WQ
WIRELESS QUARTER
Issue 4, 2023

The Cellular IoT Issue

The Future is Massive

The tech behind tomorrow's high density wireless networks

Nordic disrupts cellular IoT and DECT NR+

Building a reliable smart electricity grid

NORDIC CELEBRATES 40 YEARS OF INNOVATION

CONSTRUCTION INDUSTRY GETS CONNECTED

RAPID CELLULAR IoT DEVICE DEVELOPMENT

NORDIC SEMICONDUCTOR

Welcome

Geir Langeland
EVP Sales & Marketing

The approach of a new year is always a good time for a business to reflect. During 2023, Nordic Semiconductor achieved some important technical results. The company retained its position as the number one supplier of Bluetooth LE solutions while building on its leading reputation as a major player in cellular IoT. We also launched the nRF70 Series, a low power Wi-Fi 6 solution for locationing and other Wi-Fi applications. And we made key progress in Matter, our Cloud services and in extending the Power Management IC range, among other product introductions.

But perhaps more importantly, an impending new year is a time to focus on what comes next. When I do this, I have a feeling of excitement about our product roadmap. For example, we recently announced the nRF54L and nRF54H SoCs. These represent Nordic's fourth generation of multiprotocol SoCs and will bring capabilities to wireless applications—from the simplest to the most advanced—that previously were not possible. Importantly, in addition to the nRF52 and nRF53 Series, the nRF54L and nRF54H SoCs will support the machine learning that will transform today's applications. I'm excited to see how our customers will use these products.

Equally exciting are our plans for massive IoT. The nRF9160 SiP cellular IoT solution was years ahead of the competition when launched in 2018 and we're building on that lead with the nRF9161 and nRF9131 SiPs. These solutions bring both greater performance and flexibility to our product offerings not only for NB-IoT and LTE-M, but also for the key massive IoT technology of DECT NR+. But more than the hardware, Nordic is the only company to offer a comprehensive, end-to-end cellular IoT platform together with world-class technical support. You can read more about our cellular IoT vision in this edition. 2024 is set to be a landmark year for both Nordic and the IoT.

> "Nordic's fourth generation of multiprotocol SoCs will bring capabilities to wireless applications—from the simplest to the most advanced—that previously were not possible

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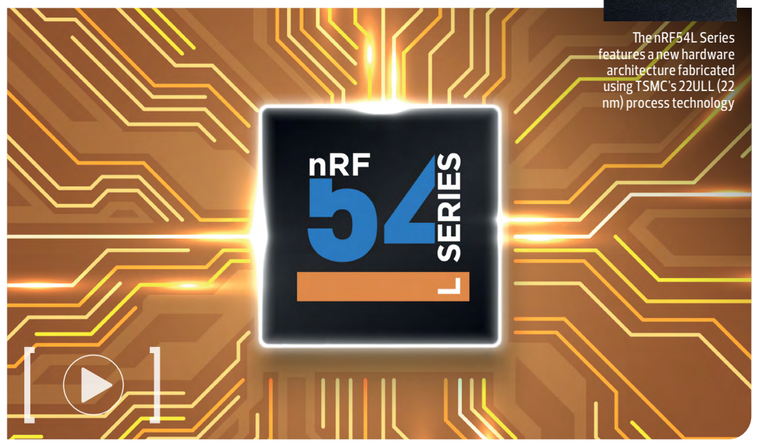
nRF54L Series expands industry's most efficient Bluetooth LE portfolio



The nRF54L Series features a new hardware architecture fabricated using TSMC's 22ULL (22 nm) process technology

Nordic Semiconductor has announced a significant addition to its nRF54 Series, its fourth generation of multiprotocol SoCs. The nRF54L Series is the logical successor to the nRF52 Series, a product family that has seen several billion SoCs delivered to thousands of satisfied customers since its introduction in 2015.

The first SoC in the nRF54L Series, the nRF54L15, is perfectly suited for the next generation of wireless IoT products. The SoC targets medical/healthcare, smart home, industrial IoT, VR/AR, PC accessories, remote controllers, gaming controllers and other IoT applications.

The nRF54L Series complements the recently announced nRF54H Series. While the nRF54L Series has wide applicability from high volume products to more advanced devices, the nRF54H Series possesses the superior processing power and large capacity memory needed for IoT products that previously have been unfeasible.

"With the nRF54L Series, Nordic reinforces its position as the world's leading Bluetooth LE company and a leader in low power wireless IoT technologies in general," says Svenn-Tore Larsen, Nordic's CEO. "The company's low power wireless engineering team is one of the best on the planet and, backed by an unwavering commitment to R&D investment, Nordic has once again redefined what's possible with the technology. The new series will allow thousands of customers to markedly raise the performance and extend the battery life of their end-products while coming up with even more innovative designs."

The nRF54L Series features a new hardware architecture fabricated using TSMC's 22ULL (22 nm) process technology. In comparison, the nRF54H Series is fabricated using the GlobalFoundries 22FDX (22 nm) process.

By investing in two wafer suppliers, Nordic has increased the flexibility of its supply chains, benefiting customers.

Smart Building

Monitor detects hazardous indoor conditions

New Zealand company AirSuite has launched an indoor monitor designed to detect environmental variables that can affect people's health and productivity. Employing a range of sensors, the AirSuite Glance can monitor carbon dioxide (CO_2), temperature, humidity, acoustics, lighting, air pressure and volatile organic compounds (VOCs), and then notify users of any potential hazards.

Environmental data is recorded every minute and is depicted on the device's ePaper display. This data is transmitted to the user's smartphone via the Bluetooth LE connectivity of Nordic's nRF52840 SoC, and to the Cloud using the LTE-M or NB-IoT connectivity of the nRF9160 SiP at least every 15 minutes.

The AirSuite Glance is designed for use in a variety of settings, including classrooms, offices, warehouses and retail spaces.

The nRF52840 SoC acts as the primary controller for the device, supervising the sensors using its Arm Cortex-M4 processor. The SoC transmits the data to the AirSuite Monitor app on a user's smartphone or tablet. The data is also transmitted to the AirSuite Cloud using the nRF9160 SiP's multimode LTE-M/NB-IoT modem, enabling remote monitoring and control of environmental conditions by, for example, facility management.

Sports & Fitness

Wearable analyzes health and fitness performance

Health and fitness technology company NNOXX has released a wearable that tracks biomarkers within the body. The device is for use by anyone from professional athletes to casual gym-goers.

Using a range of sensors, NNOXX One measures nitric oxide (NO) and muscle oxygenation (SmO_2) levels during exercise. Nitric oxide increases blood flow oxygen delivery to the heart, brain and muscles.

"Research has shown that nitric oxide is a key indicator in the overall health and fitness of an individual, and is a much more informative biomarker to monitor than tracking steps, heartrate or VO_2 max," says Justin Saul, CEO and Co-Founder of NNOXX Inc. "With NNOXX One, we have created an easy, non-invasive way to monitor this key biomarker, which in the past has required an invasive lab test to obtain. This is a game changer in fitness wearables and in helping people improve their health and performance."

NNOXX One includes photodiodes, a temperature sensor and an accelerometer, all of which are supervised using Nordic's nRF5340 SoC. The SoC features dual Arm Cortex-M33 processors, comprising a high performance application processor and a fully programmable, ultra low power network processor.

In addition, the wearable also incorporates Nordic's nRF21540 RF front-end module (FEM), a plug-and-play range extender offering enhanced link robustness with an integrated power amplifier (PA) and low noise amplifier (LNA). The RF FEM ensures, for example, that athletes exercising at one end of a sports field can reliably send their data to a smartphone at the other end.

Internet of Things

Sensor platform employs harvested solar energy

Taiwanese IoT solutions company Brocere Electronics has launched a modularized IoT sensor platform that can monitor data including temperature, humidity, pressure, movement, light, sound, Time of Flight (ToF), Long-Wave Infra-Red (LWIR), CO_2 and Volatile Organic Compounds (VOC). The Blockcraft IoT Sensor includes a range of plug-and-play sensor modules, as well as a network module to relay the data to the Cloud. The solution also includes an optional solar unit, so the device can automatically recharge when used in outdoor applications.

The IOT5 version of the network module can transmit data directly to the Cloud using the LTE-M/NB-IoT modem of Nordic's nRF9160 SiP. Alternatively, the IOT6 and IOT7 versions of the product employ the Bluetooth LE connectivity of Nordic's dual-core nRF5340 SoC to send data to a gateway, which will then transmit it to the Cloud.

The solution can be used in a variety of applications, such as commercial freezers, smart lockers, indoor fire and wildfire monitoring, smart agriculture and e-bike tracking. It can also be employed in asset tracking for cold-chain logistics applications.

Once the data has been transmitted to the Cloud, it can be accessed using the Brocere web platform or smartphone app.

In Brief

NORDIC WINS PRESTIGIOUS COMPANY AWARD

Nordic Semiconductor has been named the IoT Semiconductor Company of the Year in the *Electronics Maker* (EM) Best Awards 2023. Now in their ninth year, the EM Best Awards are India's most prestigious electronics industry awards. The awards encompass every area of electronics design and technology including innovation in the IoT. Nordic beat allcomers in the IoT Semiconductor Company of the Year category, making it three wins in three years having won Best IoT Innovation of the Year in both 2022 and 2021 with the Nordic Thingy:53 multisensor prototyping platform, and nRF9160 low power cellular IoT SiP respectively.

DEVICE MONITORS HEALTH OF TRANSPLANTED ORGANS

Researchers from Northwestern University claim the world's first device for monitoring the health of transplanted organs. Sitting directly on a transplanted kidney, the ultrathin, soft implant can detect temperature irregularities associated with inflammation and other body responses that arise with transplant rejection. The device then alerts the patient or physician by wirelessly streaming data to a nearby smartphone or tablet. In a study published in the journal *Science*, researchers tested the device on an animal model with transplanted kidneys and found it detected signs of rejection up to three weeks earlier than current methods.

SOAP OFFERS HOPE FOR LONG LASTING BATTERIES

Understanding how soap gets rid of germs—forming tiny structures that act as a bridge between water and contamination—may hold the secret to designing longer lasting batteries. According to a study in the journal *Nature Materials*, scientists from Brown University discovered that a similar process occurs in localised high-concentration electrolytes — one of the most promising substances for designing lithium batteries. Electrolytes are key in the energy-storing process as they allow an electrical charge to pass between a battery's two terminals, sparking the chemical reaction needed to convert stored chemical energy to electricity.

Asset Tracking

System provides precise position monitoring

Technology company Velavu has launched an asset management ecosystem for a range of applications including GNSS vehicle-, precision- and mixed environment-tracking. The solution is comprised of the Arda asset tag, the Manta safety wearable, the Pavo mesh anchor and the Vesta GPS tag and mobile gateway.

The small form factor Arda tag integrates temperature, humidity, motion and impact sensors, and can be placed on assets to provide positioning data, as well as environmental monitoring. Manta also provides positioning information and sensor data, but is a wrist-worn wearable.

The Pavo anchors are placed throughout a facility to form the mesh network and provide coverage in desired areas. Each anchor has a communication range of about 15 meters and a battery life of five years. The anchors can also be used interchangeably with Arda asset tags where longer battery life is required. The Vesta GPS tag and gateway can be used to track vehicles and to transmit vehicle inventory or mesh network data. The solution can be used in a variety of markets, including transportation, emergency services, healthcare and defense.

"This system is unique in that it functions using a combination of mesh network, cellular and GNSS technologies," says Dominic Peters, Co-Founder and CTO at Velavu.

The Vesta GPS tag and gateway employ Nordic's nRF9160 SiP for both its cellular capabilities and to act as a Wirepas Mesh gateway. The tag also integrates Nordic's nRF52833 SoC to communicate with other nearby mesh-networked tags enabling vehicle inventory and 'left behind alert' functionality. The asset tags, safety wearable and mesh anchors all employ the nRF52833 SoC to allow the devices to act as Wirepas nodes and anchors within the mesh network.

Wi-Fi Locationing

World's first silicon-to-Cloud locationing solution launched

With the introduction of the nRF7000 Wi-Fi companion IC, Nordic Semiconductor is now established as the world's first sole supplier of a complete silicon-to-Cloud locationing solution comprising Wi-Fi, cellular IoT and GNSS. Nordic's single vendor solution, combined with the company's world class tech support, will simplify and accelerate product development of applications based on Wi-Fi locationing.

The new nRF7000 companion IC is a unique low power Wi-Fi 6 chip, optimized for Wi-Fi network scanning on both the 2.4 and 5 GHz unlicensed frequency bands. Together with Nordic's nRF91 Series cellular IoT SiP, the nRF7000 companion IC provides SSID-based Wi-Fi locationing.

The SSID-based Wi-Fi locationing acquires accurate location fixes in an extremely power efficient manner both indoors and outdoors, in urban and suburban areas. The SSID information is then forwarded to the Cloud by the nRF9160's cellular connection with the location of the access point then identified from databases and returned across the cellular link. This is a valuable complement to GNSS, especially in buildings and in dense urban areas where GNSS can fail due to signal fading and interruptions. (*See WQ Issue 3 2023, pg28.*)

The nRF7000 IC is highly optimized for ultra low power Wi-Fi SSID scanning and does not support data communication via Wi-Fi. This optimization offers a unique balance between power consumption and precision.

Smart Building

Platform remotely monitors facility conditions

Equastar Construction & Consulting has launched a sensing and analytics platform designed to remotely monitor environmental conditions. The Gen 1 environmental sensor was co-developed by design firm, Pure Engineering and Equastar, and uses Nordic's nRF9160 SiP.

The Gen 1 supports CO_2, temperature, relative humidity, Total Volatile Organic Compounds (TVOC), motion and PM2.5 particulate matter sensors.

The nRF9160 cellular SiP enables the device to relay environmental data directly to the Equastar-IoT Cloud dashboard—custom developed by Pure Engineering—without the need to be connected to the client or building's IT network.

Sustainability

Wireless tech helps solve the world's food-waste problem

Roughly one-third of all food produced in the U.S. gets thrown away each year, according to the Environmental Protection Agency. Worldwide, the United Nations has estimated that half of all fruits and vegetables go to waste. But the authors of a new study claim automated, non-invasive and scalable technologies can play a role in reducing this waste.

Researchers from Princeton University and Microsoft Research have developed a fast and accurate way to determine fruit quality, piece by piece, using high-frequency wireless tech. The new tool gives suppliers a way to sort fruit based on granular ripeness measurements. It promises to help cut food waste by optimizing distribution: good fruit picked from bad bunches, ripe fruit moved forward.

Currently visual inspection methods often lead to poor estimates, the researchers explained. Rather than rely on how the peel looks or how it feels to the touch, advanced wireless signals can peek under the surface and reveal richer information about fruit quality.

The team developed a system for determining ripeness using wireless signals in the sub-terahertz band that can scan fruit on a conveyor belt. The sub-terahertz signals—between microwave and infrared—interact with the fruit in ways that can be measured in fine detail, leading to readouts of sugar and dry matter content beneath the surface of the fruit's skin.

Next-gen wireless systems, like the coming 6G standards, will be designed to accommodate new high-frequency bands, the researchers said. But while these bands have begun to spark new communication technologies, the Princeton-Microsoft technique is one of the first to leverage such signals for sensing, particularly for smart food monitoring.

Sustainability

Perishable goods transport solution wins sustainability challenge

A sustainable alternative to traditional refrigerated perishable goods transport has won the inaugural Nordic Semiconductor and Wevolver Connect for Good: Low Power Wireless Sustainability Challenge. The Monitoring and Anomaly Detection on Sustainable Logistics Infrastructure project ensures cold chain preservation while reducing transport costs by ten percent per kilometer. Headed by Ivan Arakistain from Spanish not-for-profit research institute, Tecnalia Research and Innovation, the project won the $20,000 top prize.

The challenge invited organizations, individual engineers, start-ups and students to submit a project that uses low power wireless technology to solve issues related to the UN's Affordable and Clean Energy, Sustainable Cities and Communities, Climate Action, and Life on Land Sustainable Development Goals (SDGs).

Tecnalia Research and Innovation's logistics solution contributes to the shift whereby transportation has a low environmental impact and is connected, efficient, safe and inclusive. It directly contributes towards the UN's SDGs by drastically reducing energy consumption for perishable goods transport and transitioning required energy sources to green ones.

The solution employs the Nordic nRF9160 DK—a pre-certified single board development kit integrating the nRF9160 SiP and Nordic's nRF52840 SoC—as well as a raft of sensors to monitor transport conditions. The sensor data is securely relayed using the nRF9160 SiP's cellular network connectivity.

In Brief

ERICSSON NETWORK AIDS PRECISION AGRICULTURE

Ericsson, in cooperation with a U.S. National Science Foundation (NSF) program, has launched its 5G network for public research together with the Agriculture and Rural Communities (ARA) team at Iowa State University (ISU). The network will be used to support precision agriculture applications and is already connecting farm sites that previously had no broadband access. Sample agriculture research will include using connected robots to collect plant phenotyping data with stereoscopic cameras generating 800 megabits per second of data. It will also include livestock monitoring with high res cameras, as well as agriculture automation.

