

WIRELESS QUARTER

Issue 3, 2019

NUMBERS GAME:
SATISFYING SPORTS
FANS' THIRST FOR STATS

FOOD FIGHT:
HOW TO MEET THE
NEEDS OF BILLIONS

Light Fantastic

Wireless technology
elevates smart lighting
beyond illumination

nRF9160 CERTIFIED BY
TELCO GIANT VERIZON

BUILD CELLULAR IoT
PROTOTYPES IN DAYS

IoT SECURITY DEMANDS
TRUSTED EXECUTION



Contents

News	
Verizon certifies nRF9160	3
News Extra	
Build cellular IoT prototypes in days	7
Analysis	
Huge growth for 'Massive IoT'	8
Comment	
Dual connectivity solutions enhance applications	9
Cover Feature	
Light Fantastic	10
Feature	
Numbers game	16
Feature	
Food fight	18
Nordic Inside	
Unlimited's electric skateboard powertrain	20
Case Study	
Pulse oximeter provides continuous health data	22
Nordic People	
Marjeris Romero	23
Tech Zone News	
Cellular module speeds fail safe IIoT development	24
Tech Briefing	
IoT demands trusted execution	25
Tech Perspective	
Powering smart meters with cellular IoT	26
Nordic Product Selection Guide	27



Welcome

Eirik Midttun
Technical Product Manager



It's been some years since enterprising engineers experimented with wireless control of LEDs and "smart lighting" was born. LEDs were a natural fit for such innovation because they used less power and lasted longer than traditional forms of lighting.

The first smart lighting products allowed early adopters to set the ambience of the household by adjusting the color and intensity of the LEDs from their smartphone. But while such applications were novel, they were hardly earth-shattering.

Later, the cost of LEDs plummeted while their efficiency and longevity dramatically increased. And wireless chips became more capable through powerful embedded processors and multiprotocol support. Both developments have attracted the attention of commercial firms because cheap (shortening payback) and energy efficient lighting immediately contributes to the bottom line and wireless connectivity allows for closed-loop feedback to maximize the power consumption advantages. Technical developments such as [Bluetooth mesh](#) have multiplied these advantages. A nice bonus is the promise of customized lighting—a welcome change from the stark illumination offered by fluorescent strips—which has been shown to boost productivity.

A result of this commercial interest is that smart lighting is now really gaining traction. The ubiquity of lighting, allied to mature wireless chips, is enabling it to form a basis for a multitude of sensors which provide the information to not only optimize energy usage but also make modern buildings safer and healthier places to be. "Lighting as a platform" is upon us, and Nordic, together with a pioneering group of lighting and building automation companies, is forming the vanguard of this illumination revolution. You can read more about it on page 10.

“The ubiquity of lighting is enabling it to support a multitude of sensors which will help to not only optimize energy usage but also make modern buildings safer and healthier places to be

Wireless Quarter is published on behalf of Nordic Semiconductor by Ecritech
www.ecritech.com

Editor
Steven Keeping steven@ecritech.com

Assistant Editor
Chris Williams chris@ecritech.com

Production Editor
Andrew Woolls-King andrew@ecritech.com

Creative Director
Sam Grimmer

Image Editors
Nathan Sargent, Neale Hobday

Print & Distribution
Printech Europe



The Bluetooth® word mark and logos are registered trademarks owned by the Bluetooth SIG, Inc. and any use of such marks by Nordic Semiconductor is under license.

© Nordic Semiconductor 2019



To subscribe to WQ visit www.nordicsemi.com/wqmag

News

The latest developments from Nordic Semiconductor

Nordic's cellular IoT SiP certified by U.S. giant Verizon

Nordic Semiconductor's nRF9160 SiP with integrated LTE-M/NB-IoT modem and GPS has been certified for operation on U.S. telecommunication company Verizon's LTE-M networks. Verizon is one of the largest telco companies in the U.S. and certification in the huge North American market from a leading firm is a major milestone for Nordic's nRF9160 SiP.

"Certification by Verizon, one of the world's leading cellular network carriers, is a notable achievement and will prove a major boost to commercial confidence in the nRF9160," says Sverre Tore Larsen, Nordic's CEO.

Meanwhile, Nordic has announced that the nRF9160 SiP is now in volume production having passed all major certifications required for end-product deployment in both LTE-M and NB-IoT cellular networks and cellular IoT product applications. These include: GCF,

PTCRB, FCC (U.S.), CE (E.U.), ISED (Canada), ACMA (Australia), NCC (Taiwan), IMDA (Singapore) and MIC (Japan). The nRF9160 SiP is certified for use in cellular bands B1-5, 8, 12-14, 17-20, 25, 26, 28 and 66.

