focused on big data, AI, ML and edge computing under the umbrella of the IoT," says Holstad. "To that end, the power and flexibility of Nordic's [nRF52833](#) SoC make it ideal for the next-generation micro:bit, which is teaching students everywhere about coding and how software and hardware work in tandem."

There's a long way to go, but technology can positively impact the lives and careers of young creators across the globe. What's more, investment in wireless tech-driven STEAM education can contribute enormously to the future talent pipeline. And if digital literacy initiatives can not only teach but inspire the coders and innovators of tomorrow, a brighter future beckons for society in a world where sustainability is the top priority.

The rise of classroom tech: from the abacus to micro:bit

Technology has always played its part in education. Thousands of years before hardware and software had been thought of children could learn practical skills using early 'computers'.

As far back as 1100 BCE, young people used the abacus—a wooden rack containing sets of beads on multiple parallel strings—to help compute numbers. Mechanical calculators—which used moving parts like gears to add and subtract—came along comparatively late, during the 17th century. Around the same time, students were taught verses with the aid of 'hornbooks' – wooden paddles holding printed lessons. In 1870, a primitive version of a slide projector called the "magic lantern" could project pictures or photographs printed on sheets of glass.

Eventually, around the middle of the 20th century, the first digital computers emerged to rewrite methods of instruction. In the 1950s, believing the traditional classroom experience was not conducive to a consistent rate of learning among different students, B.F. Skinner developed a theory of programmed learning to be implemented by 'teaching machines'. Using these mechanical devices, Skinner's method was designed to improve teaching methods for spelling, math and other school subjects.

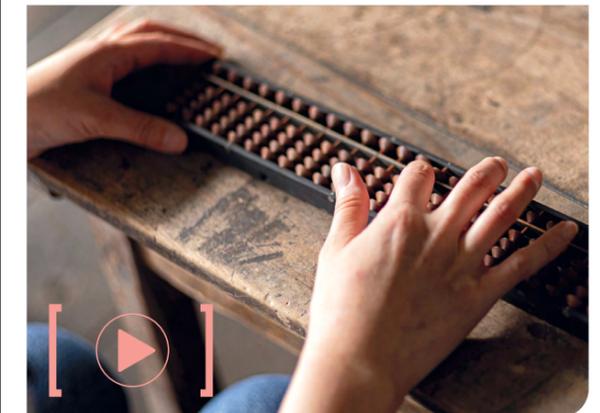
The first personal computers (PCs) for everyday use made their mark in the 1980s, quickly providing a filip to educational possibilities. IBM introduced its first PC in 1981 and Apple its Mac from 1984. And when the first personal digital assistants (PDAs) and the first widely accessible Internet browser, Mosaic, were released in 1993, classrooms everywhere began to transform.

Then, in 2005, the first Arduino kits were introduced, helping young people build simple programmable devices. A decade later, in 2015, the BBC's Make It Digital initiative launched the micro:bit – a pocket-sized, codable computer and innovative solution to support computational thinking in the U.K. The [micro:bit](#) was inspired by the BBC Micro computer built by Acorn Computers and launched in the 1980s. The Micro was widely adopted in British schools, and is generally regarded as having a transformative effect on computing in the country. In addition to the micro:bit, the BBC Micro also inspired the creation of the popular Raspberry Pi, which was originally designed to teach basic computer science in schools and developing countries.



Tech Check

Powered by the powerful 64 MHz Arm Cortex-M4 processor embedded into Nordic's [nRF52833](#), the new micro:bit v2 integrates magnetometer, accelerometer and temperature sensors, and more, supporting complex functionality such as machine learning (ML) applications

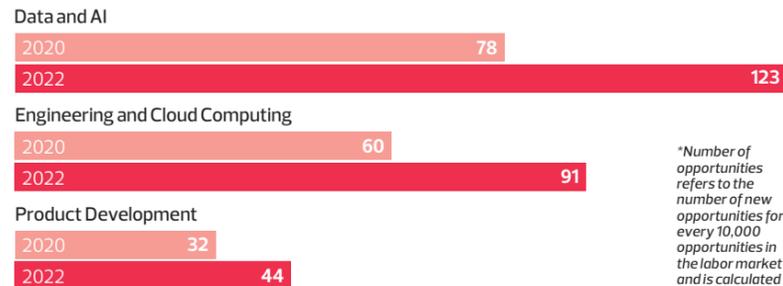


State of Play

The job opportunities of tomorrow

A 2020 study by the World Economic Forum (WEF) estimated the emerging employment areas in seven key professional clusters were set to deliver 6.1 million new jobs within a three-year period. These jobs of tomorrow promise growth and prosperity in the future workforce. The study predicted data and AI, as well as engineering and Cloud computing—disciplines that generally demand strong expertise in digital technologies—will be amongst the fastest-growing professional clusters, with product development not far behind.

Number of opportunities (per 10,000)*



*Number of opportunities refers to the number of new opportunities for every 10,000 opportunities in the labor market and is calculated as a compound average annual growth rate

Source: Jobs of Tomorrow: Mapping Opportunity in the New Economy (World Economic Forum). Figures extrapolated from data for 20 economies (LinkedIn)

Thread Together

IP-based networks offer end-to-end interoperability, scalability and ease-of-installation for building automation applications

Dubai's Burj Khalifa skyscraper is a staggering 828 meters tall and towers over the world's second tallest building, China's Shanghai Tower, by not just a few meters but by nearly 200. The building's 172,000 m² of residential space and 28,000 m² of office space makes it a monumental challenge to keep the building at a comfortable temperature for the up to 10,000 people that might be inside at any given time. To resolve that challenge, engineers turned to the IoT.