HYDROGEL ANTENNAS HELP DOWNSIZE WEARABLES

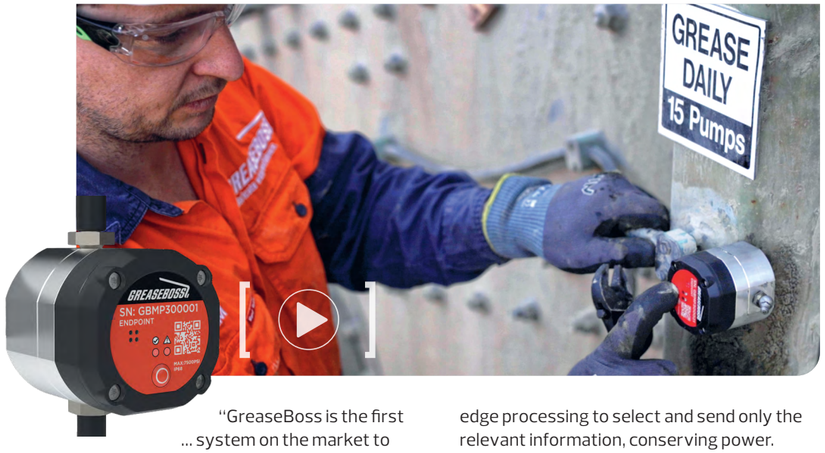
Researchers have developed a method for making tiny stretchable antennas from a hydrogel and liquid metal. The antennas could be used in wearable and flexible wireless electronics to provide a link between the device and external systems for power delivery, data processing and communication. "Using our new fabrication approach, we demonstrated that the length of a liquid metal antenna can be cut in half," says Tao Chen from Xi'an Jiaotong University, China. "This may help downsize wearable devices used for health monitoring, wearable computing and other applications, making them more compact and comfortable."

WASTE MANAGEMENT OPTIMIZED WITH CELLULAR

Norwegian company Sensorita has launched a smart waste management solution. The Sensor1 uses radar technology to assess the fill levels and contents of large waste receptacles. The product uses Nordic's nRF9160 SiP to identify the precise location of each container. This data is then transmitted to the Sensorita Cloud platform through the LTE-M/NB-IoT modem integrated into the Nordic SiP. This platform then uses advanced ML algorithms to analyze the data, calculating fill levels and predicting optimal emptying schedules, offering notifications, status updates, and integration with route planning tools.

Industrial Automation

Sensor supervises machinery lubrication management



Australian company GreaseBoss has launched a flow meter to ensure machinery and equipment maintenance in manufacturing, mining and utilities applications.

The GreaseBoss Endpoint sensor is placed in line with grease points on machinery to monitor the flow of industrial lubricant. This helps companies remotely monitor their equipment, ensuring grease is being applied evenly, and identifying any lubricator reservoirs that require refilling.

Sufficient lubrication is key for these applications, as increased friction can increase maintenance requirements and shorten the lifetime of equipment. In addition, unplanned downtime of equipment can be expensive, making predictive maintenance highly beneficial.

"GreaseBoss is the first ... system on the market to measure and verify grease delivery at scale using modern Cloud and IoT technologies," says Peter Condoleon, CTO and Co-Founder of the firm. "The GreaseBoss empowers small teams to remotely manage the greasing of massive fleets of machinery."

GreaseBoss Endpoint uses Nordic's nRF52833 SoC for data collection and sensor interface management, before relaying key metrics to a GreaseBoss gateway using its Bluetooth LE connectivity. The nRF52833 SoC's Arm Cortex-M4 processor enables edge processing to select and send only the relevant information, conserving power.

From the gateway the key data is relayed to the Cloud, from where it can be accessed and analyzed by users. From the GreaseBoss Cloud web platform, companies can check whether they are meeting their pre-set lubrication requirements, and receive alerts if any areas of non-compliance are detected.

The GreaseBoss solution is built using Nordic solution partner Memfault's IoT reliability platform for embedded observability, remote debugging and over-the-air (OTA) fleet management.

Environment Monitoring

Underwater subsystems advance ocean data collection

Observatory sensor systems are deployed off coastlines to collect and transmit a range of physical, chemical, geological and biological data. These technologies are often powered by subsea cables, which limits the distance they can operate from shore.

To solve the problem, an interdisciplinary, multi-university group of researchers has received support to develop a prototype of an Autonomous Observatory Node (AON) consisting of an underwater acoustic communication subsystem and an Underwater MicroGrid (UMG) subsystem.

"Think of it as a service station with a Wi-Fi hot spot," says research leader Yahong Rosa Zheng, a Professor of Electrical and Computer Engineering in Lehigh University's P.C. Rossin College of Engineering and Applied Science, and an expert in underwater wireless communications and signal processing.

"The node will have a power source for its sensors and autonomous underwater vehicles (AUVs) and the ability to transmit data up through the water to the Internet."

The research team plans to design an acoustic subsystem that will use numerous

transducers—devices that convert energy, similar to how a loudspeaker converts a signal into sound waves—to receive data from seafloor sensors and AUVs.

The data will then be transferred to a glider that sits on the ocean's surface. From the glider, the data can be transmitted to satellites and then to researchers' computers.

The potential applications of an autonomous observatory are vast. Data retrieved from the deep ocean could, for instance, enhance researchers' ability to detect seismic activity and improve early warning systems for earthquakes. And information about water temperature could help with climate research.

Wearables

Pin device puts AI-powered system on clothing

A wireless device called the Ai Pin, developed by smart tech startup Humane, essentially allows users to attach an AI chatbot and 'life-logger' to their clothing. The system comprises a visible wearable and a 'battery booster' that sits inside the article of clothing and grips the main unit using magnets.

Once in place, users can talk to the AI-powered system via the built-in microphone, which is able to quickly find and contextualize what the user is looking for. One feature searches the wearer's webmail inbox to provide highlights, while a messaging function can generate text in the user's tone. The device could even serve as an interpreter.

The Ai Pin includes a tiny projector that can project visuals—such as simple navigation prompts, weather alerts, notifications and more—onto the palm of a hand. The company has partnered with TIDAL for music on the move, and the device can also connect to Bluetooth earbuds. A wide-angle RGB camera can be used to scan food items at the grocery store or capture and recall memories.

Humane has partnered with other companies for access to AI models, and is launching its own mobile virtual network operator to eliminate the need for a smartphone. A central Cloud-based hub stores all the user data.

Corporate Partnership

Nordic to acquire AI/ML technology in the U.S.

Nordic Semiconductor is to acquire the IP portfolio of U.S. based artificial intelligence (AI) and machine learning (ML) company Atlazo. The agreement includes the employment of Atlazo's core team.

Atlazo, based in San Diego, is a technology leader in AI and ML processors, sensor interface design and energy management for tiny edge devices. The acquisition will further strengthen Nordic's leading position in the development of low power products and solutions for the IoT.

Nordic's acquisition of the Atlazo IP gives the company ownership of cutting edge AI/ML technology, advanced sensor front end technology for health related applications, and technology enabling processors to operate at the lowest power.

Industrial Automation

Module supports smart building, construction and industrial sectors

Taiwan-based company Coral Sense has launched a module for the smart building, construction and industrial sectors. The ABR-WM01-MLG wireless MCU module can be used by device makers or IT providers to perform complex control, monitoring and wireless communication functions.

Powered by Nordic's nRF5340 multiprotocol SoC's Arm Cortex-M33 dedicated application processor and low power network processor, the module provides high performance application processing while maintaining ultra low power consumption.

The integration of the nRF5340 SoC also enhances the module's RF power output and range capabilities. The module is designed to operate across a temperature range of -40 to 105°C.

The ABR-WM01-MLG acts as the central wireless control and communication unit within the proprietary ABR-A01 platform. It enables wireless connectivity using technologies such as Bluetooth LE, ANT and 802.15.4, facilitating seamless communication between devices, sensors and actuators.

The nRF5340 SoC enables connectivity with a wide range of Bluetooth LE-enabled devices, including smartphones, tablets and other compatible devices. This plays a fundamental role in the provision of reliable device networking.

The Nordic SoC's Bluetooth 5 Long Range extends the communication range, enabling not only mobile-to-device connections but also device-to-device communication over greater distances.

By the Numbers

$20.2 billion
by 2032

DataHorizon Research reports the cellular IoT module market size—valued at $5.8 billion in 2022—could reach $20.2 billion by 2032 at a CAGR of 13.4 percent. This demand is expected to be driven by the pivotal role such modules play in ensuring connectivity and data transmission within a cellular IoT network. The report notes that cellular IoT supports a range of network technologies including 3G, 4G, 5G, LTE-M and NB-IoT.

$42.9 billion
by 2030

The smart beacons market size—valued at $3.3 billion in 2022—is expected to grow to $42.9 billion by 2030 at a CAGR of 37.8 percent over the 2023-2030 forecast period, according to market research firm, SNS Insider. The analyst says smart beacons are likely to play a major part in how businesses interact with customers. As of 2021, nearly 490 million of the more than 4.4 billion active social media users globally utilize location-based services that are powered by beacons.

$414.6 billion
by 2032

The global wireless audio devices market size and share—valued at $92.5 billion in 2022—is anticipated to generate revenue of $414.6 billion by 2032, according to the latest study by Polaris Market Research. The report notes that the market exhibits a robust 16.2 percent CAGR over the forecasted timeframe, 2023-2032. North America was the largest market in 2022, owing to its greater use of smartphones.

Low Power Wireless

Nordic celebrates 40 years of low power electronics innovation

From humble beginnings in 1983 as a specialist in ASIC design services, Trondheim, Norway based Nordic Semiconductor is now a world leader in low power wireless IoT technologies

Long-term success in the white-hot semiconductor sector is something to be celebrated. So many companies are founded and disappear in just a few years, making those that thrive for decades rare. Founded in 1983, Nordic Semiconductor now joins that exclusive group of firms that have celebrated 40 years in the electronics business.

The history of Nordic Semiconductor is that of a 20-year-old low power wireless pioneer building on the achievements of a 20-year-old application specific integrated circuit (ASIC) design house. Nordic VLSI, founded in the early 1980s, provided the technical foundations for today's Nordic Semiconductor. (See sidebar *A tale of two companies*.)

As it celebrates it 40th anniversary, Nordic's mission today is to make low power wireless IoT connectivity accessible to all. The company does this by abstracting away as much technical complexity as possible and offering comprehensive hardware and software solutions.

"As an IoT solutions provider, Nordic looks at the problems the developer needs to solve in a holistic way," explains Kjetil Holstad, EVP Strategy & Product Management at the company. "That means taking responsibility from the battery or sensor to the antenna all the way up to the Cloud for the wireless connectivity, including the computer processing and power management."

That's part of the reason Nordic's product offerings have today expanded into every major wireless IoT connectivity protocol and technology. This includes Cellular IoT (NB-IoT and LTE-M), DECT NR+, low power Wi-Fi, Matter, Thread, Zigbee, Cloud and location services, PMICs and range extenders. Nordic's solutions are simple to design in, power-optimized and with a lower total ownership cost compared to using a mix of suppliers.

"Nordic's strategy is to deliver a range of solutions, to be a one-stop-shop for wireless connectivity and build the foundations for the next decade of growth," says Holstad.

> The rewards are proportional to the risks a company takes and its willingness to disrupt established industries – particularly in markets that could take years to reach their potential of transforming the world

Much more than just Bluetooth LE

Nordic built its IoT reputation by becoming the world's leading supplier of Bluetooth LE SoCs, but today the company is so much more than that. While it will remain the leader in this key IoT technology it is now a complete end-to-end wireless connectivity solutions provider.

What has not changed across the four decades of the company's history is ambition, commitment to exciting developers, commitment to producing class-leading and industry disrupting products, and commitment to providing an unmatched level of technical support.

An example of the company's industry-disrupting technology is cellular IoT. Nordic took a very early risk on this emerging technology and that risk is now starting to pay off. "We entered the cellular IoT market in 2018 before most of the global infrastructure required to support the technology had been built," explains Geir Langeland, EVP Sales & Marketing at Nordic. "And when we launched the nRF9160, it was years ahead of the competition in terms of power consumption, integration and performance.

"Only now, five years later, would I consider that we are seeing the potential for mass market cellular IoT deployment. That's a long time for a stock market-listed organization to wait for a return on a substantial up-front investment. But we wouldn't be poised to take full advantage of this market today if we hadn't had the courage to be early pioneers.

"The rewards are proportional to the risks a company takes and its willingness to disrupt established industries," adds Langeland, "particularly in markets that could take many years to reach their potential of transforming the world."

Langeland's words nicely sum up Nordic's approach over its 40-year history: identify the emerging wireless tech that will transform the world, pioneer commercial solutions, educate the market about their benefits and then partner with customers to help them build leading products based on those technologies. It's a company culture that won't change over the next four decades.

A tale of two companies

Back in 1983, Nordic VLSI began life as a small, specialized Trondheim-based design house. The company sold consultancy services for mixed signal application specific integrated circuits (ASICs) to individual customers in the Nordic region, and later expanded into high performance data converters.

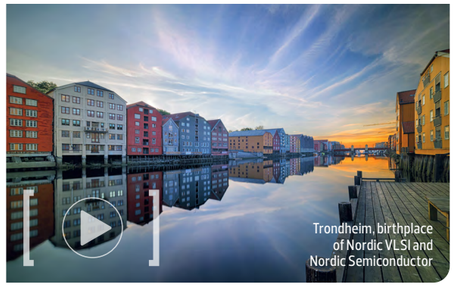
A rebranded company, Nordic Semiconductor, began to take shape from the foundation of Nordic VLSI in 2002 with the arrival of the company's recent CEO, Svenn-Tore Larsen. It was Larsen who decided the company would transform from a supplier of design services to a supplier of wireless components. The new look and new strategy company was launched in 2004.

"One of the most critical parts of wireless design is how to successfully mix analog and digital signals, which Nordic spent the first 20 years of its life mastering to an extraordinary level of expertise and competence," explains Svein-Egil Nielsen, Nordic's CTO/EVP R&D.

"This laid the foundations for me to take the company into standard RF wireless components," adds Larsen. But not just any ordinary RF wireless components: "Specifically, standard wireless components that were engineered to be able to operate at ultra low power consumption levels that could support battery-powered operation."

Since then, Nordic Semiconductor, more than any other chip company, has turned the world wireless. Nordic did this by first using license-free ISM frequency bands and later the 2.4 GHz band that formed the foundations for contemporary Bluetooth LE. Nordic effectively wrote the original engineering specification for Bluetooth LE in the early 2010s.

But it was the 2012 launch of the nRF51 Series SoCs that redefined the leading-edge of Bluetooth LE. The SoC used a powerful on-board Arm processor, lots of embedded memory and a unique software architecture that separated the RF protocol from the application software. None of these advances had been seen before in Bluetooth LE chip market. The SoC ensured Nordic's Bluetooth market dominance.



Trondheim, birthplace of Nordic VLSI and Nordic Semiconductor

Cellular IoT

Cellular IoT takes the lead as the LPWAN for the future

As the IoT matures, analysts forecast that NB-IoT and LTE-M are likely to become the dominant technique to connect long range wireless devices to the Cloud

> This decade will see a shift towards cellular connections being propelled by the digital transformation initiatives undertaken by enterprise IoT players

The IoT is maturing fast. In 2023, the global number of connected IoT devices will reach 16.7 billion active endpoints, says analyst IoT Analytics. That's a lucrative market into which wide-area IoT connectivity vendors are keen to tap. LPWANs are a critical part of the IoT's infrastructure for connecting LANs or standalone wireless devices over kilometer distances to the Cloud.

Because of the vital nature of this infrastructure, it is set to boom. According to global intelligence firm, ABI Research, LPWAN connections will reach 5.3 billion connections in 2030, with smart metering, asset tracking and condition monitoring cited amongst the most integral IoT applications. Statista forecasts LPWAN IoT connections will outnumber any other IoT connectivity technology by 2030. And a recent study by Allied Market Research projects the global LPWAN market—valued at $8.2 billion in 2022—will reach a staggering $582 billion by 2032, growing at a CAGR of 53.4 percent over the forecast period (2023-to-2032).

A technology on the rise

But while the LPWAN market is growing rapidly, it is fragmented. Nonetheless, one of the key technologies, cellular IoT, is gaining most of the traction as the bridge between remote IoT end-devices and the Cloud. As alternative non-cellular connectivity technologies like LoRaWAN and Sigfox face technical and commercial pressures (*see WQ Issue 2 2022, pg12*), according to industry research, cellular IoT is establishing itself as the LPWAN leader.