At just 10 by 16 by 1-mm in size, the nRF9160 SiP is suitable for even compact consumer and medical wearables, and asset-tracking devices, but provides a complete solution that integrates everything a cellular connection and IoT application may need beyond requiring just an external battery, SIM and antenna. The nRF9160 SiP's application processor/modem were designed from the ground-up for optimized power performance in IoT systems. The combination enables nRF9160 SiP-based devices to stay connected to a cellular network with unparalleled low power consumption.



The nRF9160 SiP is also available on a powerful single-board DK made for the IoT application developer. The [nRF9160 DK](#) comes with free development tool support, [nRF Connect for Cloud](#) demonstration platform and the [nRF Connect SDK](#) in GitHub with sample applications.

The nRF9160 SiP is the only cellular IoT solution with integrated GPS support.

Cellular panic button brings personal safety to seniors

A panic button that can transfer a user's ID and GPS location to an emergency center via NB-IoT, even when there's no connectivity from a regular cellphone network, has been unveiled by Dutch startup, Montr.

The Montr Emergency Button employs Nordic Semiconductor's nRF9160 SiP with integrated LTE-M/NB-IoT modem and GPS in a small lithium battery-powered package, and protects people in vulnerable situations such as individuals at risk of attack or accident, or seniors living at home. To activate the alarm the user double presses a button, immediately notifying an emergency response center of the user's identity and location via GPS.

To reassure the user that help is on the way the button vibrates and flashes to confirm that the emergency request was successfully received by the response center.

"A little known fact about NB-IoT is that its range and penetration far exceeds regular wideband cellular signals used by



smartphones," comments Montr Founder and Director, Stefan Meulesteen. "There is no other wireless technology capable of delivering this kind of convenience and performance using a fully licensed spectrum that covers almost the entire planet and is designed to deliver the reliability required for emergency applications. This is why I see the future of personal safety being all NB-IoT."

"While personal emergency alarms are nothing new, one that uses cellular networks without needing to be paired to a smartphone or gateway is," says Geir Langeland, Nordic's Director of Sales & Marketing. "Cellular should now become the wireless technology of choice for personal alarms."

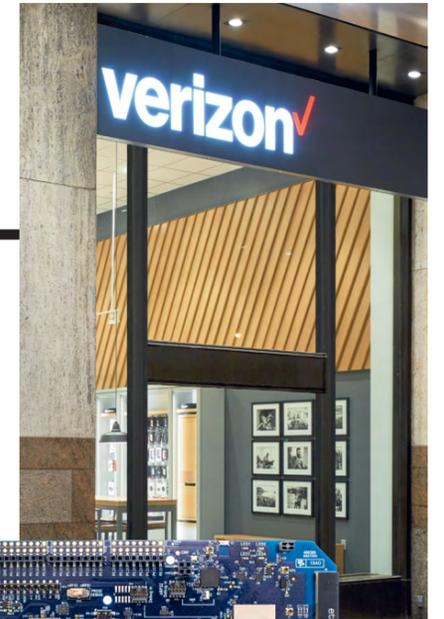
In Brief

CHINA IOT CONNECTIONS NEAR ONE BILLION

Chinese mobile operators are leading the way in terms of IoT deployments with the connection of nearly 960 million devices, according to a recent study by GSMA Intelligence. According to the report, these IoT connections are enabling mass market deployments of smart-home, -industry and -city solutions. GSMA Intelligence said China was the world's largest IoT market, with 64 percent of the 1.5 billion global cellular IoT connections.

CELLULAR KEY TO WIRELESS FUTURE

Analyst Gartner has identified what it claims will be the top ten wireless technology trends for enterprise architecture and technology innovation leaders beyond 2019. Among its predictions it said the rollout of 5G cellular systems, long range wireless power, the growth of LPWANs, wireless sensing, and wireless location tracking would all be at the forefront of wireless technology transformation.



Nordic partners with Tile, world's leading Bluetooth tracker company

Nordic Semiconductor has formally partnered with Tile, the manufacturer of the world's biggest selling Bluetooth tracking device.

The partnership will cover a range of Tile devices that will come to market in early 2020 and employ Nordic's [nRF52810](#) Bluetooth LE SoCs. The two companies will also partner to introduce Tile finding technology to Nordic chips as part of a future [nRF5 SDK](#) release.

"Tile has been working with Nordic Semiconductor since the introduction of its very first Tile 1.0 device in 2014," says Tile CEO, CJ Prober. "But we now want to take our business to the next level and see the Tile tracking and finding technology platform expand from standalone trackers to integrations with billions of Bluetooth-enabled products."

"To achieve that we are entering into a partnership with Nordic, one of the world's leading Bluetooth semiconductor companies, to share the technological and commercial challenges of going up such a steep growth curve."