Trade publication *In-Building Tech* reports that the building's maintenance team use thousands of IoT sensors linked to a Cloud platform to identify anomalies in real time. The system then runs smart predictive maintenance algorithms to keep a close eye on the Burj Khalifa's HVAC system. Apart from ensuring the building is kept comfortable under an average desert temperature of 41°C, smart monitoring has resulted in a 40 percent reduction in total maintenance hours, while improving HVAC availability to 99.95 percent with an associated reduction in unplanned reactive maintenance (see sidebar p29 *Keeping it Cool*).

While the Burj Khalifa represents architecture at its finest, the IoT can keep any building comfortable, no matter how new or old. And the wireless sensor data not only ensures occupants are neither too hot or cold, but it also helps reduce energy consumption and keeps everything running smoothly. Nevertheless there are challenges, particularly for engineers and system integrators looking for a one-size-fits-all wireless connectivity solution.

THE ANSWER IS THREAD

To install a HVAC system in a building requires connectivity between multiple nodes that will be required to collect data so the central system can automatically control the HVAC requirements across the facility. Examples of these nodes include temperature, humidity and CO₂ sensors, thermostats, occupancy sensors and demand-controlled ventilation systems. Some of these nodes will run from the mains while others will be battery-powered.

To ensure a quick, low-cost, future-proofed solution what's needed is a plug-and-play wireless tech that eliminates cabling and enables sensors to be easily moved when floorplans change. Moreover, once a wireless network is installed, it's important that devices from any vendor can be added. That makes interoperability critical.

Thread—a low-power and -latency wireless mesh networking protocol built using open and proven standards—provides interoperability thanks to Internet Protocol (IP) support and defined provisioning mechanisms that allow any compliant device to be added to the network.

Thread version 1.3.0 features some key upgrades which bring full functionality of IP routing and service discovery to Thread networks and prepares the way to future releases targeting support specifically for Building Automation protocols (for example, KNX IoT and DALI+).

Thread networks typically start by configuring a Thread Border Router which is similar to a domestic Wi-Fi access point (AP). The router's main role is to connect the Thread network to other IP-based networks. It can be deployed in one place in the building and connected using Ethernet, Wi-Fi or cellular IoT to a local network and/or to the Cloud. The router can either be sourced from the HVAC system integrator or from a commercial off-the-shelf supplier.

There are multiple provisioning mechanisms to add devices to the Thread network once the router is installed, but one option is to use the Pre-Shared Keys for the Device (PSKd) that comes with each new IoT product. By scanning a QR code on the device using a smartphone app or by adding the key directly into the Border Router interface, the installer can easily add the new device to the network. As new devices are added, the mesh adapts and extends coverage, depending on the role of each device.

For a more extensive deployment for large buildings,



mains-powered router nodes (which route traffic within the network) are placed in key locations such that the mesh network scales to cover the complete floor plan. Router nodes can double up as elements of the HVAC system (for example, a thermostat) or can be simple low cost units with the sole purpose of extending the network.

Once the Thread network is established, other devices can easily be added. And if the number of network nodes outgrows existing coverage, new router nodes or Border Routers can be added to boost the network.

FLEXIBILITY AND INTEROPERABILITY

Many nodes on a Thread network will only communicate locally (for example, a temperature sensor sending an instruction to an actuator to open or close a valve), while others will communicate over the Cloud. The Thread network supports any application layer providing it uses IP transports. This makes for a very flexible network. For example, two devices inside a building could talk to each other using the Matter protocol ([see WQ Issue 1, 2022 pg14](#)) while simultaneously elsewhere on the network, another node is talking to one Cloud provider and a second to a different Cloud provider using IP.

The flexible and interoperable characteristics of a Thread network mirror those of Wi-Fi networks built into buildings today; first the network is built to make sure there's adequate coverage and then multi-vendor devices (for example, PCs, tablets, printers and security cameras) are added later. Everything coexists nicely together. This is perhaps not surprising – both Thread and Wi-Fi rely on IP tech, which brings true end-to-end interoperability.

But more than that, for industrial applications such as HVAC, Thread has built-in standard mechanisms to enable companies to quickly build and deploy large scale networks inside buildings. Because it is simple-to-use and IP-based (ensuring end-to-end interoperability), Thread is set to be a widely adopted technology in the near future.

Smart monitoring has resulted in a 40 percent reduction in total maintenance hours, while improving HVAC availability to 99.95 percent

Keeping it cool

While the Burj Khalifa is situated in one of the hottest regions of the planet, it benefits from modern IoT and HVAC to keep its occupants cool. But before modern technology, how did we keep buildings comfortable?

The Egyptians fought the searing Saharan heat by soaking reeds in the Nile and then hanging them in windows to cool the incoming breeze. Several centuries later, the Romans were more interested in keeping warm, so luxury villas and public bath houses were built on mosaic tiled stone floors with the space underneath used as ducting for heated air to keep things toasty.