For example, Mordor Intelligence's *Cellular IoT Market Size & Share Analysis – Growth Trends & Forecasts (2023–2028)* report, reports the cellular IoT market size is expected to grow from $5.02 billion in 2023 to $14.26 billion by 2028, at a CAGR of 23.21 percent during the five-year forecast period. This global market growth will be driven by the rise in digitalization and automation across industries such as manufacturing, automotive, and energy and utilities, claims the analyst.

Cellular IoT traction comes from the key advantages it offers for massive IoT; chief among these advantages is its Internet Protocol (IP) interoperability which enables a bidirectional link between end-devices and the Cloud without the need for expensive and complex routers or gateways. Further advantages include future proofing, scalability, security and high quality of service (QoS).

Narrow band (NB)-IoT and LTE category M1 (LTE-M) are the two underlying technologies supporting cellular IoT.

Need to Know

Cellular IoT uses existing cellular base stations (with software upgrades) to connect massive IoT devices to the cloud. It is a Low Power Wide Area Network (LPWAN) technology characterized by kilometer plus range, high density end-device support, low power consumption, modest throughput and high levels of security

NB-IoT is suited to static applications. Examples include smart meters and smart streetlights. LTE-M is suited to devices that can change locations, such as with asset trackers or wearables.

These application and others have driven global cellular IoT growth to reach 2.7 billion connections in 2022, according to a Counterpoint Technology Market Research report, *Global Cellular IoT Connections Tracker*. This figure is expected to grow at a CAGR of 10.8 percent a year until 2030. At present, NB-IoT dominates in China, while LTE-M is preferred in Australia, Japan and North America. Europe supports both technologies.

Already cellular IoT connectivity has played a major role in enhancing productivity, streamlining operations, minimizing downtime, automating processes and generating cost savings across various industries, says the Counterpoint report.

Commenting on the report, Neil Shah, Research Vice President at Counterpoint, stated: "The growth will be mainly driven by cellular connectivity adoption across various sectors such as utilities, agriculture, industrial, retail and healthcare.

"Unlike the previous decade, where consumer devices like smartphones and PCs played a significant role in driving cellular connections, this decade will see a shift towards cellular connections being propelled by the digital transformation initiatives undertaken by the enterprise IoT players."

Towards a dominant share

Cellular IoT technologies NB-IoT and LTE-M are heading towards a dominant share of the LPWAN market. According to IoT Analytics, NB-IoT (47 percent) and LTE-M (10 percent) already made up 57 percent of the global LPWAN installed base in 2022, compared to 43 percent for the combined competition. Looking ahead, technology research and advisory group, Omdia, expects there will be almost 1.6 billion NB-IoT LWPAN connections in 2028 with a further 300 million LTE-M connections – around 800 million more connections than the closest competitor, LoRaWAN, and dwarfing the number of connections for Sigfox and other technologies.

In its *LPWAN Market Report – 2022*, Omdia predicts LPWAN connections will grow at a CAGR of 23 percent in the five-year period to 2028, driven predominantly by growth in NB-IoT and LoRaWAN technologies.

The analyst forecasts NB-IoT and LoRaWAN will account for 87 percent of all LPWAN connections in 2028, up from 85 percent in 2023.

Comment

Kjetil Holstad
EVP Strategy & Product Management, Nordic Semiconductor

AI and machine learning are transforming the IoT

Here's why AI and machine learning will be important for next generation products

Artificial Intelligence (AI) and machine learning (ML) are revolutionizing wireless IoT connectivity. The technologies are going to enable new categories and classes of application that were previously unthinkable.

AI and ML have the potential to turn an IoT application from useful to incredibly valuable, if not invaluable. As such, any next generation product or application that isn't incorporating AI and ML risks being left behind.

> Nordic's expertise in ultra low power consumption combined with high end processors is changing the AI and ML game

Historically, the IoT didn't use AI and ML because the computational demand required was beyond the capabilities of many of the compact, battery powered and resource constrained devices used to power the IoT. But now, Nordic's expertise in ultra low power combined with high end processors is changing the game. A prime example is the company's latest nRF54H Series. (*See pg4.*)

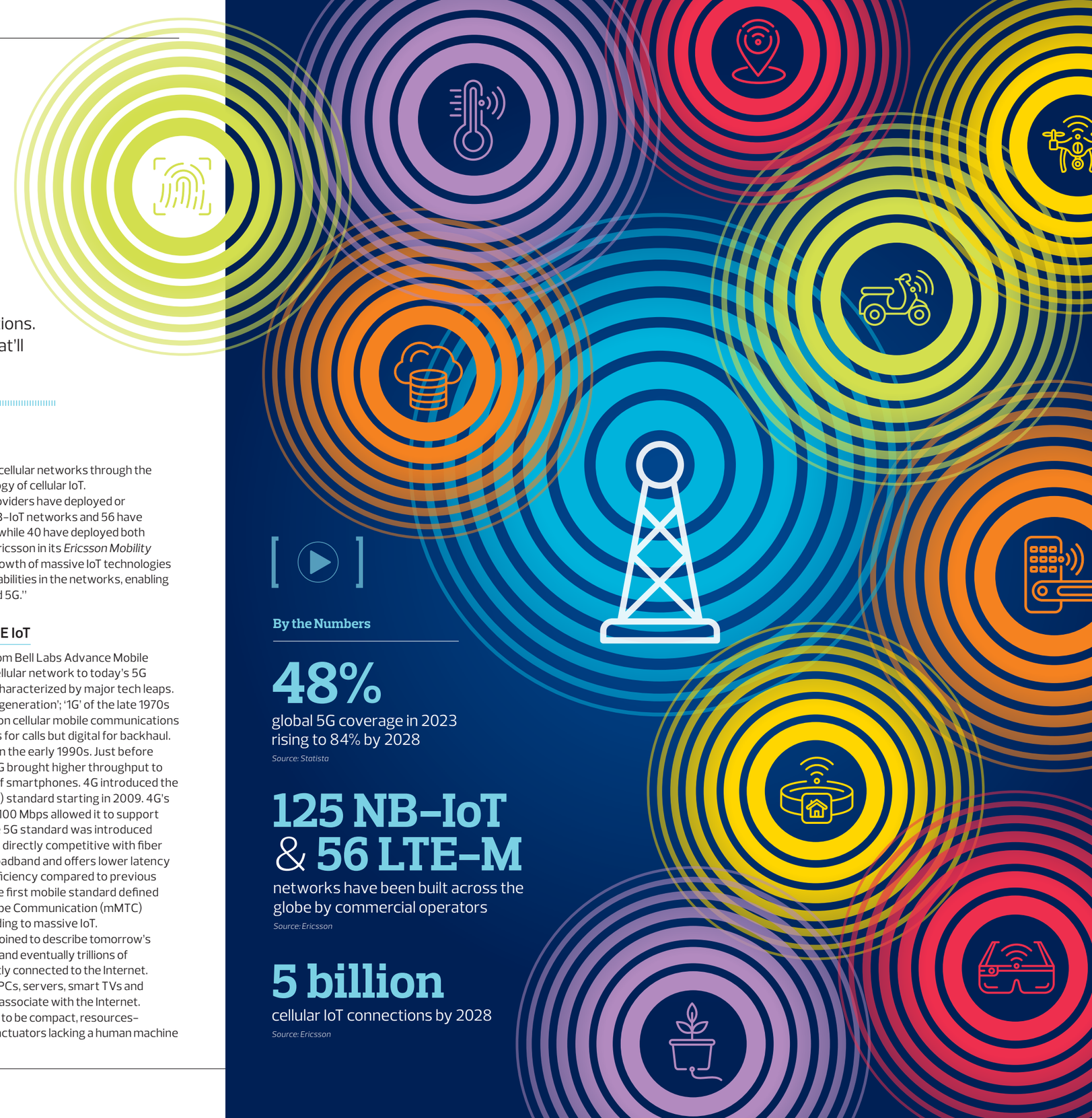
Consider the impact the nRF54H Series SoC will have on a product such as a health and fitness wearable. Traditionally, this might have been used to measure things like steps, calories burned, heart-rate or -variability and sleep patterns. But this functionality didn't require AI. Adding AI into the mix suddenly elevates that wearable to an entirely new league of capabilities.

The device would be capable of monitoring several vital signs simultaneously and recognizing a 'red light' combination of sensor data, that could be used to immediately signal and even pre-diagnose a serious medical emergency. An example might be a sudden change in blood oxygen level, heart rate, blood pressure and breathing indicating an impending cardiac event.

Suddenly the wearable becomes a 24x7 monitor that's useful for first responders and enables them to arrive with an initial diagnosis - slashing vital time from delivering critical care. That makes the wearable a transformative medical monitoring product that could help stretched healthcare budgets and above all else, save lives.

The Future is Massive

Cellular IoT and DECT NR+ are ideal for high density IoT applications. Nordic Semiconductor is designing critical parts of this tech that'll be used to connect billions of tomorrow's smart devices



In Short

Connecting small things to the IoT proved challenging because smart devices employed different, non-interoperable technologies

Today, cellular IoT LPWANs are booming because they meet the need for long-range wireless connectivity between WLANs and the Cloud

The ITU-R has made NB-IoT and LTE-M key parts of the 5G standard ensuring continued development

DECT NR+ meets all the technical requirements for massive IoT and is defined as a 5G technology. It allows engineers to build their own dense private mesh networks without the need for SIMs

Martin Cooper was supposedly a dedicated fan of *Star Trek*, the U.S. science fiction series chronicling the adventures of the USS Enterprise, a starship, as it "boldly went where no man had been before". Cooper took a keen interest in the way members of the Enterprise's crew often contacted each other using a 'communicator', a handheld two-way communication device that looked like a modern smartphone years before that was even a concept.

During the day, Cooper worked as an engineer for Motorola, a telco firm, and, taking inspiration from the communicator, wondered if there was a way to move the handheld from science fiction to science fact. The closest real-life example he had to *Star Trek*'s communicators back then were the two-way radiophones that helped police and the military stay in contact. These used small, private networks and required bulky equipment.

Cooper received a head start on his mobile through Bell Labs' work on cellular infrastructure (see sidebar *Ring, ring: the Birth of Cellular Networks*). Cooper realized he could use Bell's network to support his handheld communication device and, in 1984, after ten years of development, Motorola launched the DynaTAC. 'The Brick' as it was jokingly known could only support voice calls, weighed over a kilogram and cost the equivalent of $10,000. But it started a revolution that today sees 6.7 billion global smartphone mobile network subscriptions according to analyst statista, and smartphones with computing power and connectivity that Cooper could only ever dream about back in the 1980s.

But this subscription number is small fry compared with what's to come. While consumer tech will always be a key part of the mobile network operators (MNO) business model, it's the potential of the cellular network to support 'massive IoT' that's getting both bean counters and engineers excited. Today, statista says there are already some 17 billion things connected to the network. According to mobile technology supplier Ericsson, around three billion of those connections are supported directly by cellular networks through the rapidly emerging technology of cellular IoT.

"Globally, 125 service providers have deployed or commercially launched NB-IoT networks and 56 have launched Cat-M [LTE-M], while 40 have deployed both technologies," reported Ericsson in its *Ericsson Mobility Report June 2023*. "The growth of massive IoT technologies is enhanced by added capabilities in the networks, enabling [it] to co-exist with 4G and 5G."

FROM 1G TO MASSIVE IoT

The development path from Bell Labs Advance Mobile Phone System (AMPS) cellular network to today's 5G infrastructure has been characterized by major tech leaps. Each is represented by a 'generation'; '1G' of the late 1970s and early 80s was based on cellular mobile communications that used analog systems for calls but digital for backhaul. The all-digital 2G arrived in the early 1990s. Just before the turn of the century, 3G brought higher throughput to support the emergence of smartphones. 4G introduced the Long Term Evolution (LTE) standard starting in 2009. 4G's maximum throughput of 100 Mbps allowed it to support high-definition video. The 5G standard was introduced in 2016. The technology is directly competitive with fiber networks for Internet broadband and offers lower latency and improved spectral efficiency compared to previous generations. 5G is also the first mobile standard defined with massive Machine Type Communication (mMTC) requirements in mind leading to massive IoT.

Massive IoT is the term coined to describe tomorrow's network whereby billions and eventually trillions of small devices will be directly connected to the Internet. These 'things' are not the PCs, servers, smart TVs and smartphones consumers associate with the Internet. Rather they're more likely to be compact, resources-constrained sensors and actuators lacking a human machine

By the Numbers

48%

global 5G coverage in 2023 rising to 84% by 2028

Source: Statista

125 NB-IoT & 56 LTE-M

networks have been built across the globe by commercial operators

Source: Ericsson

5 billion

cellular IoT connections by 2028

Source: Ericsson

interface. Ericsson defines massive IoT applications as those "that are less latency sensitive and have relatively low throughput requirements, but require a huge volume of low cost, low energy consumption devices on a network with excellent coverage". The company explains that the growing popularity of IoT use cases relying on connectivity spanning large areas, and able to handle a huge number of connections, is driving the demand for massive IoT.

Just a few years ago connecting small things to the IoT was difficult and relied on expensive and complex gateways. But today, we have an elegant solution in the form of cellular IoT, specifically the LPWAN options LTE-M and NB-IoT.

Cellular IoT LPWANs are booming because they meet the need for energy-friendly, cost-effective, long-range wireless connectivity between WLANs and the Cloud. According to analyst statista, the cellular IoT technologies, LTE for Machine-Type Communications (LTE-M) and Narrowband Internet of Things (NB-IoT), make up 47 percent of today's LPWAN market and form the market leading LPWANs for secure and reliable long-range connectivity.

Because cellular IoT uses regulated spectrum, access to the network is tightly controlled—with each connected device requiring a Subscriber Identity Module (SIM) or updated version thereof such as an eSIM or iSIM—and data charges are the norm. But in return, connectivity is widespread, robust, free of interference and highly secure.

"LPWANs bridge that gap between remote IoT end devices and the Cloud," explains Martin Lesund, Technical Marketing Manager – Cellular IoT with Nordic Semiconductor. "Cellular IoT offers up to 15-kilometer range together with low power consumption. Moreover, the Quality of Service (QoS) and security of cellular IoT is far beyond competing technologies and it's supported by established global infrastructure."

> The cellular IoT market is finally ready to start reaching its full potential. Nordic is poised to take full advantage of this market today because it had the courage to be an early pioneer

NO SMARTPHONE REQUIRED

High-throughput cellular technology is extremely complex and expensive, and the hardware is bulky and power hungry. For IoT engineers, high-throughput cellular technology's high-cost, -complexity and -power consumption make it tough to build the networks of compact, battery-powered sensors that will form the IoT.

Yet, cellular modems—essentially stripped-down mobile handset modems—have found a niche for connecting expensive remote assets to the Cloud. For example, rural Intelligent Electronic Devices (IEDs) used to control smart electricity distribution grids, routinely send information back to a control center via a cellular modem. And operators of commercial equipment like vending machines can use a cellular modem to send information back to HQ rather than dispatching a service operative to manually check stock.

But the modems that power these applications are unsuitable for the low power and resource-constrained devices that will make up the IoT. Instead, cellular IoT's genesis can be found in the 3rd Generation Partnership Project's (3GPP)—a grouping of seven telecommunications standard development organizations—LTE specification Release 13. The specification defined a new low-complexity RF modem that supported the needs of LPWANs for the IoT.

When it was adopted in 2016, Release 13 specified three new technologies for LPWAN support: Extended Coverage GSM Internet of Things (EC-GSM-IoT), LTE-M and NB-IoT. It's the latter two that have since had the greatest impact.

LTE-M operates as a half- or full-duplex system featuring a bandwidth of 1.4 megahertz. The raw data throughput is 300 kilobits per second on the downlink and 375 kilobits per second on the uplink, providing approximately 100 kilobits per second both ways for an application running Internet Protocol (IP). Mobility is fully supported by the same cell handover as conventional LTE. In contrast, NB-IoT was primarily designed for energy efficiency and for better penetration into buildings and underground. The trade-off is a relatively modest throughput. NB-IoT is not based on the LTE physical layer (PHY); instead, it is a new type of RF technology with modem complexity even less than that of an LTE-M modem. NB-IoT uses a narrow 200 kilohertz bandwidth.

NOT ALL 5G IS CELLULAR

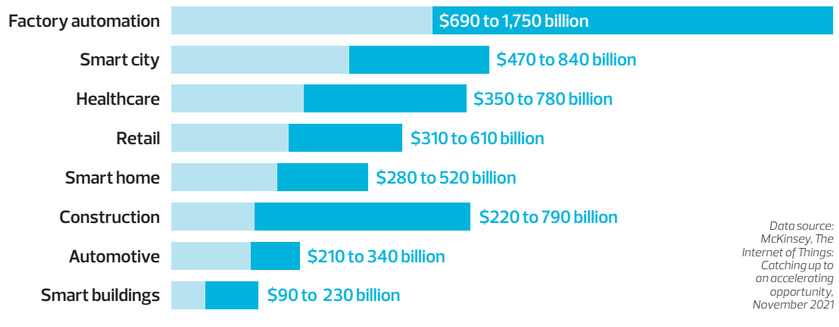
Since Release 13 in 2016, the specifications for cellular IoT have continued to evolve. For example, Release 14 introduced a second form of NB-IoT, CAT-NB2 which featured higher throughput, and introduced some advanced positioning technologies for NB-IoT. And Release 17 further increased throughput. Perhaps most importantly, while NB-IoT and LTE-M were initially developed as part of the 4G LTE standard, the 3GPP has made NB-IoT and LTE-M a key part of the 5G standard ensuring continued development as the network evolves.