Tile's devices are designed to be attached or put into anything a user wants to keep track of such as wallets, purses, backpacks, suitcases and luggage, or car key fobs. To date, Tile has sold over 26 million devices worldwide. Tile says its devices are used



to locate more than six million items every day and that it has secured over 90 percent market share in the U.S. standalone tracker device market alone.

"Consumer device tracking is one of those features where once experienced it's hard to go back," says Geir Langeland, Nordic's Director of Sales & Marketing. "And it's not hard to imagine a not-too-distant future

where a great deal of consumer products, especially portable ones that are prone to being mislaid or left behind, don't include some form of 'track', 'find', and 'don't lose' smart functionality. If this works seamlessly out-of-the-box and can be controlled from any smartphone via Bluetooth, then I can see it being a very popular and genuinely useful feature for many consumers."

Nordic expands India network

Nordic Semiconductor has signed a new distribution agreement with Millennium Semiconductors, an India-based electronic components supply company specializing in design, proof of concept and after-sales technical support across industries including [automotive](#), IoT, [smart lighting](#) and consumer electronics.

The deal covers distribution and design support for Nordic's entire portfolio of low power cellular IoT and low power short range wireless solutions.

Millennium Semiconductors has offices across India and Asia Pacific, including its headquarters in Pune, nine regional offices and two distribution centers in India, as well as overseas offices in Singapore and Shenzhen, China.

The company will have a dedicated, India-based FAE and Product Manager to oversee Nordic's product range.

By the Numbers

\$70.5 million in revenue

Nordic Semiconductor has [reported](#) Q2 2019 revenue of \$70.5 million and a gross profit of \$36.1 million, a 3.6 percent increase on profit over the same quarter in 2018. The result, in part, came as a result of the company's strong performance in Bluetooth LE. Revenue from Bluetooth ended at \$56 million, or 79.5 percent of total revenue in the quarter, up from \$52.3 million in 2018, and \$37.3 million in Q1 2019. Nordic also reported \$196,000 in cellular IoT revenue in Q2 2019, building on Q1 revenue of \$100,000 when it recognized first shipments of finished products.

\$1.1 trillion in IoT spending by 2023

Steady commercial and consumer adoption will drive worldwide annual spending on the IoT to \$1.1 trillion by 2023, according to analyst IDC. The three commercial industries expected to spend the most on IoT are discrete manufacturing, process manufacturing and transportation. Together, they will account for nearly a third of total worldwide spend by that year. The primary IoT use case for manufacturing is expected to be operations, while for transport it will be freight monitoring. The consumer market is tipped to be the second largest source of IoT spending, led by smart home and connected vehicle use cases.

Industrial IoT

Wireless vibration sensor enables IIoT asset analysis

Texas-based National Instruments (NI) has developed a wireless vibration sensor to enable online asset condition monitoring of industrial plant and machinery.

The MON-10411 Wireless Vibration Sensor employs Nordic's [nRF52840](#) Bluetooth 5/Bluetooth LE SoC to help automate the otherwise manual process of data collection. The product allows industrial plant operators to remotely analyze asset health data and monitor the need for predictive maintenance to extend the life of equipment. When mounted directly to an asset such as a large pump, motor or bearing, the device's internal MEMS triaxial accelerometer and temperature sensor monitor the health status of the asset.

Then diagnostic quality waveform data is wirelessly transmitted to NI InsightCM software, which is connected to a server via a gateway. Bluetooth LE connectivity in both the device and the gateway is powered by the Nordic [nRF52840](#) SoC. From the InsightCM

software, maintenance managers and reliability engineers can remotely respond to alerts without needing to attend the plant in person.

InsightCM software can receive data from multiple gateways, while each gateway can communicate with multiple wireless vibration sensors concurrently.

"When we first started the selection process, I identified a critical set of radio requirements, but most vendors couldn't meet those needs," says Jeff Kellam, Distinguished Engineer, NI. "Nordic [supplied code in less than a week with a working example. This level of support has been consistent through the whole experience, and really made our product possible."



Wearables

Smartwatch tracks heart rate and activity metrics

China-based smart [wearables](#) company, Do Technology, has unveiled a new high specification smartwatch that not only provides wireless smartphone control but also functions as a wearable heart rate monitor, and multimode sportswatch.

The ID205 smartwatch uses Nordic's [nRF52840](#) SoC for wireless access and control of smartphones including vibration alerts for incoming phone calls, remind/reject call functionality and music controls, while at the same time acting as a wearable health and heart rate monitor and a sportswatch with more than 14 sports modes.

The smartwatch employs a built-in heart rate sensor to monitor and collect the user's pulse

24 hours per day for personal health analysis; an accelerometer to calculate activity metrics such as steps taken, calories burned and sleep time; and a light sensor to automatically adjust the brightness of the device's screen according to changes in external light.