Fast forward several thousand years and Britain's Victorian engineers also worked out airflow is a good way to keep things comfortable so designed buildings with covered porches to provide shade, large, recessed windows for cross ventilation and high ceilings to let hot air rise out of the way of occupants.

Today's air conditioners can be traced back to the work of U.S. engineer Willis Carrier in the early years of the 20th century. But Carrier wasn't looking to keep rooms cool, rather he was tasked with solving a humidity problem that was causing pages to wrinkle at a publishing company.

Carrier patented an "[Apparatus for Treating Air](#)" to solve the humidity problem but soon realized the equipment could also be used to regulate temperature. Running the cycle one way saw heat extracted from the room for cooling while reversing the cycle allowed the same machine to heat the space.

According to the U.S. Department of Energy, the next big thing in air conditioning is non-vapor compression technology. Apart from eliminating refrigerants such as hydrofluorocarbons (HFCs), which can escape from the products and contribute to greenhouse gas global warming, non-vapor compression tech reduces air-conditioner energy consumption by approximately 50 percent.



Tech Check

[HooRii's](#) Hoo Max Industrial Gateway is a Thread Border Router that uses Nordic's nRF52833 SoC to support Thread connectivity in building automation. The nRF52833 provides mesh connectivity between Thread devices such as lighting, sensors and controllers, and the gateway. From the gateway the data can then be relayed to the Cloud using Wi-Fi, Ethernet and/or cellular connectivity



Wearables

WHOOP 4.0

This Bluetooth LE wearable provides continuous physiological data monitoring and lasts five days between charges

The global [wearable](#) sector was valued at \$40.65 billion in 2020 and is expected to expand to \$114.34 billion by 2028 according to Grand View Research. The rising prevalence of chronic diseases and obesity has contributed to the adoption of devices that provide real time information on the user's overall wellbeing. These solutions also offer physiological data such as quality of sleep, heart rate, blood oxygen level, blood pressure, cholesterol level and calories burnt



The Guinness World Record for pedaling a stationary bike is held by British athlete [Benjamin Alexis Miles](#), who in 2020 spent an incredible 277 hours, 20 minutes and 30 seconds in the saddle. Under the rules of the record attempt, Miles had to maintain a pace of 5 km every 15 minutes and was permitted a five-minute break for every hour he spent in the saddle. He spent the first 72 hours constantly cycling, banking six hours he could then later use for rest during the 12 day marathon effort

WHOOP 4.0 monitors the wearer's heart rate, heart rate variability, blood oxygen saturation, sleep data, strain and skin temperature, and can be worn on the wrist, bicep, or discreetly enclosed within specially designed WHOOP Body technical garments. The data is collected and organized within the key pillars of strain, sleep and recovery, offering users insights that provide guidance, coaching, and actionable feedback to help develop new healthier habits

Stationary bikes are incredibly efficient when it comes to burning calories. According to Harvard Health, riding an exercise bike for a period of thirty minutes at a moderate pace can burn up to 250 calories for the average individual. If you are looking for a more intense workout, professional cyclists on a hill climb stage in the Tour de France can burn 800 calories in thirty minutes, or more than 120,000 calories total during the three week long tour

The first ever stationary bicycle was designed by British inventor Francis Lowndes, who created his contraption in 1796. The gigantic machine utilized two wheels connected to wooden rods that users could crank with their hands and feet to give themselves a full body workout. It wasn't called a stationary bicycle of course because neither the bicycle nor the word describing it had yet been invented. Instead, he called it the 'Gymnasticon' a device he claimed could treat gout, palsy and rheumatism



WHOOP 4.0 provides a daily recovery score calculated from an individual's heart rate variability, resting heart rate, sleep duration, and respiratory rate as a way to quantify readiness to perform or a greater need for rest. A 'Strain Coach' feature gives users an exertion-level recommendation based on that recovery score as well as the strain they've already accumulated that day. WHOOP 'Sleep Coach' provides nightly personalized recommendations for when you should go to bed and wake up to help maximize recovery



Tech Check

The [nRF52840](#) Bluetooth LE SoC integrates a 64 MHz Arm Cortex-M4 processor with floating point unit (FPU). The SoC is used to power the WHOOP 4.0's Bluetooth LE connectivity. The SoC has been engineered to minimize power consumption with a fully-automatic power management system. This helps the WHOOP 4.0 wearable to deliver up to five days of continuous physiological data monitoring before needing a recharge

Asset Tracking

Asset tracker uses cellular connectivity to communicate vehicle location

The Nordic nRF9160 SiP-powered RecovR vehicle locator can be used by dealerships for car lot management, or customers for theft recovery

The next time you pass a car dealership, spare a thought for the journey each new vehicle has been through to take its position on the salesman's forecourt. The automotive industry has a highly complex supply chain from point of manufacture, through global intermodal freight transport distribution, storage at a bonded car lot, and ultimately to a dealership for sale. Especially in the U.S., dealers sometimes have hundreds of shiny new cars on their lots, and getting them from pre-delivery inspection (PDI) into customers' hands quickly enables the highest possible profit.