State of Play

A new way to boost the global economy

When Kevin Ashton, 'the father of the IoT', posited the global network, he saw it automating and therefore increasing the amount of data computers could work with by many orders of magnitude, allowing for informed analysis and rapid action without human intervention. However, Ashton's vision of the network differs in a critical way from what we have now. While he saw billions of cheap and compact sensors dumbly feeding their data to a centralized computing resource, today, thanks to incredible advances in embedded processing and wireless connectivity, the IoT's intelligence is highly distributed. That distributed intelligence is enabling engineers to build platforms that will add trillions to the world's economy.

2025 potential economic value of the IoT in various market sectors



Data source: McKinsey, The Internet of Things: Catching up to an accelerating opportunity, November 2021

Special Report: Cellular IoT

Nordic Viewpoint:

Geir Langeland
EVP Sales & Marketing, Nordic Semiconductor

Svein-Egil Nielsen
CTO/EVP R&D, Nordic Semiconductor

Customers first

For end users cellular IoT couldn't be simpler to use. In many cases it will be no more complicated than opening the box and turning it on to get immediate wireless connectivity that will almost never go down.

But that simplicity and reliability hides an awful lot of behind-the-scenes wireless complexity. In fact, if wireless is a complex area of electronics design, then cellular takes it ten times further.

For us at Nordic Semiconductor this will mean extending one of our most cherished and long-held company traditions: our technical support is second-to-none. And supporting our customers every step of the way through their technological development journey is in our DNA as a company.

Nordic always puts its customers first. And when it comes to technological support, this means taking full responsibility for helping them quickly find a fix to any problems whether the issue stems from a Nordic part or not, and regardless of how large or small the customer.

What marks Nordic apart is this is not just words or a statement of good intentions. We have the R&D department and experts that can solve pretty much any technical problem a Nordic customer might run into while developing their wireless IoT product or application. And this can mean the difference in some cases between a product making it to market in a profitable timeframe or not making it to market at all.

Cellular will be one of many

As the IoT grows, so will the range of companies that will need its benefits. And they won't necessarily want to become experts in IoT technology to leverage those benefits.

They will want Nordic to be a one-stop-shop for all their IoT connectivity needs and this is what's driving our mission.

It means Nordic has to offer the fullest range of standards-based solutions. And standards simply mean a healthy multi-vendor market companies can rely on to protect them in the long term.

It's also extremely common to combine more than one wireless tech within an application. So, it's useful if the vendor has done all the heavy technical lifting and engineered its solutions to work seamlessly together. For example, combining Bluetooth LE and low power Wi-Fi in the smart home.

Nordic also appreciates that in an emerging market like IoT, it may well have to offer an even wider range of IoT technologies in the future.

Cellular IoT and DECT NR+ are both prime recent examples in that they both appeared to come from nowhere. So, I would not feel comfortable predicting they will be the last word in massive IoT, there's probably more to come.

What Nordic Semiconductor aims to do, therefore, is not a one-size-fits-all approach, but rather give its customers the ability to mix-and-match technologies as required using a unified and simple development environment.

The next phase of massive IoT growth will leverage these 5G networks. Engineers have been thinking ahead to predict what will be needed and have defined a future including 'massive machine type communication' (mMTC). It's a future that sees the very large-scale installation of low-power wireless for machine-to-machine (M2M) applications. Such technology will be designed for the deployment of up to one million devices per kilometer.

NB-IoT and LTE-M are being further developed to meet the demands of mMTC but they won't be alone; DECT New Radio (NR)+ (also known as DECT-2020 NR) also meets all the technical requirements for mMTC including those for Ultra Reliable and Low Latency Communications (URLLC). DECT NR+ is defined as a 5G technology — albeit not a cellular one. The specification was developed by ETSI and is based on technology from the DECT Forum.

NR+ uses the 1.9 GHz operating frequency. This is a global, license-free spectrum allocation and because there are no data charges, DECT NR+ is cheaper to run than its licensed equivalents. This means that instead of having to use licensed networks, engineers can build dense private mesh networks using a free band and without the need for SIMs. Range is hundreds of meters indoors or up to several kilometers outdoors. It can support up to four billion unique radio devices in a network and up to one million nodes per square kilometer. 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). (*See WQ Issue 2 2022, pg14.*)

Tech Check

Leveraging low power LTE technology, advanced processing capabilities and robust security features, the nRF9161 offers high performance and versatility. It brings enhanced features including support for DECT NR+ and 3GPP Release 14 LTE-M/NB-IoT

AT THE FOREFRONT OF MASSIVE IOT

Nordic Semiconductor launched its cellular IoT solution, the nRF9160, a low power SiP with integrated LTE-M/NB-IoT modem and GNSS, back in 2018. That made the company a pioneer in the emerging technology of cellular IoT and today it has built on that foundation to become the first to offer a fully inclusive, world-class, massive IoT solution. Nordic's offering brings simplicity, stability and cost efficiency to cellular IoT design, manufacture and deployment.

If the IoT is to reach its promised potential, it will need a comprehensively engineered foundation. By introducing end-to-end support for cellular IoT, Nordic is among the leaders in helping its customers build IoT infrastructure that will last. But the company is only just getting started; its plan is to be a major designer and supplier of critical parts of the infrastructure we'll use to connect billions of tomorrow's smart devices for years to come. Read on to find out how.

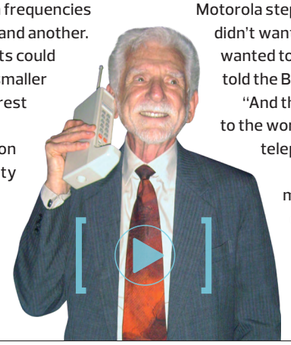
Ring, ring: the birth of cellular networks

1947 was something of a watershed moment for the communications sector. It was not only the year that the transistor (the switch at the heart of all of today's digital electronics) was invented but also the year that Doug H. Ring sketched out the rough design for a standard cellular phone network. According to *Interesting Engineering*, across eight pages, the Bell Labs engineer laid the intellectual groundwork for today's cellular networks. At the time, Ring was thinking about car phones, but the technology was just as capable of supporting the mobile handsets that hadn't been thought of yet.

The clever part of Ring's plan was to cover the country with a network of small cells (circular in his sketch but later more like the hexagonal cells of a honeycomb) each of which would contain a base station. These base stations would send and receive messages from mobile phones over radio frequencies. Any two adjacent cells would operate at different frequencies, so there was no danger of interference. The base stations would connect the radio signals with the main telco network, and the phones would seamlessly switch frequencies as they moved between one cell and another. Cellular operation meant handsets could be relatively low power and use smaller batteries as the range to the nearest base station would be short.

The tech to build Ring's invention was lagging and it would be twenty more years before two other Bell Labs engineers, Richard Frenkiel and Philip Porter, could construct the cells into a more practical concept for a mobile telephone network for automobiles. By the end of the 1970s the Bell Labs Advance Mobile Phone System (AMPS) was up and running on a small scale. But Bell Labs was having less success in building an actual portable, handheld telephone for use in the car.

That's where Martin Cooper (pictured) and Motorola stepped in: "We believed people didn't want to talk in cars and that people wanted to talk to other people," Cooper told the BBC in a 2003 interview.



"And the only way [to] prove this to the world was to build a cellular telephone."

On April 3, 1973, Cooper made the first public call from a cellphone to a man he'd been competing with to develop the device – one Joel Engel, head of AT&T-owned Bell Labs.

Cellular IoT

Ahead of the Game

Nordic entered the cellular IoT market even before the infrastructure had been built. But such an ambitious approach was needed to build a truly disruptive solution

Cellular is brutally hard to get right," says Nordic's CTO/EVP R&D, Svein-Egil Nielsen. "In fact, the standards and regulatory requirements make it easily five to ten times more complicated than Bluetooth. So, to me this will make it an extremely hard market for any new player to enter. But that's exactly what we did five years ago. And we have never looked back."

When Nordic entered the cellular IoT market in 2018 there was no market for the technology because the global infrastructure had not yet been built. Even so, there were some incredibly big, optimistic predictions about how large the market would grow and how quickly.

This hype served to fuel some unrealistically high market expectations that didn't materialize. And in some ways, this created the perception that cellular IoT wasn't all it was touted to be. "But nothing could be further from the truth," says Nielsen. "There was a reason the world's major network operators were much slower than anticipated to roll out their network coverage for both the NB-IoT and LTE-M flavors of cellular IoT.

"The delay wasn't because the operators were being slow or lazy. It was because they wanted to get it right. And that meant in the true cellular wireless technology fashion, making sure their networks would offer to IoT applications the same legendary security, reliability, global coverage and scalability that cellular for smartphones had demonstrated for decades."

According to Geir Langeland, EVP Sales & Marketing with Nordic, building a robust network was critical, but doing so stalled commercial development. He sees that changing with the potential for mass cellular IoT deployment. And not a moment too soon for a market-listed organization like Nordic which is waiting for a return on the substantial up-front R&D investment it made in the technology. "However, we wouldn't be poised to take advantage of the increase in commercial activity if we hadn't had the courage to be early advocates for cellular IoT," notes Langeland.

> The nRF9160 is almost five years old and still years ahead of the competition in terms of power consumption, integration and performance

BRINGING IT ALL TOGETHER

Nordic used its time during the five year full global rollout of cellular IoT wisely. What it did was develop a platform solution from the ground up that was far ahead of its competitors: the nRF91 Series, starting with the nRF9160 LTE-M/NB-IoT SiP.

"The multimode nRF9160 is still years ahead of the competition in terms of power consumption, integration and performance," says Kjetil Holstad, Nordic's EVP Strategy & Product Management. "But this has created a massive educational challenge for us. Many prime potential customers are yet to realize that it's now technologically and commercially possible to make anything connected anywhere. And with cellular I mean out-of-the-box without having to worry about building a network or even having to connect to a gateway. It's switch-on-and-go territory for the end users."

And while you can't expect to run a cellular IoT product from something as small as a coin cell battery, you can expect to run it for extended periods of time from slightly larger regular batteries. The latest developments in battery technology could see cellular IoT applications operating for similar lengths of time as Bluetooth wireless tech. That means years in some use cases. And recent advances in energy harvesting hold the promise of extending these battery operating lifetimes to many years if not decades in the not-too-distant future.

THE NORDIC EDGE IN CELLULAR

"Nordic's nRF91 Series SiP cellular solutions use such powerful on-board computer processors they can also make the ability to do AI and machine learning [ML] at the edge completely viable," explains Holstad. "That means delivering on the core promises of the IoT: the ability to do ten times more with ten times less such that the initial investment doesn't just pay for itself, it saves Nordic customers substantial amounts of money in the long run."

"If you're not thinking about AI and ML, you really should be," adds Nielsen. "This isn't coming ten years from now, or even five years from now. This is where everything is heading, on countless product roadmaps, that will come to market within the next couple of years.

"With AI and ML will come a level of IoT intelligence and therefore usefulness that has never been previously available. As such, if your next generation product or application isn't planning to use AI and ML, then it risks being completely outclassed—even invalidated—by your competitors that do use these technologies.

"The game changer is the ability to do AI and ML at the edge on a single cellular IoT device that can run off batteries for long periods of time: that's the Nordic edge in cellular."

ADDING DECT NR+

Nordic's nRF9160 SiP has since been joined by the two new powerful additions to the cellular IoT SiP range: the nRF9161 and nRF9131 LTE-M/NB-IoT and DECT NR+ ('NR+') solutions. These not only further redefine the disruptive commercial and technological possibilities of cellular IoT, they also introduce native NR+ support and capabilities to cellular IoT for the very first time.

NR+ is a license-free technology (like ISM band wireless technologies such as Bluetooth LE and unlike traditional cellular which is based on licensed spectrum), but will now be built, standardized and maintained as a cellular-like wireless tech. This will include, for example, a radio physical layer (PHY) and the use of signal modulation and coding schemes instantly familiar to any cellular engineer.

> With AI and ML will come a level of IoT intelligence and therefore usefulness that has never been previously available

Unlike traditional cellular, NR+ will not require a cellular base station to operate. It will operate as a private network using the global, license-exempt 1.9 GHz band requiring no frequency planning or spectrum leasing costs. But NR+ will be a state-of-the-art 5G technology that promises to deliver all the benefits of cellular at much lower cost. These include the seamless ability to scale globally to not just millions but billions of IoT nodes, with cellular's legendary security and reliability (beyond a few dead spots due more to the physics of electromagnetic wave propagation and interference than any technical shortcomings in cellular).

NR+ is a pure-play IoT wireless technology that promises to deliver ultra reliable wireless connectivity in completely new M2M applications where failure is not an option. Think autonomous self driving vehicles or high speed robots that operate alongside human factory or warehouse workers, for example. Or critical infrastructure in buildings, cities and utilities networks.

NR+'s reliability will exceed that of wired installations such as Ethernet. This is because the technology will employ self-healing mesh networking techniques that eliminate single points of failure. And NR+ promises latencies matching that of wired networks from the start. Nordic's first nRF91 Series-based NR+ solution, for example, will offer one millisecond latency between devices and a throughput of three megabits per second.

This performance will apply to densities up to one million devices per square kilometer. It is performance that makes NR+ a truly unique wireless technology in a class of its own.

"DECT NR+ is a big deal," explains Langeland. "It's the first ever non-cellular wireless technology to become part of a cellular generation ('G') standard, starting with 5G. It's also completely license-free and targets massive IoT applications targeting millions or billions of nodes. This takes massive IoT over 5G and private 5G networking from unaffordable for all but a privileged few to something any company can access."

THE NEXT FIVE YEARS

The IoT is going to play a major role in solving some of the planet's biggest problems not least of which are climate change, sustainable consumption, conserving precious natural resources, improving health outcomes and making the world a happier, safer, healthier place for all.

It's been a long-time coming, but 2024 could well be the year cellular IoT technology starts to become more mainstream. This means being installed in a wide range of products and forming the critical backbone that provides global connectivity to countless IoT applications.

"Rewards are proportional to the kind of risks you are prepared to take and your willingness to disrupt established industries," concludes Langeland. "This requires endless amounts of tenacity and patience to keep going when things get tough. And they will get tough when you're at the forefront of an emerging market that often didn't exist before you entered it.

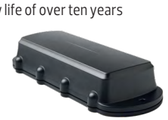
"But it's what it takes to develop a wireless technology that has not just the potential but actual ability to transform the world. And that starts with giving our customers the ability to develop market-leading products that offer commercially viable capabilities that were once unthinkable, even just five years ago."

Tech Check

The P Alert Meth Alarm developed by Technosphere uses a Nordic nRF9160 SiP to send alerts, via a user's smartphone, to a Cloud platform if the use or manufacture of methamphetamine is detected in a property

A newly launched example of using harvested solar energy in cellular IoT with Bluetooth LE connectivity is Brocere Electronics' Blockcraft modular IoT Sensor platform that can be used to monitor a wide range of data including temperature, humidity, pressure, movement, light and sound

The Remora3 cellular IoT asset tracker from Digital Matter delivers a claimed battery life of over ten years and uses the Nordic nRF9160 SiP with integrated LTE-M/NB-IoT modem and GNSS to offer either GPS, GLONASS, Galileo, BeiDou or QZSS to work out its location



Nordic Viewpoint:

Kjetil Holstad
EVP Strategy & Product Management, Nordic Semiconductor

Svenn-Tore Larsen
CEO, Nordic Semiconductor

Abstracting away complexity

Today Nordic's mission is to make low power wireless IoT connectivity accessible to everyone. This includes abstracting away as many unnecessary layers of technical complexity as possible and offering more of the hardware and software required to build a robust and market-ready turnkey solution.

Going from a Bluetooth wireless connectivity company to an IoT solutions provider requires you to look at the problems you are solving in a more holistic way.

That means you take responsibility from the battery or sensor, to the antenna, all the way up to the Cloud for the wireless connectivity, including the computer processing and power management. You also need to take responsibility for how each part of the whole chain affects the overall power consumption when you're keeping energy usage as low as possible.

To own the whole supply chain and meet customer demand, Nordic's product offerings today have expanded into every major wireless IoT connectivity protocol and technology. This includes not just cellular IoT (NB-IoT and LTE-M) but also the newest massive IoT technology, DECT NR+, as well as low power Wi-Fi, Matter, Thread, Zigbee, Cloud and location services, PMICs and range extenders.