Once the raw sensor data has been collected, proprietary algorithms calculate the key health and activity metrics. The ID205 then sends the data to the company's 'VeryfitPro' iOS- and Android-compatible app on the user's smartphone where they can assess their own activity data and trends over time.

"Nordic has a great industry reputation, with its technologies and products fully recognized by the market," says Ryan He, VP of performance of the chip itself, Nordic's developer friendly community and the quick support from application engineers were also important factors for us."



In Brief

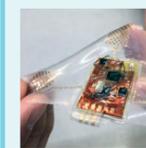
ASIAN SMART ELECTRICITY METERS BOOM



The installed base of smart electricity meters in Asia's four main markets will reach almost 966 million in 2024, up from 613.4 million last

year, according to a new research report from analyst Berg Insight. The study revealed that the installed base of [smart electricity meters](#) in China, India, Japan and South Korea will grow at a CAGR of 7.9 percent during the period. Over the next six years, smart meter penetration among electricity customers in these Asian countries is projected to increase from around 67 percent in 2018 to 94 percent by the end of 2024.

STRETCHABLE WEARABLE BOOSTS HEALTH



A Bluetooth LE wearable monitor built with stretchable electronics could allow comfortable, long term health monitoring of

adults, children and babies without concern for skin injury or allergic reactions caused by conventional adhesive sensors with conductive gels. According to developers at the Georgia Institute of Technology, the monitor can broadcast ECG, heart rate, respiratory rate and motion activity data as much as 15 meters to a portable recording device such as a smartphone or tablet computer using Bluetooth LE connectivity.

SMK UNVEIL BLUETOOTH VOICE ACTIVATED REMOTE

SMK Corporation, has released its BTRC01BLE Remote Control reference design employing Nordic's [nRF52832](#) SoC. The remote control reference design is suitable for manufacturers of media streaming devices including smart TVs and set top boxes based on the Android TV operating system. The remote control provides touch key and voice control operation. The Nordic SoC provides both the computational power to manage the remote control's voice operation as well as the low latency Bluetooth LE wireless connectivity between the remote control and the Android TV-compatible device.



Smart Home

Xiaomi smart door lock delivers wireless security solution

Lumi United—a member of smartphone and electronics giant Xiaomi's ecosystem of companies—has launched a new commercial and domestic smart lock. The lock offers multiple unlocking options including secure Bluetooth LE and NFC connectivity.

The Xiaomi Mijia smart door lock employs Nordic's [nRF52840](#) SoC to provide long range wireless connectivity to a user's smartphone, where, from the Xiaomi Mi Home app, the user can configure the lock and remote alarms, review a history of when the lock has been opened, as well as unlock the Xiaomi Mijia. From the main interface of the Mi Home app, clicking on the lock icon unlocks the door via Bluetooth LE connectivity.

The Nordic SoC incorporates an Arm TrustZone CryptoCell-310 cryptographic module and an AES 128-bit hardware accelerator. These features support a wide range of asymmetric, symmetric and

hashing cryptographic services for secure applications, protecting the Xiaomi Mijia unlocking process.

Alternatively, the smart lock can be unlocked using NFC via the nRF52840's NFC-A tag and a user's NFC-compatible smartphone. The lock also supports other unlocking options including fingerprint, password and emergency key unlocking.

As the hardware management platform for all Xiaomi ecosystem [smart home](#) solutions, the Mi Home app also allows the user to connect their smart lock to other Xiaomi as well as third-party smart home devices, enabling full connectivity throughout the smart home.

"[We selected] Bluetooth LE technology ... as it is not only faster but also provides a better consumer experience and satisfies our need for stability," says Tao Liu, Lumi Product Manager.



Smart Health

Brain cells controlled using Bluetooth LE

Researchers from the Korea Advanced Institute of Science and Technology (KAIST) have developed a soft neural implant that can be wirelessly controlled using a smartphone and Bluetooth LE technology.

The development is the first wireless neural device capable of indefinitely delivering multiple drugs and multiple color lights, which neuroscientists believe can speed up efforts to uncover brain diseases such as Parkinson's, Alzheimer's, addiction, depression and pain.

A team from the School of Electrical Engineering at KAIST developed the implant that uses replaceable drug cartridges and Bluetooth LE connectivity to target specific neurons of interest using drugs and light for prolonged periods. Controlled with a simple user interface on a smartphone, neuroscientists can trigger any combination or sequencing of light and drug delivery in any implanted target without the need to be inside the laboratory.

The technology significantly overshadows the conventional methods used by neuroscientists, which usually involve rigid metal tubes and optical fibers to deliver



the drugs and light. Apart from limiting the subject's movement due to bulky equipment, the rigid structure of the metal tubes causes lesions in soft brain tissue over time, therefore making them unsuitable for long-term implantation.