The volume of cars on dealer lots can make it difficult for staff to keep track of inventory and locate the correct vehicle when the customer makes a request. Where they are originally parked isn't always where they end up because of the complicated game of car Jenga employees have to play to extract a particular car surrounded by dozens of others. In addition, because cars in lots often don't yet have license plates, traditionally they have been identified using their Vehicle Identification Number (VIN). This is a labor-intensive exercise even for medium-sized lots. Many dealers also operate multiple sites, so tracking down cars is like trying to find a needle in a haystack.

"Car dealers can't sell what they can't find," says Patrick Hauert, SVP Product & Marketing, Kudelski IoT, a unit of global technology and security provider Kudelski Group. "And although inventories are currently low, larger dealers can have more than 500 vehicles across multiple lots and locations. Enabling them to find that inventory quickly ensures cars move through the process from arrival to sales quickly and efficiently."

I am here

To meet this challenge, Kudelski IoT has released its RecovR vehicle locator device that can be placed without specialized installation into individual vehicles and uses cellular connectivity to periodically transmit the GNSS location of the vehicle to the RecovR Cloud-based web platform, and/or the smartphone app. From there, the vehicle's precise location can be pinpointed, enabling dealership staff to quickly locate a vehicle without recourse to any manual, time-sapping methods like running around the lot with a key fob held high in the air. The cellular connectivity is enabled by Nordic Semiconductor's nRF9160 SiP, a cellular IoT solution. And when RecovR doesn't have line-of-sight visibility to GNSS satellites, it can use cellular base station data to triangulate an approximate location of the vehicle.



Need to Know

The vibration-resistant and weatherproof RecovR weighs 100g and provides for an operating temperature range of -40° to 85°C, making it ideally suited to automotive use. It can either be placed inside the vehicle, or hidden in a compartment to minimize the risk of detection for car theft recovery applications

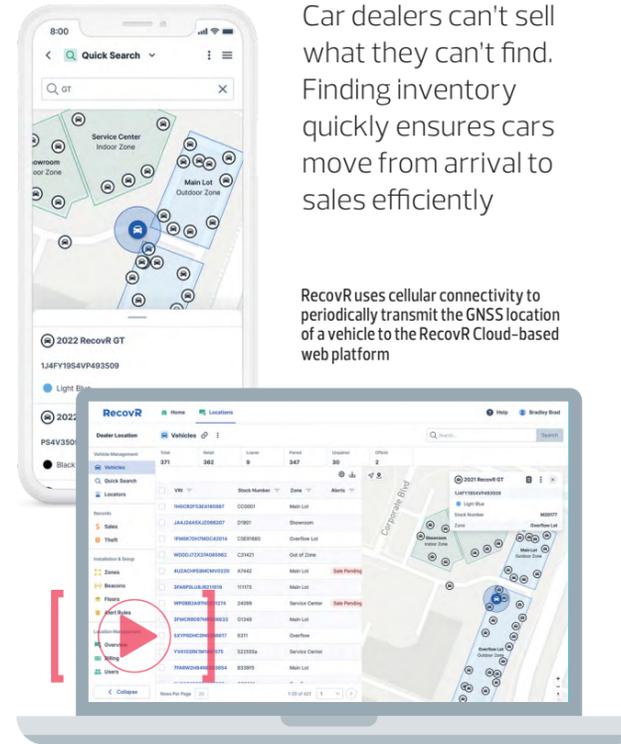
New car buyers who want to protect their vehicle from theft can also use RecovR. The product can handle the U.S.'s hot Phoenix summers and chilly Chicago winters and is small enough to be hidden practically anywhere inside a vehicle. And with the addition of its integrated accelerometer and 'Lock Location' feature the unit can quickly notify an owner via a smartphone app if their vehicle is on the move, and, via GNSS, where it is.

The Nordic nRF9160 SiP combines cellular network location data with GNSS trilateration for precise position monitoring, and provides its position to Cloud-based applications upon request. Live tracking data for stolen vehicles can then be shared with third parties—for example law enforcement—to assist with theft recovery.

The device is secured by Kudelski IoT's proprietary keySTREAM security technology to ensure the device and its data are protected against cyber threats.

"Reliable cellular connectivity ensures we are able to transmit the location of the vehicle no matter where it is," says Hauert. "And the ability to roam onto multiple cellular networks increases the coverage where there are blind spots on one network."

"While most other solutions are wired and require installation, RecovR is wireless, self-contained and can be placed almost anywhere in the vehicle. "The wireless connectivity provided by the nRF9160 SiP is a huge



Car dealers can't sell what they can't find. Finding inventory quickly ensures cars move from arrival to sales efficiently

RecovR uses cellular connectivity to periodically transmit the GNSS location of a vehicle to the RecovR Cloud-based web platform

advantage because not only is installation thirty times faster, it makes the device harder for thieves to find, and hybrid and electric vehicle manufacturers are increasingly prohibiting the connection of aftermarket devices to the car's electrical system," says Hauert.

Five-year battery life

If the beauty of the solution is in its simplicity, its extended battery life is fundamental to the device's utility. The single, non-rechargeable 8 Ah capacity battery achieves a life of approximately five years, thanks in part to the ultra low power consumption of the nRF9160 SiP. The SiP features PSM and eDRX power-saving modes which allows the device to sleep for extended periods of time.

"We worked closely with our partners to fine-tune the power consumption of the device, finding a balance between the best possible service and the longest possible battery life," says Hauert. "Nordic enabled us to achieve this five-year total battery life while still providing location information more often than competitor solutions."