These solutions must be simple to design in, power-optimized and have a lower cost of ownership compared to using a mix of suppliers.

Cellular follows in Bluetooth technology's footsteps

Nordic originally redefined the Bluetooth wireless connectivity market with the launch of its nRF51 Series. And now it is redefining what's possible to do in cellular IoT with its leading-edge nRF91 Series.

Nordic has a track record of being first-to-market with class-redefining wireless IoT connectivity products that leave its competitors scrambling to catch-up, while Nordic focuses on developing the next breakthrough.

The company is also first to launch products featuring key upgrades to the various standard based IoT technologies it supports.

Most importantly for Nordic's customers it means that if they specify a Nordic solution into one of their products the device will be capable enough to cope with several future generation upgrades.

Such future proofing can not only yield significant cost savings but also deliver time-to-market competitive advantages.

But we will also continue to refine our solutions – just as we've now done with the nRF91 Series. For example, the nRF9160 cellular IoT SiP was years ahead of the competition when launched in 2018 and now the nRF9161 and nRF9131 take a significant leap forward. The SIPs enhance not only NB-IoT and LTE-M, but also the key massive IoT technology of DECT NR+. And our products will always be backed by world-class technical support.

Power to the People

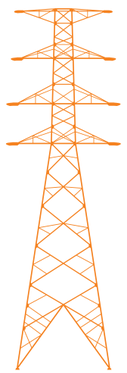
As our power infrastructure ages, and renewable energy and electric vehicles increase grid complexity, cellular IoT is becoming an essential tool in ensuring network reliability

In Short

Power grids are already hugely complex machines, and as renewable energy and EVs enter the mix, things are getting more challenging

The IoT is a key weapon in supporting ongoing power network reliability from smart grid management and energy monitoring, to consumption analytics and maintenance

Cellular IoT provides a ready-made connectivity solution because it's a robust, wireless technology tailor-made for large scale IoT deployments like smart meters



July 30, 2012 was a hot day in northern India, but 32° C wasn't unusual for that time of year. Two of the country's four electricity grids were under pressure, but that wasn't unusual either, particularly during the summer months. At 2:30 am, unexpectedly, circuit breakers on the line between Bina and Gwailor tripped. This line fed into the transmission section between Agra and Bareilly, causing breakers to trip there too. Within hours the power failures cascaded through the grid, shutting down every major power station in the affected states, and causing the largest power outage in history. That record didn't last long. The next day the grid went down again, this time impacting an estimated 670 million people—almost 10 percent of the world population. Chaos ensued. It took 15 hours to restore 80 percent of the service.

Around the world, grid engineering challenges stem from the fact that the networks are enormously complex and widely distributed, and as such lack the flexibility to accommodate new factors such as renewable energy.

The U.S. power grid, for example, is actually three grids, completely isolated from one another. This fragmentation is problematic because experts agree increasing the capability to transfer power between regions would mean more efficient power plant performance during normal operation, and the ability to efficiently share resources during high demand. As Aaron Bloom, Executive Director of NextEra Energy Transmission said at a Federal Energy Regulatory Commission (FERC) workshop last year: "The U.S. is the only macro grid in the world that doesn't have a plan of any type."

While India is now investing in smart grid tech—notably large scale smart meter projects—to address its disruptions, and the EU and China have continental and national grid development plans, the U.S. does not.

The lack of grid flexibility is pertinent because the power grids that were designed in the 1960s and 1970s to support the one way flow of energy from centralized power stations to consumers via expansive transmission and distribution networks, are becoming more complex – and bidirectional. Distributed energy resources in the form of rooftop solar photovoltaic (PV) units, batteries in electric vehicles (EVs), hydrogen fuel cells, wind turbines and biomass generators are increasingly common, and are also feeding energy back into the grid, unimaginable when the infrastructure was established 50 years ago.

"With the energy mix becoming more complex … renewable energies have created imbalances that generate temporary surpluses that need to be managed," says Lorenzo Amicucci, Business Development Manager at Nordic Semiconductor. "At the same time, the uptake of EVs will put huge stress on the grid. To manage this complexity, we need to collect data at scale, analyze it and have in place incentives to drive improvements in consumer power consumption choices. This means around-the-clock monitoring of the grid has become critical to ensure it is robust and efficient."

ENTER THE IoT

In India and elsewhere, investment in energy infrastructure is a priority to ensure utility grids are efficient while serving growing demand. The IoT is becoming a key weapon in efforts to support the ongoing reliability of networks from smart grid management and energy monitoring to energy consumption analytics, and predictive maintenance.

In the case of grid condition monitoring, fault detection and maintenance, low power cellular IoT in particular should prove a key enabler, because it provides an answer to the difficult and unique problems faced by geographically expansive power networks. Wherever power infrastructure is, so too is cellular IoT—or near enough—which is vital when you consider the U.S. electricity grids, for example, are comprised of over 7,300 power plants, 250,000 km of high-voltage power lines and millions of kilometers of low-voltage power lines and distribution transformers. That's a lot of territory to cover if a fault occurs, and if its location can't be easily identified.

Conventional fault location techniques rely on customers telling power companies there is a problem. The location of the fault can then be narrowed down by geographically grouping customer fault reports, at which point crew patrols can be dispatched to the approximate area to locate the fault, isolate the line, and restore power. In urban areas that can take hours, in remote areas it could be days.

Cellular IoT-connected sensors installed on network infrastructure provide an alternative, identifying the presence of a fault or the likelihood of a fault before it even occurs. For example, voltage, temperature, accelerometer and surge counter sensors could indicate fire, power surges or even the collapse of a transmission tower, likely brought about by extreme weather, animal or human interference (see sidebar pg23 *Why power outages happen*). Integrating NB-IoT or LTE-M LPWAN connectivity in the devices that house these sensors enables this data to be relayed back to the grid operator, and with the addition of Global Navigation Satellite System (GNSS) trilateration, the location of the fault can also be readily pinpointed. So far so good, but over millions of kilometers that's a whole lot of sensor data that needs to be relayed to the Cloud.

That's where machine learning (ML) at the edge is coming to the fore. "Using an ML model to reliably distinguish between a significant and insignificant event on the grid eliminates the cost of transmitting unimportant data over the network to the Cloud," says Amicucci. "Instead the device only sends an alarm when it determines human intervention is required. This not only reduces cost, it reduces the power consumption of potentially millions of devices operating in remote environments on battery power, where battery replacement is simply impractical."

THE ENERGY MIX

If all power companies had to worry about were network faults that would be one thing. But the advent of renewable energy means maintaining a balance between supply and demand becomes more intricate with the need to contend with substantial variations in power generation from a host of different sources. Today, almost a third of electricity worldwide comes from renewable sources according to the International Energy Agency (IEA), while the International Renewable Energy Agency (IRENA) forecasts that by 2050, 90 percent of the world's electricity can and should come from renewable sources. That's good, but what are those sources, what impact do they have on the grid, and how do power companies manage renewable variability to ensure a reliable power supply 24/7?

According to the IEA's *Global Energy Review 2021*, 99 percent of renewable energy comes from four sources – wind, solar, hydro and bioenergy. The availability of wind- and solar-generated power is of course variable. But the variability of these resources is typically pretty predictable. Accurate forecasts combined with many years of historical data, allow grid operators to balance and adjust resources as required. For example, wind farm turbines use a host of sensors to not only predict maintenance requirements, but also to measure and record metrics such as wind speed, power and yaw angles. The same is the case for solar installations. In 2020, Japanese energy solutions company, West Group, released its PCS Monitoring System (PMS) enabling remote data collection from commercial solar power installations.

Power conversion system data from each solar array, as well as data from luminance, temperature and humidity sensors is relayed to the PMS via a cable connection. The luminance sensor detects the level of sunlight, while the temperature and humidity sensors record general

> "The United States is the only macro grid in the world that doesn't have a plan of any type
>
> Aaron Bloom, Executive Director, NextEra Energy Transmission

environmental conditions to determine the efficiency of the solar array. The PMS integrates two Nordic nRF9160 SiPs to provide data and application edge processing and cellular network connectivity to relay the data to a grid control center where it can be reviewed and acted upon accordingly. Variability can also be mitigated through energy efficiency, diversification of technologies and their locations, power storage and demand response.

"Buildings that are more efficient need less heating or cooling and change their temperature more slowly, so they can coast longer on their own thermal capacity ... during peak-load periods," said Amory B. Lovins, co-founder and chairman emeritus of the Rocky Mountain Institute, writing in *Yale Environment 360*. "Batteries are rapidly becoming cheaper [and] at the same time, new storage technologies with diverse attributes continue to emerge.

"A third option for stabilizing the grid as renewable energy generation increases is geographical and technology diversity. The idea is simple: if one of the sources, at one location, is not generating electricity at a given time, odds are that some others will be."

Demand response meanwhile involves providing incentives to shift or shed electricity demand in wholesale and ancillary power markets to help balance grids dominated by variable power generation sources. Cellular IoT-powered smart meters can not only measure and record electricity consumption and generation, plus

> "Vehicles can charge at times of high renewable production, then supply energy back to their homes or the grid during peak demand hours or times of low renewable output

The Enua Charge employs Nordic's nRF9160 SiP and nRF9151 SoC to provide Cloud and smartphone connectivity to charge EVs when electricity is cheapest

communicate this information to consumers and utilities, they can also receive signals from utilities or other service providers such as price changes, incentives or requests to modify consumption. Cellular IoT provides a ready-made connectivity solution because it's a robust, wireless technology tailor-made for large scale IoT deployments like smart meters. Demand response can then be controlled automatically and imperceptibly to reduce peak demand, and enable the aggregation and remote control of smaller dispersed renewable resources, according to the IEA.

"One recent study found that the U.S. has 200 gigawatts of cost-effective load flexibility potential that could be realized by 2030 if effective demand response is actively pursued," Lovins said.

In 2020, U.S. engineering and product design agency, Apricity—subsequently acquired by Fortune 1000 backup power generation products manufacturer Generac Holding Inc.—launched its Apricity Ara cellular IoT and proprietary wireless mesh domestic water heater controller. The device is attached in-line with the power supply of each water heater, allowing it to be controlled remotely by the local power utility using LTE-M wireless tech. This results in the water still remaining near optimal temperature but avoids unnecessary electricity consumption during peak periods This in turn avoids spikes in demand that can increase the cost and inefficiency of running local power grids.

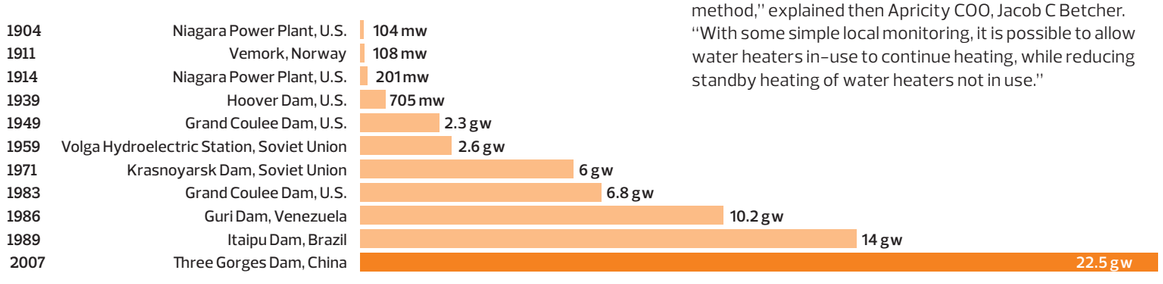
"During times of peak electricity demand, asking dormant hot water heaters to temporarily reduce their energy consumption is a very effective power load reducing method," explained then Apricity COO, Jacob C Betcher. "With some simple local monitoring, it is possible to allow water heaters in-use to continue heating, while reducing standby heating of water heaters not in use."

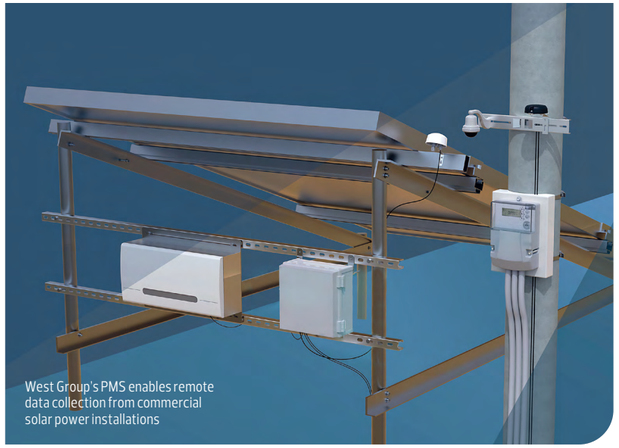
State of Play

The balance of power

Since the early 20th century, the largest power station in the world has been a hydroelectric power plant. In 1904, the largest in the world was the Niagara Power Plant at Niagara Falls in New York with a capacity of around 104 MW. Since 2007, the record for the largest power station has been held by the Three Gorges Dam in Hubei Province, China, with a capacity of around 22.5 GW, over 200 times larger than the Niagara Power Plant and generating enough electricity for the instantaneous demand of nearly 17 million homes.

Progression of the world's largest power stations by capacity





West Group's PMS enables remote data collection from commercial solar power installations

EVs DRIVE GRID UPGRADES

According to the IEA, one in ten passenger vehicles sold worldwide last year were all-electric. And while there are wide geographical variations, sales of EVs are enjoying year-on-year exponential growth. The impact on the grid not only depends on the number of EVs, but also on how they're charged, and how they can transfer energy back to the grid. Currently most EV drivers plug in when they arrive home, and then unplug when they leave the following morning, but the vehicles themselves are typically drawing current for only about three hours. Many chargers start delivering electrons immediately, but with potentially tens of thousands of drivers all plugging in at around the same time, the surge of demand could easily overwhelm the grid. The solution is to coordinate charging sessions to smooth the demand curve; the EV sector is offering help.

For example, in 2023 Norway-based EV technology company, Enua, launched a smart, portable EV charger that allows EV owners to charge their vehicles smartly. "Integrating LTE-M allows the charger to be connected so the user can respond to dynamic electricity price changes and only charge their vehicle when the prices are at their cheapest," says Torben Aune, Enua CEO.

EVs can also help integrate renewables into the grid in so called vehicle-to-grid (V2G) systems. V2G systems enable the charged power to be pushed back to the grid from car batteries, allowing utilities to balance variable demand. While the concept is robust, V2G is not fully operational. But smart meter rollout and cellular IoT will be key, enabling bidirectional communication enabling the utility to tell the EVs when to send electricity back to the network.

To ensure a reliable supply of power we need to understand, monitor and manage the supply and demand for energy at enormous scale. With fast, quality wireless networks, all our energy consuming devices can be connected to the smart grid of the future in what is dubbed 'The Internet of Energy'. Energy companies will be able to optimize resources and maximise grid performance. Governments can develop informed policies and regulation, and consumers can save money. It's a win-win-win for the smart grid of the future, and the planet.

Tech Check

Nordic's nRF9160 is a low power cellular IoT SiP. The integrated modem supports both LTE-M and NB-IoT wireless connectivity. Arm TrustZone technology helps build solid and secure IoT applications that feature secure boot, trusted firmware updates and root of trust implementations without performance compromise, ideal for smart grid applications

Why power outages happen

Leaving aside unpaid electricity bills, the most common cause of power outages wherever you live is almost always severe weather. Lightning strikes, fallen trees, fallen streetlights and high winds are common culprits, as are ice and snow. Power outages due to weather cost the U.S. economy between $18 and $33 billion each year in lost output and wages, spoiled inventory, delayed production and damage to grid infrastructure.

Wildfires and natural disasters can also play havoc with the grid. Earthquakes can cause significant damage to power infrastructure, while in areas prone to wildfire, power companies may proactively shut off lectricity to prevent the risk of fire. If it's not a natural disaster, it's probably a human one. Vehicles crashing into utility poles or other electrical equipment and unauthorized digging disturbing underground cables are the two most common human-made culprits, although thieves stealing copper wire from substations is distressingly frequent.

Then if it's not us, it's probably an animal. Depending on where in the world you live, squirrels, termites, birds, snakes or rodents are likely responsible for short circuiting electrical equipment. Inconvenient for you and me, shocking for the creature.

Then of course there are the times when we all want our electricity at the same time and power grid overload leads to blackouts across the network. According to the International Energy Agency (IEA) cooling represents around 10 percent of global electricity demand. In hotter countries, it can rise to more than 50 percent in summer. In Texas, for example, every 1°C increase in the average daily temperature above 24°C drives electricity demand up by 4 percent according to the IEA.

Sometimes power goes off f r reasons we can't easily predict – like the weather in space. A severe space weather event—for example, a solar flare or coronal mass ejection—can create variations of the Earth's magnetic field, called geomagnetic storms. These variations cause currents to flow in power networks leading to asset damage. Such an event cut power for around 6 million people in the Canadian city of Quebec in March 1989. The overheating of transformer cores caused homes and businesses to lose electricity for nine hours.