Although some efforts have been made to partly mitigate adverse tissue response by incorporating soft probes and wireless platforms, the previous solutions were limited by their inability to deliver drugs for long periods as well as their bulky and complex control setups.

Researchers build millimeter scale Bluetooth LE antenna

A team of researchers from the University of Michigan has built what is claimed to be the first millimeter scale device capable of broadcasting and receiving Bluetooth LE signals with a high level of accuracy.

Led by Associate Professor David Wentzloff, the team said the achievement would help achieve ubiquitous IoT connectivity, and further the applications possible with microscale computers.

According to Wentzloff, antennas are hard to shrink down to this size, and they consume a relatively high amount of energy compared to what the computing device can generate.

The team combined the device's oscillator and antenna in a way that made a power amplifier unnecessary. The result is a millimeter scale Bluetooth LE transmitter and antenna that consumes only 0.6 milliwatts during transmission. When incorporated into a microscale computer, the solution will allow the computer to communicate with a smartphone.

"I'm really excited about the future research directions that will be opened up by [this solution]," says Wentzloff.

News Extra

Build cellular IoT prototypes in just days

The Nordic Thingy:91 is a simplified cellular IoT development tool which offers immediate operation, nine sensors, and support for short-range wireless including Bluetooth 5 and NFC

The IoT of the future will be made up of complementary wireless technologies. According to a report by analyst Deloitte, the choice of wireless network technology for a particular application will depend largely on the range and throughput required. For example, power frugal RF technologies such as Bluetooth LE and Zigbee will be good foundations for battery powered sensors sending small amounts of data across a building network. In turn, cellular IoT (LTE-M/NB-IoT) technologies will be good options for connecting those building networks to the Cloud via base stations positioned perhaps several kilometers away.

For developers, an IoT founded on complementary RF technologies makes their job more complex; instead of "one-size-fits-all", engineers will have to get to grips with different protocols and work out how to get them playing nicely together. However, with the introduction of the [Nordic Thingy:91](#), the challenges of designing a multiprotocol IoT product have just got a little easier.

The Thingy:91 is a cellular IoT rapid prototyping platform based on the [nRF9160 SiP](#). As such, the product comes pre-certified for global, low-power, long-range LTE-M/NB-IoT applications. The nRF9160 includes Arm TrustZone security for trusted execution and Arm CryptoCell for application layer security. Thingy:91 also includes a Nordic nRF52840 advanced multiprotocol SoC for complementary short range wireless technologies such as Bluetooth 5, Thread, Zigbee and ANT.

To help developers quickly get started on prototypes, the Thingy:91 is delivered complete with an asset-tracking application. Asset tracking is a sector that will benefit from a combination of cellular IoT and Bluetooth 5. For example, perishable items in a shipping container could have their temperature monitored using low cost, low maintenance Bluetooth 5 sensors while the actual container could have its position tracked by long range cellular wireless technology.

"The Nordic Thingy:91 can be used to better understand the journey of goods from the warehouse to the customer so that fast deliveries can be planned, and the quality of the product can be maintained," says Tzeno Galchev, Product Manager, Inertial Sensor Group, Analog Devices. "If it cannot map the journey, it will determine where responsibility lies in the chain."

"Users are looking for wireless trackers of temperature,



Thingy:91 makes turning a proof-of-concept into a real product straightforward, right down to using the same code and development environment



Tech check

The Thingy:91's [nRF52840](#) SoC is Bluetooth 5, Thread 1.1, and Zigbee PRO -certified and uniquely supports concurrent wireless connectivity of the protocols. The SoC combines a 64 MHz, 32-bit Arm Cortex M4 processor with FPU, 2.4-GHz multiprotocol radio, 1MB Flash memory and 256 kB RAM

pressure, humidity and volatile organic compounds [VOCs] to assist them in taking action to provide real time asset tracking in the field," says Dr. Peter Weigand, Vice President of Marketing at Bosch Sensortec.

eSIM included

The Thingy:91 is housed in a 6 by 6-cm plastic and rubber case which includes a USB connector to charge the device's 1440-mAh rechargeable Li-ion battery. The product's sensor list includes environmental sensors for measuring temperature, humidity and air pressure, plus a color and light sensor, a Bosch Sensortec BME680 gas, temperature, humidity and air pressure sensor plus separate low power and high G-force accelerometers from Analog Devices.

Thingy:91 even comes with a Nano (4FF) eSIM card from [iBasis](#) preloaded with 10 MB of data to enable automatic, out-of-the-box cellular LTE-M/NB-IoT connectivity and roaming in a growing list of countries.