"The high-quality support offered by Nordic helped us a lot in overcoming issues we faced during our development," adds Hauert. "We also appreciated the community around Nordic DevZone, as well as the rich documentation and code examples."

Janne Kallio

CEO, iProtoxi



Industrial IoT and remote monitoring go mainstream

Not only industry stands to benefit from cellular IoT, but the environment too

You wouldn't know it from all the bullish growth forecasts you hear, but there's still plenty of work to be done to make traditional industries aware of the benefits of the IoT.

Many of these industries have grown up using machine to machine (M2M) but that tech was limited because it wasn't possible to make devices that could operate for several years on a single charge, and long battery life along with stable connectivity is fundamental to the success of today's industrial IoT solutions.

Modern LPWAN technology—for example Nordic Semiconductor's nRF9160 SiP on which all iProtoxi's cellular IoT solutions are based—is highly power efficient and can

who aren't equipped to undergo such a transformation. Almost all digital transformation programs fail due to employee resistance and lack of management support. However, the benefits to the bottom line and the environment can be significant.

To give one example, approximately 1500 of our "Aistin Level" smart devices have been deployed across Oulu, Finland, enabling the city's



main waste management services to optimize its routes around the collection of trash cans. The devices allow just-in-time collection and avoid the wasted time and fuel required to service full-fall trash cans. Extrapolate this out over applications across air, water, oil and gas distribution, as well as level control in tanks and silos, and the scale of the opportunity is huge.

Tip of the iceberg

And when the device size, cost and power consumption comes down even further, IoT functionality will be embedded in all new use cases. Energy harvesting will enable energy autonomy. Satellite IoT will allow remote communication. Machine learning and AI will be used as a matter of course for improving data quality, while end-to-end security will provide reassurance.

However, there are many challenges on the IoT product journey. Multiple iterations may be required to reach desired results. This is time consuming and creates resistance, but off-the-shelf solutions also exist. Most importantly the journey is worth it. You can reduce operating costs, open up new business opportunities and tackle the challenges of sustainable development – a goal the world will thank you for.

Many digital transformation programs fail due to employee resistance and weak management

even operate on harvested energy. Superior antenna performance and high sensitivity radios mean use cases in rural areas, or even underground, are no longer out of reach. At the same time, Cloud service providers have made it possible to concentrate on the application itself, without the need to handle physical servers.

Nevertheless, some of these traditional sectors still need convincing because enterprise software can be complex, and can pose a challenge for organizations

[Tech Zone]

An in-depth look at Nordic's wireless solutions



Prototyping

Updated Nordic nRF Connect SDK improves development experience

Nordic Semiconductor has upgraded its [nRF Connect SDK](#) with some major software enhancements for developers working with the company's low power wireless and cellular IoT solutions.

The SDK offers developers a framework for building size-optimized and energy efficient software for memory constrained devices as well as powerful and complex software for more advanced devices and applications.

The SDK integrates the Zephyr real-time operating system (RTOS) and a wide range of samples, application protocols, wireless stacks, libraries and hardware drivers.

nRF Connect SDK includes several key

enhancements to the development software including a Bluetooth 5.3 qualified stack. The SDK v2.1.0 also includes full [Matter](#) over Thread and adds experimental support for Matter over [Wi-Fi](#) for the [nRF5340](#) SoC used with the [nRF7002 Companion IC](#). The incorporation of Matter over [Thread](#) comes after Nordic was the first company to earn a Thread 1.3 certification badge for the SDK earlier this year. Thread 1.3 is a prerequisite for Matter over Thread.

nRF Connect SDK also features other capabilities that enable developers to design better IoT products more quickly.

For example, the SDK includes experimental support for [Bluetooth LE Audio](#) including an

application for the [nRF5340 Audio DK](#), Nordic's LE Audio development kit.

The SDK also includes obstructed satellite visibility detection for GNSS which stops the satellite fix process when difficulties might increase power consumption.

"The nRF Connect SDK offers a single code base for all our devices and software components," says Krzysztof Loska, Technical Product Manager, Nordic Semiconductor.

"That's why the SDK has quickly become the definitive software development platform for Nordic's entire wireless IoT product range."

Beacons

Estimote SpaceTime OS RTLS promises optimized asset use



Estimote has launched its SpaceTimeOS real-time location system (RTLS). It uses multiple wireless technologies to create a digital twin (a virtual representation in real-time of a physical object or process) of any organization, enterprise, office, home or other environment with centimeter-precise positioning.

This 'computer game' representation can then be configured in software to track, monitor and optimize almost anything a user desires with an ease and simplicity that has not existed in the beacon industry before.

SpaceTimeOS uses Nordic [nRF52840](#) SoC-powered Estimote Anchor Beacons placed in the corner of rooms that communicate with each other and the Cloud using a combination of [Bluetooth LE](#) and [cellular IoT](#) wireless technology. These spatially-aware

beacons use Ultra Wideband (UWB) time-of-flight technology to compute their relative position to each other and automatically map the exact dimensions of the room. Any asset that has an UWB tag will immediately appear on that map. Each Estimote Anchor Beacon also features a pressure sensor (altimeter) to detect height above ground, inertial sensor (gyroscope) to streamline installation and not activate while moving, and temperature.