Work in Progress

Traditionally slow to evolve, the construction sector is belatedly embracing wireless innovation – laying the foundations for onsite productivity gains and safer projects

In Short

Historically the construction sector has taken time to innovate, but wireless tech is helping the industry reach its potential

Connected construction offers potential advantages over manual operations, from improved transparency and data-driven insights to superior workflows and better margins

Significant construction productivity and safety gains can be made using wireless solutions such as smart building material monitors and wearable devices for workers

Coral Sense developed its ABR-WM01-MLG wireless MCU module employing Nordic Semiconductor's nRF5340 SoC—the world's first wireless SoC with two Arm Cortex-M33 processors—to deliver a low power, long range solution for developers

No industry shapes our daily lives more directly than architecture, engineering and construction (AEC). AEC in some form has underpinned the very nature of society from ancient times to today. It influences the way almost every organization operates. From the buildings we call home and the transport infrastructure we rely on to reach our destinations, to our workplaces, schools, hospitals and entire cities, AEC has a fundamental impact on communities across every continent around the world.

And construction is a giant of the global economy. Not only does the sector employ around seven percent of the world's working population, it's also responsible for about $10 trillion (13 percent of world GDP) of spending on related goods and services each year. And around 50 percent of a construction project's total cost relates to labor.

Yet historically the construction sector has earned a reputation for being one of the slowest to innovate. In many ways, construction sites today resemble those of a century ago – think paper blueprints, scaffold towers and manual bricklaying. As such, the industry has remained subject to a severe productivity problem. While automation and digitalization have been transforming sectors like manufacturing and retail, construction has failed to embrace new technologies.

But the growth potential is obvious. A 2017 McKinsey Global Institute report estimated that by adopting tech, over time the construction industry could generate a 50- to-60 percent overall productivity improvement, boosting the sector's value by $1.6 trillion annually.

Already digital adoption is accelerating on the back of strong demand for infrastructure, a shortage of skilled labor, and increased expectations for data transparency and integration among stakeholders. An estimated $50 billion was invested in AEC tech between 2020 and 2022—85 percent higher than the previous three years—according to the latest McKinsey research. During the same period, the number of deals in the industry increased by 30 percent.

Analyst, Reports and Data, expects the global connected construction site market—incorporating earthmoving, lifting and material handling, concrete pouring, paving and road construction, and other application categories—will grow from $1.97 billion in 2022 to reach $2.3 billion in 2032, registering a CAGR of 17 percent during the forecast period. This growth is expected to be driven by increased usage of cutting-edge technologies including the IoT, big data analytics and AI, as well as a greater emphasis on sustainability in the building sector. GlobalData predicts that by 2025, construction companies will spend $36.9 billion globally on Cloud services and solutions, up from $17.4 billion in 2020, reflecting a CAGR of 16.3 percent.

Investment is being made in technology that can help pave the way forward. The rise of low power wireless tech-based solutions is beginning to disrupt this traditional sector. For example, companies are increasingly taking advantage of real-time field reporting by connecting and tracking materials, equipment and workers at the construction site.

OPTIMIZING THE WORKSITE

Imagine a construction project manager arriving on site or at the office—or even being able to work from home—and, before even finishing their morning cup of coffee, logging-in to a complete construction management platform to access near real-time project data and task alerts. This information then enables fast, actionable decisions and workflows from the back office to the field, through to the extended project team and all external stakeholders. Far from a pipedream, this scenario describes the experience of a connected construction site functioning without the silos that limit collaboration.

Connected construction offers layers of potential advantages over manual operations. For one, it can improve active and passive communication and transparency on the worksite – picture a worker reporting back to a supervisor via a smart device, or sensors and tags embedded in vehicles and equipment providing important updates such as the location and fuel status of a specific concrete truck. Connected-construction vehicles like dump trucks, backhoe loaders, excavators and mobile cranes, for example, would enable location detection and monitoring of usage/subsystems via embedded cellular and Global Navigation Satellite System (GNSS) technology.

And by turning estimates into actual data, more accurate project timelines and budgets become available. This allows site managers and construction teams to pinpoint precisely when one stage of a project is completed so the next stage can begin. Ultimately, better workflows and more reliable information will lead to improved margins.

The scope to remotely control and monitor equipment is critical to the promise of connected construction. That's why Taiwan-based company Coral Sense developed its ABR-WM01-MLG wireless MCU module employing Nordic Semiconductor's nRF5340 SoC—the world's first wireless SoC with two Arm Cortex-M33 processors—to deliver a low power, long range solution for developers. The module is designed to cater to the unique requirements of the smart construction sector, among a host of other industries. (*See pg9.*)

"The ABR-A01 platform offers enhanced wireless connectivity, network integration and monitoring capabilities, making it suitable for building, construction and industrial automation applications," explains Sog Yang, Executive Director, Coral Sense.

In addition to its wireless connectivity with various Bluetooth LE-enabled devices, the ABR-WM01-MLG module incorporates Nordic SoC-enabled Bluetooth Mesh functionality. This significantly broadens the range of potential applications, encompassing control, monitoring and management systems – particularly for use cases that require low power devices in construction environments.

Connected sites can also extend to material monitoring. By integrating sensors into essential materials like concrete, project teams can access real-time data on the construction material's curing status and strength to improve the overall quality.

German company ConcR GmbH has launched a smart building material monitoring solution that analyzes the physical attributes of concrete as it dries and 'matures', to check when it is safe to proceed with the next stage of construction. The Nordic-powered cellular IoT solution provides data across the lifecycle of cementitious building materials like concrete and screed starting from construction until 25 years in operation. This enables a data centric insight within each lifecycle phase for planners, engineers, contractors and owner-operators.

The ConcR Sensors are attached to a rebar (a reinforcing steel bar used to strengthen concrete slabs) before the concrete is poured. The sensors are connected to the ConcR Box, which sends the data—collected every ten minutes—directly to the Cloud. This solution can record temperature, relative humidity, residual moisture, pH and chloride levels, providing key insights into the strength and durability of the cement or concrete.

"These physical attributes are vital from a civil engineering perspective," explains Burak Acilan, Founder and CEO at ConcR GmbH. "Without the validation that the concrete poured on-site meets the required technical specifications, construction cannot proceed. This makes the ConcR solution ideal not only for quality monitoring, but also for project management."

The ConcR Box is powered by the Nordic nRF9160 low power SiP. The multimode LTE-M/NB-IoT modem enables the nRF9160 to transmit the sensor data directly

WakeCap Technologies use hard hats to connect workers and entire job sites via Wirepas Connectivity Suite, a scalable and easily deployable battery-powered wireless mesh network

Feature: Connected Construction

to the Cloud. The RF performance of the ConcR solution is optimized to achieve maximum range, critical in construction environments characterized by substantial concrete and cement structures, which typically pose significant signal RF attenuation challenges.

Once the data has been sent to the Cloud, it can be accessed using the ConcR Insights web dashboard or mobile app. By analyzing this data, the platform can provide important insights into metrics such as the evolution of concrete strength, and provide automated notifications when metrics surpass specified levels.

Beyond its low power capabilities, the nRF9160 provided ConcR with several other important advantages. "In addition to its low power consumption, and the power conservation enabled by the PSM and eDRX modes, we also selected the nRF9160 SiP due to the incredible RF sensitivity, which we found to be superior to that of competitive solutions," says Maysam Ibraheam, Head of Engineering at ConcR GmbH. "The support for both NB-IoT and LTE-M was beneficial, as was having a [SiP] that included both an [application] processor and modem in one small package."

> Companies are increasingly taking advantage of real-time field reporting by connecting and tracking materials, equipment and workers at the worksite

THE SAFER THE BETTER

Meanwhile, when it comes to human resources, the construction industry is one of the deadliest in the world. In the U.S., one in five workplace fatalities each year are construction workers—more than fatalities in the country's mining and farming industries combined—with falls the leading cause of work-related death in the sector. But construction work today is much safer than ever before (see sidebar *Safety first: Protecting workers through centuries of construction*). In the past, fatalities for big projects used to number in the thousands.

A connected construction site enhances every worker's safety, as well as their productivity. To that end, WakeCap

Technologies launched an enterprise solution using sensors integrated seamlessly into existing personal safety equipment. They use hard hats to connect workers and entire job sites via Wirepas Connectivity Suite, a scalable and easily deployable battery-powered wireless mesh network.

WakeCap is a wearable product designed to overcome the challenge of digitizing the construction sector's field logistics and workforce. The company claims the solution enables "real-time" and "real-motion" site reporting and analytics. It also provides complete and accurate visibility of worker flow traffic and equipment location – with no training, configuration or connectivity infrastructure required.

In operation, the hard hat-worn sensors track the wearer's location on a worksite and record any incidents of force on the hard hat. Network nodes are placed throughout the worksite and wirelessly linked with the hard hats. The network relays comprehensive site activity data, including worker time, location and motion/shock analytics, to a Nordic SoC-equipped gateway, which sends the data to the Cloud.

This information provides decision-makers with real-time, data-driven actionable insights via the WakeCap Analysis Platform on web or smartphone app. For example, WakeCap's analytics compare the on-site work crew timing with staffing and project management plans, highlighting unexpected problems early and avoiding delays or extra costs. It all adds up to improved efficiency, safety, job site control and profitability; in other words, precisely what this massive sector needs to reach its potential.

WakeCap demonstrates the value of mesh connectivity in an area where power is not available and where the radio environment is challenging and variable. The devices rely on Wirepas Connectivity Suite, the flagship product of Wirepas, a Tampere, Finland-based software company. The large scale, low power mesh connectivity software enables cost-effective, scalable IoT solutions with unprecedented scale, density, flexibility and reliability.

The Wirepas mesh network primarily allows each WakeCap hard hat to relay essential data forward to another hard hat or anchor node, maximizing coverage across a large worksite and reducing the number of anchor nodes or gateways required. Thanks to Wirepas Connectivity Suite routers' exceptionally low power consumption, the anchors are battery-operated. Thus, the system is straightforward to install on job sites.

Looking ahead, innovation such as that from Coral Sense, ConcR and WakeCap can drive the construction industry to a more productive future. But as of today, the new age of connected construction remains a work in progress. Nevertheless, as more and more platforms emerge in which construction equipment, vehicles, devices, personnel and locations can communicate with each other over wireless networks, our built environments and the people who build them will benefit greatly.

The ConcR smart building material monitoring solution can achieve a battery life of over two-and-a-half years, using Li-SoCl2 batteries, thanks, in part, to the class-leading power consumption of the nRF9160 SiP, which supports both PSM and eDRX power saving modes

State of Play

The changing (inter)face of construction

Within the construction industry, a growing number of firms are recognizing the importance of modern technology to help them address key business challenges, including project scheduling, budgeting, forecasting and quality control. According to a 2021 GlobalData survey, more than half (54 percent) of construction firms cite improving productivity as a key driver for adopting new technologies, 48 percent identify increased competitiveness as a driver and 33 percent want to leverage the benefits of new tech to reduce construction project costs.

Key drivers to construction firms adopting new technology

(% of total, respondents selecting up to three drivers)

Source: GlobalData

Safety first

Protecting workers through centuries of construction

Long before the advent of cranes and skyscrapers, ancient civilizations understood the importance of construction safety. From the remarkable pyramids of Egypt to the architectural marvels of ancient Rome, successful projects were built on the implementation of rudimentary safety measures – such as ropes, ramps and scaffolding.

In medieval times, meticulous craftsmen taught apprentices about the value of precision and caution. Wooden scaffolds and basic safety harnesses were used to safeguard workers during the construction of soaring cathedrals and castles. It took 200 years (1173-to-1372) to complete construction of Italy's Leaning Tower of Pisa — time well spent, as it allowed generations of builders to prevent catastrophic collapses.

When the Industrial Revolution (1760-to-1840) arrived, reshaping the construction landscape through the deployment of machinery, safety considerations became paramount. Innovations like hard hats and safety goggles quickly became standard for factory workers in the industrialized world.

Thanks to the extensive adoption of guard rails and safety screens, not a single worker died in the construction of the iconic Eiffel Tower (1887-to-89) in Paris. But other forms of danger still lurked; the world's deadliest construction project later took place in the early 20th century. Built between 1904 and 1914, the Panama Canal was responsible for a death toll of more than 30,000 workers (40 percent of its total workforce), making it the construction project with the highest documented fatality rate in the world. Most of these fatalities were due to infectious diseases such as yellow fever and malaria, but the construction work itself was also extremely dangerous. Workers had to blast through the mountainous jungle, while the rainy season meant contending with mudslides. Even once workers managed to control the deadly mosquito population, common causes of death remained drowning, electrocution and the unfortunate activity of prematurely igniting dynamite.

Audio & Music

AnkerWork M650

This hands free wireless microphone brings professional audio and video quality to social media content creators

According to social media landing page Linktree there are 207 million content creators worldwide. While not all are professionals, it's a significant growth area in terms of Internet based income as increasing numbers of people hope to monetize content. Professional standard, wireless audio equipment could provide content creators the edge they need to stand out in a crowded market

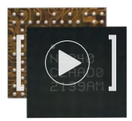
The AnkerWork M650 wireless microphone solution includes two transmitters—each of which employ a high sensitivity omnidirectional microphone for sound pickup—as well as a receiver, all employing Nordic Semiconductor's advanced dual core nRF5340 multiprotocol SoC. Audio data is relayed from the transmitters to the receiver using the proprietary TrueLink wireless protocol that enables high definition audio pickup and stereo sound input over a 200 meter range

Of the 200 million plus content creators worldwide, the most successful is arguably Jimmy Donaldson, AKA MrBeast. With more than 300 million followers, Donaldson's fan base is nearly as large as the U.S. population, earning him a whopping $82 million per annum in a share of digital advertising revenue. His stunts include surviving in Antarctica for 50 hours and building a Wonka chocolate factory. He has also launched multiple brands and merchandise including restaurants and snack foods

Each AnkerWork M650 transmitter includes a magnetic back clip so it can be easily attached to the wearer's shirt, and comes with a furry wind cover and VoiceShield noise reduction technology to reduce any potential background noise. Audio data is relayed to the receiver using the nRF5340 SoC's 2.4 GHz multiprotocol radio. The receiver features a high resolution LCD touch screen enabling the user to adjust input and output and audio settings with one touch control

Who invented the microphone? That's open to debate. In 1877, German–American inventor Emile Berliner filed a patent for a microphone, a patent that was then bought by Alexander Bell—the inventor of the telephone—for $50,000, or about $1.5 million in today's money. The problem was, electric light bulb inventor, Thomas Edison, had also filed a microphone patent, and a legal battle ensued that lasted 15 years. Finally, in 1892, the U.S. Supreme Court made a ruling in favor of Edison, a judgement that remains disputed to this day

Fashion—from the French word façon meaning face, appearance, design or beauty—is one of the key value creating industries for the world economy. If it were ranked alongside individual countries' GDP, the global fashion industry would be the seventh largest economy in the world, according to McKinsey. Two brands dominate, Nike and Louis Vuitton, collectively worth $70 billion, outstripping by a distance the likes of Hermes, Gucci and Adidas



Tech Check

Nordic's nRF5340 SoC integrates two powerful Arm Cortex-M33 processors; a high performance application processor capable of DSP and Floating Point with 1 MB Flash and 512 KB RAM, and a fully programmable, ultra low power network processor with 256 KB Flash and 64 KB RAM. The processors provide enough processing power for advanced applications like the AnkerWork M650 running an LC3plus codec, picking up a clear sound and assuring a stable connection at the same time

Waste Management

John Holland employs asset trackers for spoil management

Digital Matter's Nordic nRF9160 SiP-powered Oyster3 and Remora3 form the basis of John Holland's SpoilTRAC system

> By facilitating overall waste management, the platform encourages spoil reuse across projects, optimizes plant and personnel utilization, and presents opportunities for enhanced sustainability outcomes

With over 600 million tons of construction and demolition waste generated in the U.S. in 2018 alone (according to the Environmental Protection Agency (EPA)), proper disposal is crucial. And it's not just the spoil volume – the wide variety of waste types, from inert to hazardous, present serious logistical challenges for construction firms trying to adhere to the strict and regulated demands for disposal or recycling.

Having clear records of the amount and type of spoil, and where it has been discarded, can help companies avoid fines. Any mistakes can be costly - the EPA, for example, recently tripled the maximum fines for improper disposal to over $70,000 per day in California.

"Conventional processes for spoil tracking are labor intensive, time consuming and carry with them considerable risks of delay, overcharging, illegal spoil dumping and missed spoil re-use opportunities," says Fazil Hassan, Digital Development at Australian construction company John Holland.

To combat these problems, John Holland has implemented its award-winning SpoilTRAC system to monitor the movement of construction site waste - from extraction all the way to disposal. Based on IoT technology company Digital Matter's Oyster3 and Remora3 battery-powered geolocation asset tracking devices, this solution features an IP67-rated weatherproof, ultra rugged housing to help protect it from extreme conditions while mounted on dump trucks.