"The Nordic Thingy:91 is aimed at professional developers, and non-cellular IoT specialists alike," says John Leonard, Senior Product Marketing Manager at Nordic. "Not only does it allow developers new to the world of cellular IoT to get a proof-of-concept [PoC] up and running very quickly in order to gain necessary project and budget approvals, it also makes turning that PoC into a real product very straightforward, right down to using the same code and development environment."

Inside Thingy:91, the nRF9160 SiP integrates a dedicated application processor and multimode LTE-M/NB-IoT modem. At just 10 by 16 by 1 mm the SiP is the most compact cellular IoT solution on the market. The SiP is also the only commercial cellular IoT module with integrated GPS support to allow a combination of GPS and cellular data to be used for more accurate positioning than either technology is capable of when used in isolation.

The Thingy:91 is designed to be programmed using Nordic's [nRF Connect SDK](#) with integrated Zephyr RTOS. Software and hardware design files are available from the Nordic Semiconductor website.

Internet of Things

Ericsson forecasts huge growth for 'Massive IoT'

NB-IoT and LTE-M technologies are anticipated to make up almost half of all cellular IoT networks by 2024, according to latest research from telco giant

New research by global telco infrastructure leader Ericsson predicts the total number of cellular IoT connections will reach 4.1 billion in the next five years, more than double the 1.9 billion 5G connections expected to exist within the same timeframe. While the eye opening forecast for cellular IoT in the latest [Ericsson Mobility Report](#) (June 2019) is notable, as remarkable was the reports prediction that NB-IoT and LTE-M technologies—referred to collectively as “Massive IoT”—will account for 45 percent of all cellular IoT connections in 2024.

Massive IoT primarily incorporates wide area use cases where massive numbers of cost effective, low energy devices perform low complexity tasks with small data volumes, achieve long battery life and require low throughput. Among the likely applications for Massive IoT are medical wearables, smart metering and asset management via tracking sensors—areas currently supported by [Nordic Semiconductor cellular IoT technology](#) across the healthcare, utilities, and logistics sectors respectively.

NB-IoT and LTE-M deployments

Already NB-IoT and LTE-M deployed on commercial networks are supporting large volumes of devices in these major industries.

“These technologies complement each other and there is an emerging trend towards service providers deploying one common network supporting both technologies,” the Ericsson report states. “[LTE-M] is suited to use cases that require relatively higher throughput, lower latency and voice support, whereas NB-IoT is suited to use cases with very low throughput that are tolerant of delay but require extended coverage.”

According to a report from the GSA, an industry organization representing companies across the worldwide mobile ecosystem, industry commitment to LPWAN technologies has, over the past 18 months, been characterized by significant growth in the number of networks supporting NB-IoT and LTE-M networks, and in the number of IoT modules based on those cellular IoT technologies.

The document, [IoT Ecosystem: NB-IoT and LTE-M Report](#) (April 2019) states there are now 124 deployed/launched NB-IoT or LTE-M networks, 141 operators actively investing in NB-IoT technology (up from 116 a year ago) and 60 operators actively investing in LTE-M technology (up from 47). In addition, GSA has identified 210 devices supporting NB-IoT (or Cat-NB1), of which 74.3 percent are modules, 18.1 percent are asset trackers, and 5.2 percent are routers. USB modems, vehicle onboard units (OBUs) and smart



watches make up the balance.

At present, the majority of cellular IoT devices are connected via legacy 2 and 3G technologies. While the number of legacy connections is expected to increase slightly until 2022, Ericsson predicts the total will stabilize over the following two years.

In addition to Massive IoT (cellular LPWAN technologies) accounting for more than four in ten cellular IoT connections in the not too distant future, Ericsson forecasts the presence of three other cellular IoT use case segments. The first is broadband IoT (expected to account for 35 percent of cellular IoT connections by 2024) where LTE (4G) networks already support wide area use cases for various applications including millions of modern vehicles, drones and extended reality (XR) technologies. Next is critical IoT where new 5G networks will enable more complex wide area and local area use cases requiring ultra reliability and low latency, such as interactive transport systems and smart grid automation. And third comes industrial automation IoT where 5G networks will support the most demanding local area use cases and private network deployments for specialized manufacturing and industrial applications.

The reality, Ericsson claims, is that 2 and 3G networks will eventually reach a plateau, whereas 4G networks are still growing and 5G networks are anticipated to rise rapidly from 2020 onwards.

Need to Know

The growing popularity of IoT use cases that rely on connectivity spanning large areas, and are able to handle a huge number of connections, is driving the demand for “Massive IoT” technologies. It is now possible to develop battery-powered sensors that are connected to a Cloud-based platform that handles device data and management. These devices can be tailored to fit specific applications.