"The number one challenge in attaching beacons [is] manually explaining to your software system where each is located," explains Estimote CEO & Co-Founder, Jakub Krzych. "SpaceTimeOS [now automates] this process."

Education

Nordic back on the road again with Tech Tour program

Nordic tech experts are hitting the road again for the [Nordic Tech Tour of North America](#), Europe, the Middle East and Africa (EMEA). The North America version runs until October 19, 2022 and takes in 17 venues. The [Nordic Tech Tour, EMEA](#), runs until November 29, 2022 and will visit a host of countries including South Africa, Germany, the U.K., France and Israel.

The Nordic Tech Tour will provide existing customers as well as developers unfamiliar with Nordic technology the opportunity to meet the company's engineers face-to-face.

Wi-Fi and the Nordic [nRF7002](#) Wi-Fi 6 Companion IC will form a key part of the content. Spanning 48 cities in North America and EMEA, the events will also highlight Nordic's latest innovations in [Bluetooth LE](#), Wi-Fi and [cellular IoT](#).

Smart City

Cellular IoT contest winners promote sustainability

The Make it Smart with [Nordic Thingy:91](#) contest—launched in conjunction with the maker, hacker and hobbyist community website, Electromaker—called on participants to plan, design and prototype cutting-edge cellular IoT projects for smart homes and smart cities.

Participants were provided with Nordic Thingy:91 prototyping platforms and could also incorporate ML on their edge device. A jury of experts declared Md. Khairul Alam Taifur, Jens Ganzmann and Vinoth Selvaraj the winners of the contest, each receiving a share of a \$3,000 prize pool.

The overall winner, Md. Khairul Alam Taifur, created a remote, solar-powered environmental monitoring system that can gather a variety of environmental data before relaying the information to a remote server using the lightweight MQTT protocol.



Modules

Nordic-powered module supports low power edge processing applications

Sweden-based Silicon Witchery has developed a powerful new module based on Nordic's nRF52811 SoC. The ultra small form factor (6 by 12 mm) S1 Bluetooth-FPGA System-on-Module supports tiny battery powered products and is primarily designed for edge processing applications requiring demanding algorithms while consuming limited energy. Target applications include wearables, medical research devices and consumer products.

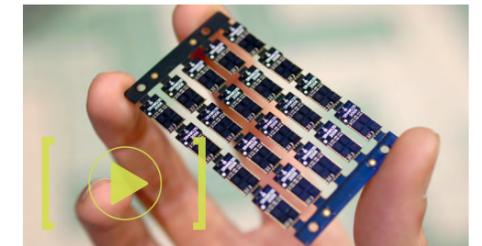
"The [nRF52811](#) SoC was the only device that could give us the tiny form factor we needed, while still providing plenty of headroom for user applications," says Raj Nakarja, Chief Engineer & CEO, Silicon Witchery.

The S1 Module is the first wireless module that combines Nordic's nRF52811 SoC with a field-programmable gate array (FPGA), according to the company. FPGAs have long been used for implementing fast DSP, but are now becoming popular for applications that typically require immense computing power. Fast FPGA I/O interfaces place little constraint on the types of sensors that can be connected.

The nRF52811 SoC functions as the S1 Module's main network processor. The SoC also manages the system power, output rails and sleep functions of the FPGA.

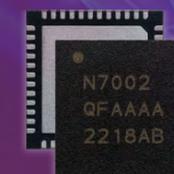
FPGAs are ideal for aggregating large amounts of data into smaller, more manageable payloads. This data can then be transmitted using the nRF52811 SoC wireless connectivity.

The S1 integrates an advanced power management IC (PMIC) which includes a single cell Li-Po charger. The nRF52811 SoC has full control of the PMIC and can adjust parameters for customer applications where power consumption is paramount.



Meet nRF7002

Dual-band Wi-Fi 6 companion IC



Adds low-power Wi-Fi to our nRF52, nRF53 and nRF91 Series SoCs and SiPs.

LEARN MORE ABOUT OUR WI-FI SOLUTION
nordicsemi.com/nRF7002



DECT NR+ bridges critical gap in the IoT

As part of the ITU's 5G technical specification, DECT NR+ offers a license-free, low latency, high density private network. What's under the hood?

At the last count there were around 14 major standards covering IoT and cellular technologies. But it seems even these weren't enough to detail everything the IoT needs. Now another open standard, European Telecommunications Standards Institute's (ETSI) DECT New Radio (NR)+, has been introduced. DECT NR+ aims to fill a need for a robust, scalable private network for massive Machine Type Communication (mMTC) and Ultra Reliable Low Latency Communication (URLLC) applications. Such applications include smart factories, smart cities and autonomous transport. (See panel below *DECT NR+: forming the base of the 5G triangle*.) Nordic Semiconductor's strategy is to support the IoT technologies that cater for the widest range of applications while being based on open standards and built to exacting technical specifications. Examples include [Bluetooth LE](#), [Matter](#), [Wi-Fi](#) and [NB-IoT/LTE-M](#). DECT NR+ also fits the bill.

The technology meets the requirements defined in the International Telecommunication Union's (ITU), International Mobile Telecoms (IMT)-2020 5G document. This is an umbrella document detailing the fifth generation technology standards for radio networks. (See [WQ Issue 2, 2022 pg14](#).)