The wireless operation of SpoilTRAC allows for easy installation, removal and transfer between vehicles. This flexibility is important in construction projects, which often involve multiple subcontractors with their own kit.

Outfitted with an onboard temperature sensor and three-axis accelerometer for movement detection, high-G events and rotation counting, the Oyster3 and Remora3 can also identify when the truck's tray has moved into the predetermined tilt position, indicating that the spoil has been discarded.

Reliable asset monitoring

Employing Nordic's nRF9160 SiP, the Oyster3 and Remora3 devices combine cellular network location data with GPS trilateration to precisely locate each disposal truck. The devices complement GPS with cell tower location fallback when GPS signals are unavailable. The nRF9160 SiP's LTE-M/NB-IoT modem can then transmit the truck's location to the SpoilTRAC platform.

This platform offers detailed information on the spoil category of each load, accompanied by a map illustrating loading and unloading points. Because construction sites and licensed landfills are geofenced and tagged with the classification of refuse, if a contaminated load is dropped in the wrong location an illegal dumping alert is triggered.

By facilitating overall waste management, the platform encourages spoil reuse across projects, optimizes plant and personnel utilization, and presents opportunities for enhanced sustainability outcomes. Additionally, the use of cellular connectivity to transfer data to the platform ensures robust coverage while trucks are on the move.

"The cellular functionality of the nRF9160 made it easier to build a solution, as the amount of upload and download data is not constrained to the same extent as other LPWAN tech," explains Ken Everett, CEO at Digital Matter.

"[For example], the Remora3 is capable of 'second-by-second' [near real-time] tracking—which is unique on a battery-powered device—to support extended aggressive reporting requirements including highly accurate speed reporting, as well as run hour and odometer monitoring on mobile assets," explains Everett.

"The solution is perfect for any asset which requires aggressive long-term tracking with 'low touch' requirements – for example, tracking heavy machinery that doesn't have an easily accessible power source," says Everett.

Need to Know

The Nordic nRF9160 offers excellent low power cellular operation, caters for both LTE-M and NB-IoT, and allows Digital Matter to put its application code on to the SiP, thereby doing away with the need for an external microcontroller.

Further advantages

Beyond providing the robust connectivity for efficient data transfer, the Nordic nRF9160 SiP delivers further advantages to the Digital Matter solutions.

"It also allows us to manage and update the devices in the field. We provide over-the-air firmware updates as well as other device management functions," says Everett.

Battery life was also a critical factor when selecting the Nordic SiP, according to Everett. "Extending product lifetime significantly reduces operational costs for businesses – and eliminates the logistical nightmare of sourcing and coordinating battery changes, especially across large deployments," he explains.

The Oyster3 tracker boasts a battery life of up to ten years with daily position updates, or seven years with movement based location updates, and issues alerts when the battery level is low. The Remora3 features a "deploy once" battery life allowing it to perform typical movement-based tracking for over ten years.

"Digital Matter went through an extensive analysis of competing cellular modems and decided on the nRF9160 due to its feature set and, most importantly, the very low power operation," adds Everett. "Nordic has done an excellent job in achieving the lowest power levels of all modules evaluated."

Peter Pooran
CEO, Airsuite

Air quality monitoring helps create healthier conditions

Data analysis provides a better understanding of the factors influencing our indoor environments

The Te Haratau project—an initiative by the New Zealand Ministry of Education—was created on the back of research linking learning outcomes of students to the quality of their indoor environments.

AirSuite was born out of this project, when it became clear there was a wider scope of potential benefits outside of the education sector. We found continuously monitoring a range of indoor environmental variables could result in positive outcomes in terms of health, productivity and staff retention – many potential benefits far too important for any organization to ignore.

> In recent years, advancements in wireless technology have helped create a variety of scalable solutions

Wireless connectivity can provide near real-time responsiveness for air quality monitoring, which is necessary as environmental factors can change rapidly – for instance, increased carbon dioxide levels in crowded meeting rooms. These alerts enable immediate interventions, which is not attainable through historical data analysis.

In recent years, advances in wireless tech have helped create a variety of scalable solutions for indoor air quality monitoring, and allow for flexible placement of a wide range of sensors—measuring factors such as humidity, carbon dioxide, air pressure and volatile organic compounds (VOCs)—independent of local IT networks.

Cellular connectivity has emerged as a game changer, allowing companies to bypass local Wi-Fi networks and mitigate cybersecurity risks.

Better batteries and reduced power consumption have also significantly extended the lifetimes of wireless solutions. This also eliminates the hassle of frequent battery replacements, enabling companies to locate sensors where they are needed most.

Additionally, the simplification of systems has greatly reduced startup and overhead costs. It has now reached the point where anyone can deploy these products and have access to live data in just minutes. This has eliminated the need for IT support or installation technicians, making it accessible for even more companies.

The power of data analysis

The integration of AI and ML tools in wireless air quality monitoring promises a new era of intelligent data analysis, offering greater value for thorough predictive insights. This facilitates informed decisions for better health outcomes.

The growing emphasis on Corporate Social Responsibility (CSR) and the prioritization of employee wellbeing are anticipated to further drive the adoption of these solutions.

Devices like the AirSuite Glance are empowering organizations to curate the optimal environment for their most valuable assets – people.

[Tech Zone]

An in-depth look at Nordic's wireless solutions

Internet of Things

World-leading processing efficiency with nRF54H20 multiprotocol SoC

Nordic Semiconductor has announced that its nRF54H20 multiprotocol SoC—the first in the nRF54H Series—has proven its world leading processing efficiency, along with superior processing performance. This underscores the potential of the SoC to enable innovative IoT end-products that were previously impossible.

EEMBC ULPMark-CoreMark (ULPMark-CM) benchmarks the processor configured either for maximum processing efficiency or performance, using CoreMark as the workload. The nRF54H20's application processor achieved the following scores: Configured for maximum processing efficiency – ULPMark-CM score of 170 with 515 CoreMark; and configured for maximum processing performance – ULPMark-CM score of 132 with 1292 CoreMark.

The score shows that the application processor in the nRF54H20 offers a unique combination of efficiency and performance. Most processors are optimized for one of these attributes, but with the nRF54H20 developers can take advantage of both, by dynamically changing configurations.

In addition to the benchmarked application processor, the nRF54H20 features additional Arm Cortex-M33 processors and multiple RISC-V coprocessors optimized for specific workloads. While the measured performance of the application processor is remarkable, when combined with the other processors, the overall performance of this SoC will be even higher.

Enabling advanced IoT applications with a single low power wireless SoC provides a new approach to the design of end-products.

For example, a separate general-purpose microcontroller and an additional wireless SoC can be replaced with just a single compact SoC.

With this level of integration, new IoT end-products will consume less energy and be smaller, and development will be simpler.

Power Management

nPM1300 PMIC enters mass production

Nordic has announced that its recently released nPM1300 Power Management IC (PMIC) is now available for volume purchase through Nordic's distribution network. The nPM1300 is available as a QFN package with the chip scale package (CSP) coming soon.

With its two ultra efficient buck DC-to-DC converters, two load switches that double as Low Drop Out voltage converters (LDOs) and integrated battery charging, the nPM1300 is ideal for battery-operated applications. It reduces an end-product's Bill-of-Materials (BoM) by combining circuitry that typically requires five or more discrete components into a single chip.

The unique algorithm-based fuel gauge of the nPM1300 uses battery voltage, current, and temperature monitoring for higher accuracy than voltage-based fuel gauges, while keeping the PMIC's own power consumption considerably lower than coulomb counter-type fuel gauges.

Audio & Music

Module enables live wireless audio applications with sub 5 ms latency

A new wireless audio technology launched by New Zealand company Virscient enables live performance and gaming applications with ultra low latency audio over low power wireless connectivity.

Targeted at professional live performance, the LiveOnAir module integrates Nordic's dual-core nRF5340 multiprotocol SoC, and supports various use cases including digital wireless microphones, in-ear monitors, gaming headsets, and other scenarios where latency and audio quality are critical. The LiveOnAir module allows OEMs to rapidly develop high performance wireless audio solutions supporting ultra low latency transport of 24-bit/48 kHz audio while keeping the Bill-of-Materials (BoM) low.

The solution includes a software transport that can support a range of topologies, codecs and RF options that allow optimization for the specific requirements of any given use case. When used with the nRF5340 SoC, the software runs over Bluetooth LE connectivity to deliver mono or stereo audio with less than 5 milliseconds end-to-end latency.

The nRF5340 integrates dual Arm Cortex-M33 processors providing a high-performance application processor alongside a fully programmable, ultra low power network processor – making the SoC an ideal choice for LE Audio applications. For low power digital microphone applications, Virscient provides a complete hardware/software reference design, also based on the nRF5340 SoC.

LiveOnAir integrates Nordic's nRF21540 FEM and nPM1300 PMIC for extended range and power management advantages respectively.

Wearables

Sensor platform enables advanced wearable applications

Australian design firm Genesys Electronics Design has launched a modularized sensor platform for developers of wireless wearable solutions. The GP5000 Wireless Wearable Sensor (WWS) integrates Nordic Semiconductor's nRF52840 multiprotocol Bluetooth LE SoC to provide the wireless connectivity, alongside an extensive suite of sensors designed to enable a range of both medical and non-medical wearable applications.

The GP5000 WWS is comprised of two core components, a baseboard integrating the Nordic SoC, and a customizable plug-in sensor board. The baseboard includes a six-axis inertial measurement unit (IMU), a magnetometer, a temperature and humidity sensor, an ambient light sensor and a pressure sensor.

The sensor board can also be supplied with a wide range of optional sensors to record air quality, force, proximity, heart rate, SPO_2 and sound, for example.

The on-board sensors are supervised by the nRF52840 SoC's powerful Arm Cortex-M4 processor with floating point unit (FPU), which is capable of the processor-intensive computations required by advanced wearable designs.

The platform can be powered by either a replaceable or rechargeable coin cell battery.

To achieve efficient power management and charging of the rechargeable coin cell, the platform also integrates Nordic's nPM1300 power management IC (PMIC).

The nPM1300 PMIC simplifies system design by including essential functions required for embedded Bluetooth LE designs into one small package, enabling longer run times and efficient battery charging with fewer components.

Audio & Music

Module simplifies Bluetooth LE Audio development

An advanced module for wireless audio product design, based on Nordic Semiconductor's nRF5340 high-end multiprotocol SoC, has been launched by IoT company, Shenzhen Feasycom. The FSC-BT631D module is described by the company as the world's first Bluetooth module that can support both LE Audio and Bluetooth Classic. In addition to the nRF5340 SoC, the module integrates a Bluetooth Classic transceiver chipset for enabling legacy Bluetooth wireless audio applications.

For example, audio equipment solutions employing the Feasycom module can connect to audio source devices such as a smartphone, laptop or TV using Bluetooth Classic, then transmit audio to an unlimited number of other LE Audio devices using Auracast broadcast audio.

Tech Briefing

Accelerate cellular IoT product development

Here's how to ease design complexity, lower cost, optimize power consumption and shorten time-to-market of a cellular IoT or DECT NR+ end product

Nordic Semiconductor recently announced that it's the first company to offer a fully inclusive, world-class massive IoT solution. (*See WQ Issue 2 2023, pg10.*) The company says the solution forms a comprehensive, end-to-end cellular IoT platform with support for DECT NR+ ('NR+') and comprises new products based on nRF91 Series SiPs. The platform is said to bring simplicity, stability and cost efficiency to cellular IoT design, manufacture and deployment.

Such an approach makes getting a cellular IoT project off the ground much easier than relying on different suppliers for various parts of the solution. In the conventional supply model, one company might supply the cellular module, while another supplies the modem, another the microprocessor and yet another the power management. This not only makes the design more complex, it's also very likely to push up the power consumption because the component parts are not optimized to work together. Moreover, the cost of the solution is likely to be higher.

With Nordic, a developer can source all the hardware, firmware, development tools, technical support and Cloud services required for cellular IoT from a single supplier. This eases complexity, lowers cost, optimizes power consumption and shortens time-to-market for a cellular IoT end-product that might be in the field for over a decade.

> Nordic now enables the developer to source all hardware, firmware, development tools, technical support and Cloud services required for cellular IoT from a single supplier

New nRF91 Series hardware

Nordic released its first cellular IoT product, the nRF9160 SiP with integrated LTE-M/NB-IoT modem and GNSS, in 2018. In a compact SiP measuring just 10 by 16 by 1 mm the product comprises an application processor, modem, RF Front End, power management and other elements. Upon its introduction, the nRF9160 offered some key advantages, including global certification and the lowest power consumption of any complete cellular IoT device on the market. Since its launch, the nRF9160 has received new software that has further lowered the power consumption. The nRF9160 has already been used in a wide range of products such as asset trackers, smart meters, wearables and climate sensors.

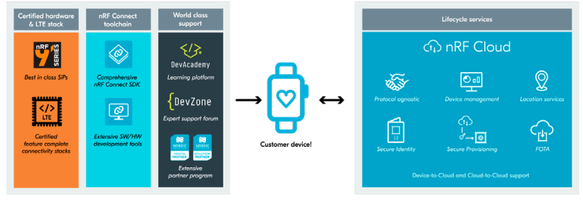
But now Nordic has announced something new; the nRF9161 is a precertified SiP featuring an Arm Cortex-M33 application processor, 1 MB Flash and 256 KB RAM, and requires minimal firmware migration effort from the nRF9160. The SiP supports 3GPP release 14 for LTE-M and NB-IoT with GNSS or runs the NR+ firmware stack. This is a license exempt protocol for scalable, decentralized massive mesh networks operating on the global 1.9 GHz band. (*See WQ Issue 2 2022, pg14.*)

Like the nRF9160, the nRF9161 is designed for low power operation. The firmware has been updated to include power consumption improvements (plus enhancements to location precision). Firmware development with the nRF9161 is supported by a DK and there's a new prototyping platform planned called Thingy:91 X. Thingy:91 X includes the nRF7002 companion IC for Wi-Fi SSID, the nRF5340 multiprotocol SoC, and the nPM1300 and nPM6001 Power Management ICs (PMICs).

The nRF9161 is joined by the nRF9131 mini SiP. This is 50 percent smaller and 25 percent lower profile than the nRF9161. It is feature and software compatible with the nRF9161 and is a good fit for NR+ and high-volume cellular products. The nRF9131 saves space because it doesn't include internal power management and some passive components and crystals have been removed. Unlike the nRF9161, use of the nRF9131 does require the customer to take responsibility for some of the design certification – although Nordic supplies a full reference design and Bill-of-Materials to ensure best performance and help limit the scope. The nRF9131 EK will be available for Proof-of-Concept (PoC) and pilot testing, and the nRF9161 DK is available for comprehensive firmware development. The nRF9161 nRF9131 are due for launch in Q1 2024.

How to connect securely to the Cloud

Cloud connectivity can be complex and costly, but with Nordic's nRF Cloud Security Services the process is made easier. First, the Secure Identity service enables the user to authenticate devices based on Nordic root-of-trust which can also be used to allow access to their Cloud. Then nRF Cloud Secure Provisioning allows remote provisioning with the required credentials and custom configurations. The platform enables, for example, a group of devices shipped to one location to be remotely configured with a specific power saving mode while another group of similar products shipped to another location can be configured to other parameters and credentials to connect to another Cloud end-point. During provisioning the device is 'claimed' and 'bound' through the Secure Identity service. Then it's provisioned, deployed and connected to the Cloud for normal operation. (See figure below.) nRF Cloud also offers IMEI management for allocation of IMEIs to customers' devices and to allow optional use of their own TAC ranges – saving cost compared to ordering through GSMA. It also enables simpler reporting of IMEIs to MNOs when necessary.



Nordic is the first company to offer a comprehensive, end-to-end cellular IoT platform with support for DECT NR+. The solution comprises new products based on nRF91 Series SiPs and bring simplicity, stability and cost efficiency to cellular IoT or NR+ design, manufacture and deployment

New firmware and development tools

Nordic has accompanied the SiP and mini SiP launch with enhanced cellular modem firmware stacks. Modem firmware 2.0 (which runs on the nRF9161 and nRF9131 but not the nRF9160) meets the requirement for 3GPP Release 14 LTE-M/NB-IoT plus GNSS. Improvements over the older firmware include: power saving mode for roaming devices; improved time-to-first-fix (TTFF) performance for GNSS satellite acquisition; SoftSIM support (also supported on the nRF9160); and global certification with Mobile Network Operators (MNOs). There is also an NR+ firmware stack for the nRF9161 and nRF9131; the stack is supplied by Nordic partner Wirepas and is accompanied by a software development kit (SDK).