These technologies complement each other and there is an emerging trend towards service providers deploying one common network supporting both technologies

According to the Ericsson report, LTE network population coverage could grow from around 75 percent in 2018 to around 90 percent in 2024, while 5G deployments are gaining momentum worldwide and could cover up to 65 percent of the world's population in 2024.

“As market after market switches on 5G, we are at a truly momentous point in time,” Fredrik Jejdling, Executive Vice President and Head of Business Area Networks, Ericsson, said in the report. “No previous generation of mobile technology has had the potential to drive economic growth to the extent that 5G promises. It goes beyond connecting people to fully realizing the IoT and the Fourth Industrial Revolution.

“Digital infrastructure can make distance less relevant than ever ... 5G is the key to making it all work – driving economic value from enhanced mobile broadband to industry digitalization. That, in turn, will require an ecosystem of technology, regulatory, security and industry partners to deliver on the potential.”

The additional capacity and bandwidth created by the emergence of the 5G global cellular network will also increase the space available for cellular IoT devices to thrive, leading to significant uptake of cellular IoT around the world.

With the design and development of its [nRF9160](#) SiP LTE-M/NB-IoT solution, Nordic Semiconductor is poised to take advantage of today's 4G networks and rapidly transition to 5G networks once they are switched on.

Svein-Egil Nielsen
CTO: Nordic Semiconductor



Dual connectivity solutions enhance applications

Nordic's Thingy:91 helps engineers prototype products for applications demanding low power cellular IoT and short range wireless support

The market is looking for combined Bluetooth LE and cellular IoT (LTE-M/NB-IoT) solutions.

A prime application bringing together short range technology using the license free ISM band with cellular using licensed spectrum is shipping containers. In that application, relatively inexpensive Bluetooth LE powered sensors could be used to monitor the condition of each item of cargo in a given container while a gateway using LTE-M (the version of cellular IoT best suited to mobile applications) could be used to track the container's progress along the road.

Another application that would benefit from combining RF technologies is a multistory parking lot whereby Bluetooth LE could be used to monitor spaces and guide drivers to vacant ones while a gateway using NB-IoT (the version of cellular IoT preferred where longer range and/or superior penetration of obstacles such as walls and ceilings is needed), aggregating data from many Bluetooth LE sensors could inform the remote lot owner about overall occupancy.

Greater integration

If the history of silicon technology teaches us anything it's that solutions tend towards greater integration. That makes it likely that market driven demand will lead to a combined Bluetooth LE and NB-IoT/LTE-M integrated solution. It's even possible that market pressure could lead to combined licensed/unlicensed RF spectrum LPWAN IoT wireless solutions – although I question the value of such a product. If unlicensed RF spectrum LPWAN technologies manage to survive the



full scale roll-out of NB-IoT/LTE-M, there might be applications in remote parts of the world with no cellular infrastructure where it could be more commercially feasible to build an unlicensed LPWAN network. A combined LPWAN module could then typically use the cellular network but switch to unlicensed LPWAN when in that remote area. But it's also possible the major cellular operators will build out infrastructure to even the most remote areas.

From an engineering perspective, combining cellular and unlicensed RF technology at the module level is not complicated. The bigger challenge is antenna design. Engineers can either use a single antenna (matching for multiple frequencies and sources) or use multiple antennas each dedicated to a tight range of operating frequencies. If multiple antennas are preferred, it's important to ensure proper isolation between antenna systems to eliminate crosstalk.

Nordic has eased the challenges of combined product prototyping with the introduction of the [Nordic Thingy:91](#). The product features Nordic's cellular IoT solution, the [nRF9160](#) SiP, teamed with the [nRF52840](#) short range wireless multiprotocol SoC. (See [pg7](#)) The [nRF9160](#) SiP supports LTE-M and NB-IoT in the same compact package allowing designers to experiment with both versions of cellular IoT.

Light Fantastic

In tomorrow's buildings smart lighting will provide a platform for data driven applications the like of which have never been seen before

In Short

The flexibility, efficiency and longevity of LEDs is driving the rapid replacement of conventional lighting

Wireless mesh network technology brings bidirectional connectivity that makes configuration, control and monitoring of smart LED lighting simple

Wireless mesh networking is complex and requires specialist companies to implement

Mass market adoption of smart lighting relies on educating customers about its benefits

The next stage for smart lighting is 'Lighting as a Platform', enabling the infrastructure to support advanced building management systems

Smart lighting is the most glamorous manifestation of the IoT. It perfectly melds the aesthetics, efficiency and longevity of solid state lighting (SSL) with the connectivity, control and scalability of wireless network technology. Such is the perfection of this fusion it's almost as if the two technologies underpinning smart lighting—LEDs and low power wireless—were developed as one.