As part of that specification, DECT NR+ needs to meet some very strict technical requirements. But unlike other 5G standards it is license exempt; this means that users can deploy their own private networks safe in the knowledge it is based on proven technology, some of which underpins the highly-secure and ultra reliable global cellular infrastructure.

Better yet, users won't need any base stations, installation is simple, the network is highly scalable up to millions or even billions of devices at a density of up to a million per square kilometer, range is hundreds of meters indoors or up to several kilometers outdoors and there are no ongoing data charges.

High throughput or low power consumption

DECT NR+'s 1.9 GHz operating frequency is a global, license-free spectrum allocation (with the current exception of Japan, India and China). DECT NR+ can support very large point-to-point, star and mesh topologies, and also connect many separate networks together. Networks can be customized to support high data rates (up to several gigabits per second) or low power consumption (below 10 microamp average power consumption) and there are no complications with SIMs. And the tech offers advanced encryption standard (AES) and counter with CBC-MAC (CCM) security.

Perhaps most significantly, DECT NR+ can achieve over 99.99 percent reliability. The reliability is built into the

lower layers of the technology's RF protocol ('stack'), so integrators don't have to worry about including details such as packet checking and rechecking in the application layer. This saves resources and lowers power consumption. But what else is included in the stack?

Built on proven engineering

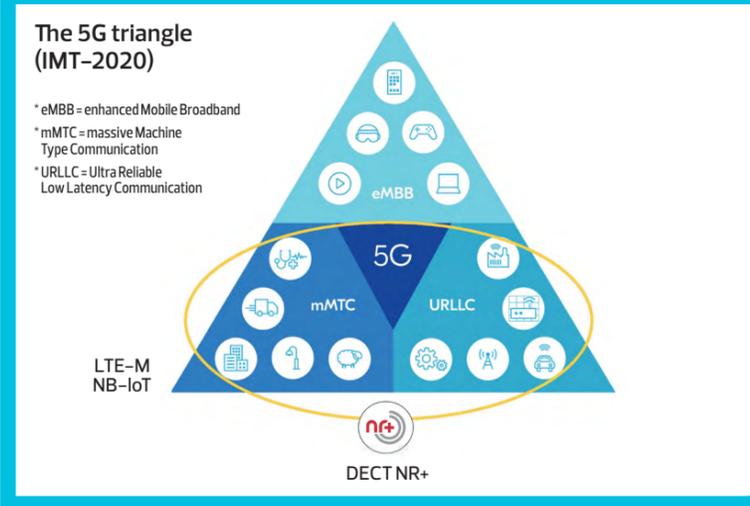
The DECT NR+ stack comprises four layers (plus a user defined application layer): Physical (PHY), Media Access (MAC), Data Link Control (DLC) and Convergence (CVG). The PHY layer builds on proven wireless tech. For example, it uses cycle prefix orthogonal frequency division multiplexing (OFDM) modulation for uplink and downlink with multiple input and multiple output (MIMO) support. Compared to FDM, OFDM allows for overlapping channels, saving bandwidth.

The PHY also supports physical data channel (PDC) modulation of binary phase shift keying (BPSK - one

“ Nordic's strategy is to support the IoT technologies based on open standards and built to exacting technical specifications

DECT NR+: forming the base of the 5G triangle

The IMT-2020 document sets 5G standards not only for how the spectrum allocation should be used but also for mobile and broadband use cases. There are three application groups: enhanced Mobile Broadband (eMBB) (high throughput cellular for consumers); massive Machine Type Communication (mMTC) (massive deployment of low power wireless nodes for M2M applications); and the new case of ultra reliable low latency communication (URLLC). DECT NR+ can support both mMTC and URLLC use cases. To do this it must provide down to one millisecond communication latency between nodes, 99.99 percent packet level reliability and deployment densities up to one million nodes per kilometer. While the technology, along with LTE-M and NB-IoT, meets the requirements for mMTC use cases it currently is the only wireless tech that can satisfy URLLC. URLLC will serve applications such as autonomous driving and remote surgery.



DECT NR+ is ideal for smart city deployment such as connected streetlights. Apart from checking power consumption and illumination intensity of the lights, the wireless tech can be used to support other pole mounted sensors such as congestion monitoring, air quality and sidewalk occupancy

bit per symbol), quadrature PSK (QPSK - two bits), 16 quadrature amplitude modulation (QAM - four), 64-QAM (six), 256-QAM (eight) and 1025-QAM (10). There is also support for 'turbo coding rates', frequency division multiple access (FDMA), time division multiple access (TDMA) and FDMA/TDMA. The maximum theoretical throughput of DECT NR+ is nine gigabits per second (although Nordic plans to focus on the low power version of the tech for mMTC application which will offer a maximum throughput of three megabits per second).

Another key aspect of the PHY is hybrid automatic repeat request (HARQ). HARQ enables the PHY to support retransmission requests if packets fail to be received. This means higher stack layers such as the application layer don't need to perform retransmissions, saving resources.

The basic operating bandwidth of each channel is 1.728 MHz with a basic frame link of 10 milliseconds. Each frame is further split into 24 standard time slots which can be aggregated or split into smaller time slots. Each standard time slot is 416.7 microseconds and contains 10 symbols.