Evaluation of the new SiPs is simplified with updated and new tools. These can be used to evaluate power consumption, modem performance and Cloud services, via AT commands or precompiled samples. The online Power Profiler tool enables the user to estimate the power consumption for their use case. The developer can set modem parameters based on application specifications and MNO guidelines to quickly asses power consumption needs and possible battery life.

nRF Connect for Desktop includes a power profiler (which requires the purchase of Nordic's Power Profiler Kit II) and a cellular monitor which analyses modem traces, evaluates communication and enables network testing. These are powerful tools for debugging and development.

For firmware development Nordic offers the nRF Connect SDK, the unified code base for all Nordic's hardware. It includes the Zephyr RTOS, protocol stacks and drivers. The SDK also includes reference apps and samples and a free-to-use Integrated Development Environment (IDE), nRF Connect for VS Code IDE. The IDE includes everything expected of modern design software (for build, flash and debug) including visual and command line support, Device Tree Visual Editor and a custom board wizard.

nRF Cloud IoT Services platform

A cellular device is required to communicate with the Cloud efficiently. Nordic offers nRF Cloud to enable device-to-Cloud communication or enable custom Clouds to access the award-winning nRF Cloud services (6th China IoT Technology Innovation Awards, 2021) through REST APIs (Cloud-to-Cloud).

nRF Cloud offers agnostic connectivity transport with support for CoAP, MQTT and REST. Nordic introduced CoAP over UDP to optimize power consumption during communication, but also to provide a protocol that works efficiently with both LTE-M and NB-IoT.

The developer can pick and choose the services they need for their application. nRF Cloud also includes device management services such as firmware-over-the-air (FOTA) updates, message storage and the ability to send device alerts and logs.

nRF Cloud Location Services offers a complete selection of location services including: Assisted GPS (reducing TTFF from minutes down to seconds and resulting in precise positioning and increased battery life); Predictive GPS (similar to Assisted GPS but with satellite data valid for up to two weeks – enabling the device to stay offline longer and still benefit from the assistance data); Service Set Identifier (SSID) Wi-Fi scans of nearby Wi-Fi access points to determine location (accuracy down to 20 meters while working inside and out); multi-cellular locationing (neighborhood accuracy of 500 meters); and single-cellular locationing (accuracy of one kilometer).

With nRF Cloud Location Services, a developer can combine these techniques or pick just one to suit their accuracy against power consumption requirements. There are a range of location vendors supported in nRF Cloud Location Services, so users are assured of the most accurate information for their region.

Nordic also provides Security Lifecycle services from blank to securely connected device including secure boot, authenticated FOTA and secure key/data storage.

The nRF91 Series is the lowest power complete cellular IoT device on the market. Together with this low power hardware, Nordic offers efficient firmware, protocols and optimized Cloud services. Such a single integrated solution for global deployment lowers costs, optimizes performance and accelerates time-to-market for cellular IoT products.

A Nordic webinar entitled *Accelerate cellular product development* is available from tinyurl.com/mrypx66a

Tech Check

The nRF9161 is a fully integrated SiP for cellular IoT and DECT NR+. It features a multimode LTE-M/NB-IoT modem with GNSS and NR+ support. LTE band support ranges from 600-to-2200 MHz and NR+ band support is at the 1.9 GHz frequency. The SiP is certified for global operation. It incorporates a dedicated 64 MHz Arm Cortex-M33 application processor

Nordic Product Guide

This handy summary describes all of Nordic's IoT solutions

NORDIC SEMICONDUCTOR

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

RF SoCs and SiP

		nRF 9 SERIES	nRF SERIES 53	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		●	●	●	●				
TYPE	SYSTEM-ON-CHIP (SoC)		●	●	●	●	●	●	●	●
	SYSTEM-IN-PACKAGE (SIP)	●								
CORE SYSTEM	CPU	64 MHz Arm Cortex-M33	128 MHz Arm Cortex-M33 +64 MHz Arm Cortex-M33	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4	64 MHz Arm Cortex-M4
	FPU	●	●	●	●	●				
	DSP INSTRUCTION SET	●	●	●	●	●	●	●	●	●
	CACHE	●	●	●	●	●				
	MEMORY	1 MB Flash, 256 KB RAM	1 MB Flash, 512 KB RAM +256 KB Flash, 64 KB RAM	1 MB Flash, 256 KB RAM	512 KB Flash, 128 KB RAM	512 KB or 256 KB Flash, 64 KB or 32 KB RAM	256 KB Flash, 32 KB RAM	192 KB Flash, 24 KB RAM	192 KB Flash, 24 KB RAM	192 KB Flash, 24 KB RAM
	CLOCKS	64 MHz / 32 kHz	128 MHz / 64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz
SECURITY	ARM TRUSTZONE	●	●							
	ARM CRYPTOCELL	310	312	310						
	ROOT-OF-TRUST	●	●	●						
	SECURE KEY STORAGE	●	●							
	PSA CERTIFICATION	Level 2	Level 2	Level 1						
RADIO	LTE-M/NB-IoT/GPS MODEM	●								
	CERTIFIED LTE BANDS	1–5, 8, 12–14, 17–20, 25–26, 28, 66								
	FREQUENCY	700–2200 MHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz
	MAXIMUM TX POWER	23 dBm	3 dBm	8 dBm	8 dBm	4 dBm	8 dBm	4 dBm	4 dBm	4 dBm
	RX SENSITIVITY	-108 dBm (LTE-M), -114 dBm (NB-IoT), -155 dBm (GPS)	-98 dBm (1 Mbps)	-95 dBm (1 Mbps)	-96 dBm (1 Mbps)	-96 dBm (1 Mbps)	-95 dBm (1 Mbps)	-97 dBm (1 Mbps)	-96 dBm (1 Mbps)	-97 dBm (1 Mbps)
	ANTENNA INTERFACE	50 Ω single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Single-ended
PERIPHERALS	HIGH SPEED SPI		●	●	●					
	TWI, SPI, UART	4xTWI/SPI/UART	4xTWI/SPI/UART +TWI/SPI/UART	2xTWI/SPI, SPI, 2xUART	2xTWI/SPI, SPI, 2xUART	2xTWI/SPI, SPI, UART	2xTWI/SPI, UART	TWI/SPI, SPI, UART	TWI, SPI, UART	TWI, SPI, UART
	QSPI		●	●						
	USB		●	●	●		●			
	PWM	4	4	4	4	3		1	1	
	PDM	●	●	●	●	●		●	●	
	I2S	●	●	●	●	●				
	ADC, COMPARATOR	ADC	●	●	●	●	COMP	ADC, COMP	ADC, COMP	ADC
	TIMER, RTC	3, 2	3, 2 + 3, 2	5, 3	5, 3	5, 3	4, 2	3, 2	3, 2	3, 2
	TEMPERATURE SENSOR	●	●	●	●	●	●	●	●	●
CERTIFICATIONS		nordicsemi.com/9160cert	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC	CE, FCC
OPERATING TEMPERATURE		-40 to 85°C	-40 to 105°C	-40 to 85°C	-40 to 105°C	-40 to 85°C	-40 to 105°C	-40 to 85°C	-40 to 85°C	-40 to 85°C
SUPPLY VOLTAGE RANGE		3.0 to 5.5 V	1.7 to 5.5 V	1.7 to 5.5 V	1.7 to 5.5 V	1.7 to 3.6 V	1.7 to 5.5 V	1.7 to 3.6 V	1.7 to 3.6 V	1.7 to 3.6 V
DEVELOPMENT KITS		nRF9160 DK, Nordic Thingy:91	nRF5340 DK, nRF5340 Audio DK, Nordic Thingy:53	nRF52840 DK, nRF52840 Dongle	nRF52833 DK	nRF52 DK, Nordic Thingy:52	nRF52833 DK	nRF52840 DK	nRF52 DK	nRF52 DK
PACKAGES		10x16x1.04 mm LGA	7x7 mm aQFN94 (48 GPIOs), 4.4x4.0 mm WLCSP95 (48 GPIOs)	7x7 mm aQFN73 (48 GPIOs), 6x6 mm QFN48 (30 GPIOs), 3.5x3.6 mm WLCSP94 (48 GPIOs)	7x7 mm aQFN73 (42 GPIOs), 5x5 mm QFN40 (18 GPIOs), 3.2x3.2 mm WLCSP (42 GPIOs)	6x6 mm QFN48 (32 GPIOs), 3.0x3.2 mm WLCSP50 (32 GPIOs)	5x5 mm QFN40 (18 GPIOs), 2.53x2.53 mm WLCSP44 (18 GPIOs)	6x6 mm QFN48 (32 GPIOs), 5x5 mm QFN32 (17 GPIOs), 2.48x2.46 mm WLCSP33 (15 GPIOs)	6x6 mm QFN48 (32 GPIOs), 5x5 mm QFN32 (17 GPIOs), 2.48x2.46 mm WLCSP33 (15 GPIOs)	2.48x2.46 mm WLCSP28 (10 GPIOs)

PMICs

nPM FAMILY

		nPM1300	nPM1100	nPM6001
TYPE	PMIC	●	●	●
FEATURES	BUCK REGULATOR	2	1	4
	BATTERY CHARGER	●	●	
	LDO	2		2
	LOAD SWITCH	2		
CHARGER	TERMINATION VOLTAGE	3.5 to 4.45 V	4.1 to 4.2 V or 4.25 to 4.35 V	
	MAX CHARGING CURRENT	800 mA	400 mA	
	POWER PATH MANAGEMENT	●	●	
	THERMAL PROTECTION	●	●	
	BATTERY COMPATIBILITY	LiFePO4, Li-ion, LiPo	Li-ion, LiPo	
POWER RAILS	INPUT VOLTAGE	4 to 5.5 V	4.1 to 6.7 V	3 to 5.5 V
	USB COMPLIANCE	Type-C	●	
	REGULATED OUTPUT VOLTAGE	1 to 3.3 V	1.8 to 3 V	0.5 to 3.3 V
	MAX CURRENT PER BUCK	200 mA, 200 mA	150 mA	550 mA, 200 mA, 150 mA, 150 mA
SYSTEM MANAGEMENT	SYSTEM MONITORING	System-, input bus- and battery-voltage; battery-current and -temp; die temp		
	FUEL GAUGE	●		
	HARD SYSTEM RESET	●		
	TIMED WAKE-UP	●		●
	WATCHDOG TIMER	●		●
	SHIP MODE / HIBERNATE	●	●	●
	BROWN-OUT DETECTOR	●	●	●
	LED DRIVERS, GPIOs	3, 5	2, 0	0, 3
	CONTROL INTERFACE	TWI	Pin-configurable	TWI
REGULATORY COMPLIANCE		CE, JEITA, RoHS	CE, JEITA, RoHS	CE, RoHS
OPERATING TEMPERATURE		-40 to 85°C	-40 to 85°C	-40 to 85°C
EVALUATION KITS		nPM1300 EK	nPM1100 EK	nPM6001 EK
PACKAGE OPTIONS		5x5 mm QFN32, 3.1x2.4 mm WLCSP	4x4 mm QFN24, 2.1x2.1 mm WLCSP	2.2x3.6 mm WLCSP

Range Extender

nRF21540

Description: The nRF21540 is an RF front-end module (FEM) that improves range and connection robustness for Nordic's nRF52, nRF53 and nRF54 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, Matter, Thread, Zigbee and 2.4 GHz protocols. The RF FEM's TX output power is dynamically adjustable and can be set to comply across all geographical regions. The RF FEM can be used with Nordic's extended temperature-qualified nRF5340, nRF52833 and nRF52820 SoCs in industrial applications.

Tech Spec

Output power
Adjustable in small increments up to +21 dBm

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

Input supply
1.7 to 3.6 V

Package
4 by 4 mm QFN16

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

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

Cloud Services

nRF Cloud Services

Description: nRF Cloud Services are optimized for Nordic's low-power IoT Devices. nRF Cloud Services consists of nRF Cloud Location Services, and Device Management and Security Services will be available soon. Both Device-to-Cloud or Cloud-to-Cloud use cases are supported. CoAP and MQTT protocols are both supported.

Services: nRF Cloud Location Services include Assisted GPS, Predictive GPS, Wi-Fi, single-cell and multi-cell, and supply accurate and power-efficient location data for IoT devices employing nRF91 Series products. The Wi-Fi feature requires a Wi-Fi scanning IC, such as one of the nRF70 Series companion ICs. Each location feature has accuracy and power efficiency benefits, so switching between different location services during operation can be useful. nRF Cloud also includes a firmware-over-the-air update function, whereby the nRF91 Series' modem firmware, middleware and/or application firmware can be updated.

Tech Spec

Location services
A-GPS, P-GPS, Wi-Fi, Single-Cell, Multi-Cell

Additional features
Device-to-Cloud and Cloud-to-Cloud use cases
CoAP, MQTT and REST API support

Supported products
nRF9160, nRF9131, nRF9161 SiPs, nRF7000, nRF7001, nRF7002 companion ICs

Applications
Industrial, smart appliances, asset tracking, RTLS

Wi-Fi 6 companion ICs

nRF70 Series

Description: The nRF70 Series comprises three Wi-Fi companion ICs. The nRF7001 offers low-power 2.4 GHz connectivity, while the nRF7002 operates in both the 2.4 and 5 GHz bands. The nRF7000 is designed purely for active and passive scanning of Wi-Fi networks. These ICs ensure excellent coexistence with Bluetooth LE devices, advanced power saving with TWT and OFDMA for efficient uplink and downlink communication.

Operation: The nRF70 Series companion ICs provide low power, secure Wi-Fi connectivity as well as Wi-Fi assisted locationing based on Service Set identifier (SSID) scanning. The nRF70 Series accompany Nordic's nRF52 and nRF53 Series Bluetooth LE SoCs, and the nRF91 Series cellular IoT SiPs. The nRF70 Series can also be used as companion ICs in applications hosted by non-Nordic products. For non-Nordic host products, Nordic supplies the appropriate Linux drivers via the GitHub developer platform (github.com).

Tech Spec

Compliance
nRF7001: IEEE 802.11b (Wi-Fi 1)/g (Wi-Fi 3)/n (Wi-Fi 4)/ax (Wi-Fi 6)
nRF7002: IEEE 802.11a (Wi-Fi 2)/b/g/n/ac (Wi-Fi 5)/ax

Package
6 by 6 mm QFN

Features
Low power, good coexistence with Bluetooth LE, TWT

Development tools
nRF7002 DK, nRF7002 EK, nRF7002 EB

Applications
Asset tracking, smart home, industrial

Fourth generation SoCs

nRF54H20

Description: The nRF54H20 is a revolutionary multiprocessor and multiprotocol SoC for Bluetooth LE (supporting all Bluetooth 5.4 features), LE Audio, Bluetooth Mesh, Thread, Matter, ANT+ and 2.4 GHz proprietary protocols with a new 4 Mbps throughput option.

Technical details: The nRF54H20 features multiple processors optimized for specific types of workloads. The application processor was tested with ULPMark-CoreMark and outclassed other wireless SoCs and low-power general purpose MCUs both in processing performance and efficiency. The nRF54H20's radio offers long range and improved robustness with 10 dBm TX power, 100 dBm RX sensitivity for Bluetooth LE and -104 dBm for 802.15.4. In addition to remarkable processing power, ample memory and best-in-class radio, the SoC is also equipped with advanced peripherals and state-of-the-art security features, including physical protection. The nRF54H20 will enable developers to build revolutionary IoT products, with simpler designs, reduced sizes, longer battery life and the ability to perform more advanced tasks, including the execution of machine learning models.

Tech Spec

Processing
Multiple Arm Cortex-M33 processors (clocked up to 320 MHz), Multiple RISC-V coprocessors

Memory
2 MB non-volatile memory, 1 MB RAM

Advanced peripherals
High-speed USB (480 Mbps), CAN FD controller, 2x I3C, 14-bit ADC

Security (in bold)
Designed for PSA Certified Level 3 IoT security standard

nRF54L15

Description: The nRF54L15 is an ultra low power multiprotocol SoC for Bluetooth LE, Bluetooth Mesh, Thread, Matter, ANT+ and 2.4 GHz proprietary protocols with a new 4 Mbps throughput option. The nRF54L Series enhances the popular nRF52 Series with greater processing power and efficiency, more memory, security and new peripherals – all in a more compact package.

Technical details: nRF54L15 doubles the processing power of nRF52840 SoC while reducing power consumption. This processing efficiency, combined with a low power consumption radio and low sleep currents, extends battery life or allows for a reduction in form factor by using smaller batteries. Larger memory enables multiple RF protocols to run concurrently and aids firmware update functionality. The radio brings lower latency and longer range with up to 8 dBm TX power and -98 dBm RX sensitivity for 1 Mbps Bluetooth LE. The nRF54L15 offers security services such as Secure Boot, Secure Firmware Update and Secure Storage. It is designed for PSA Certified Level 3.

Tech Spec

Processing
128 MHz Arm Cortex-M33 processor

Memory
1.5 MB non-volatile memory, 256 KB RAM

New peripherals
Global RTC, 14-bit ADC, Software-defined peripheral enabled by a RISC-V coprocessor

Security
Designed for PSA Certified Level 3 IoT security standard