The MAC layer supports point-to-point, star and mesh networking topologies. The network uses 'Leaf' (corner) nodes. These are connected to either a 'Relay' node or a 'Sink' node. Relay nodes pass on data traffic to Sink nodes. Sink nodes are the backbone of the network; they take in all the data and forward the data to the Cloud or to some central control station. Nodes can change roles such that, for example, any node can become a Sink node to accelerate passage of data beyond the network.

Up to four billion devices on a network

The MAC layer can facilitate autonomous device provisioning, and self-organizing and -healing. (This means the designer doesn't have to worry about incorporating these functions into the application layer which in turn improves reliability.) If, for example, a Sink node loses its connection to the Cloud, the MAC layer will heal the network and allow that node to automatically connect to a nearby Relay node and from there to another Cloud-connected Sink node to pass on its data to the Cloud.

This happens without interaction from any upper layers (again saving resources and improving reliability).

NR+'s identification (ID) construction includes a 32 bit network ID which enables up to 16.7 million unique global networks and up to 256 overlapping networks in a single radio area. A 48 bit Radio Device (RD) ID enables up to four billion unique RDs in a single network and 65,000 within radio communication distance. There are also special addresses for broadcast and backend traffic.

The RDs have two operating modes: they can either send data to another node (when operating as portable termination points or PTs) or route traffic to other clusters (fixed termination points or FTs).

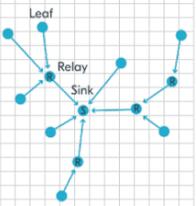
The DLC layer provides the necessary segmentation and packet routing functions for the MAC layer. Finally, there is the CVG layer. This provides adaptation functions between the application layer and the NR+ radio interface. The layer also includes functionality such as security services with ciphering and integrity protection. There is also a transmission function which includes segmentation and reassembly, retransmission, flow control, duplicate removal and delivery order services. The CVG also includes the endpoint multiplexing service. CVG can connect using the IPv6 protocol for Cloud connectivity without the need of a gateway.

Leaf and Sink nodes require all four layers of the NR+ stack, while Relay nodes only require PHY, MAC and DLC layers because they are simply passing through data.

The specification for DECT NR+ Release 1 has been published by ETSI. This specification explains the detailed engineering behind the DECT NR+ stack.

Nordic is embracing NR+ because it bridges a big gap in the IoT by introducing a new 5G standard for mMTC and URLLC using a global license-exempt spectrum and based on proven elements of cellular tech.

In partnership with [Wirepas](#), Nordic is developing an NR+ solution based on its nRF91 Series architecture. The first products will be available in 2023 for applications as wide ranging as factories, warehouses, asset tracking, robots, street lighting, traffic management and professional audio.



Need to Know

This schematic of a simple DECT NR+ network shows the node types. Leaf nodes sit at the end of network arms gathering data. The data is passed to Relay nodes which forward it to Sink nodes. Sink nodes form the backbone of the network; depending on whether the Sink nodes have IPv6 support the data is passed directly to the Cloud or otherwise forwarded to a gateway

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 51 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	1MB Flash, 256 KB RAM	1MB Flash, 512 KB RAM +256 KB Flash, 64 KB RAM	1MB Flash, 256 KB RAM	512 KB Flash, 128 KB RAM	512 KB or 256 KB Flash, 64 KB or 32 KB RAM	256 KB Flash, 32 KB RAM	192 KB Flash, 24 KB RAM	192 KB Flash, 24 KB RAM	192 KB Flash, 24 KB RAM
	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
PERIPHERALS	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
	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
CERTIFICATIONS	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	nRF52832 DK, Nordic Thingy:52	nRF52833 DK	nRF52840 DK	nRF52811 DK	nRF52810 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)	

Range Extender

nRF21540

Description: The nRF21540 is an RF front-end module (FEM) that improves range and connection robustness for Nordic 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. The RF FEM suits all applications that require increased range and/or robust coverage. 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 proprietary protocol applications. The RF FEM's TX output power is dynamically adjustable and can be set in small increments to comply with the allowable range across all geographical regions. The RF FEM can be used with Nordic's extended temperature-qualified nRF5340, nRF52833 and nRF52820 SoCs in industrial applications such as professional lighting.



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 hardware
The nRF21540 Development Bundle (DB) comprises an nRF21540 DK and an nRF21540 Evaluation Kit (EK)

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 Nordic's 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 wearables, medical devices, and other size constrained devices. When optimized for size, PCB usage is around 23 mm²

including passives. This increases to around 27 mm² when optimized for performance.

Operation: The dual-mode regulator operates at up to 92 percent power conversion efficiency, prolonging battery life of Nordic SoC-based applications using a rechargeable battery. 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

Description: nRF Cloud is a versatile IoT connectivity enabler that can be directly used with Nordic's cellular 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 Location Services are offered in nRF Cloud and include GPS and cell-based location services. The product supplies accurate and rapid location data for customer

connected devices. The A-GPS service can reduce time-to-first-fix significantly compared with regular GPS. The result is lower latency and improved power consumption. P-GPS downloads predictive data, extending validity of assistance data. Cell based services use base stations to predict location. SCELL uses a nearby cell tower, whereas MCELL uses multiple cell towers to triangulate a position. If power saving is more important than location accuracy, the cell based services are a good option. They are also useful for indoor positioning. Pricing for the different 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

Introducing nRF7002

Nordic's first Wi-Fi IC



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