In truth, the combination is entirely serendipitous; a fortunate convergence of two independent lines of enquiry both of which trace their genesis back to the turn of 20th Century. (See sidebar *From curiosity to commercial success.*) No matter, it's a marriage that offers so much potential that the industry is about to explode. For example, according to the U.S. Department of Energy (DoE), by as early as next year LED lighting will account for 77 percent of U.S. lighting sales. And analyst, IndustryARC, says smart lighting—wirelessly connected SSL—is rapidly replacing 'dumb' LED fixtures. The company says the global smart lighting market size was worth \$6.87 billion in 2018 and is exhibiting double digit annual growth.

This growth is driven in part by LEDs' green credentials; the technology saves energy and reduces carbon emissions (and consumer bills). The DoE says LEDs use at least 75 percent less energy (and last 25 times longer) than incandescent lighting and, in the U.S. alone, by replacing conventional bulbs with LEDs, electricity consumption has been cut by 348 TWh and bills by \$30 billion. Moreover, by not burning the fossil fuel needed to generate that electricity, 100 million tonnes of CO₂ emissions are avoided.

But smart lighting is so much more than a clean, efficient and sustainable technology. Because lighting is a fundamental element of the fabric of every building, the wireless technology built into each fixture can not only make it simple to configure, control and optimize the illumination, but also support a wide range of distributed sensors that help save even more energy, improve productivity and enhance building security.

However, while the technology is rapidly emerging, there are many hurdles to overcome before the analysts' forecasts become reality. Some of these are technical, others are a matter of consumer perception. But a group of pioneering companies are leaping these hurdles and smart lighting's graduation to the mainstream is coming closer.

GREEN WHITE LIGHT

LED lights have key advantages over both incandescent and fluorescent alternatives. The prime benefit is energy efficiency. A 100-W incandescent bulb radiates most of its energy as heat with just 5 percent converted to visible light; as a result, the device's efficacy is just 10 lumens (a measure of luminous flux) per Watt. Compact fluorescent lamps are better, with an efficacy of 40 lumens per Watt (lm/W) but the LED is best of all with commercial units producing about 100 lm/W. With lighting consuming around 20 percent of global electricity generation that efficacy makes LEDs a poster

child for environmentalists. LEDs also last much longer than conventional light sources; typical operational life of 30,000 hours is common, which equates to ten to 15 years in typical use. In comparison, an incandescent bulb lasts up to 1000 hours while the best CFLs make it to 15000 hours. SSL's longevity also helps cut down on waste material—most of the materials can be recycled—and the devices don't contain the hazardous mercury common to CFLs.

Compared to incandescent bulbs, LEDs run at lower temperatures (although not exactly cool; temperatures around the device's semiconductor junction can exceed 120°C) which allows for compact, novel fixture form factors

which were previously not possible. So-called white LEDs (the devices at the heart of most commercial lighting) are typically formed using a blue LED as a "photon pump" surrounded by a specially formulated phosphor. Most of the blue light is absorbed by the phosphor and re-emitted as yellowish light while the rest passes through. It is the combination of blue and yellow that makes the emitted light appear white to the eye. Manufacturers tweak the combination of blue LED and phosphor to produce products with a range of color "temperatures" (from bluish-white "cool" lamps to yellowish-white "warm" ones). More sophisticated luminaires do away with the phosphor and



The marriage of LEDs and low power wireless technology offers so much potential the smart lighting industry is about to explode



instead electronically combine the light from red, green and blue LEDs such that the mix of their outputs can produce virtually any color of the visible spectrum.

LEDs aren't without drawbacks. They are more expensive than conventional lighting (although the price has plummeted in recent years) and tricky to dim. And because the LED at the heart of a luminaire is finicky, it requires complex electronic drivers to ensure a precise constant current/constant voltage power profile is maintained.

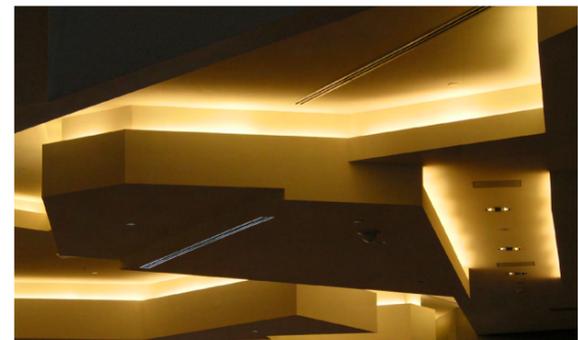
But these disadvantages pale when compared with the positives, and the momentum towards an LED illuminated world is unstoppable. For example, according to the International Energy Agency (IEA), global LED uptake has risen from a lighting market share of 5 percent in 2013 to 40 percent by 2018. The agency expects penetration to reach 90 percent by 2030.

THE POWER OF MESH NETWORKING

LEDs are undoubtedly a novel technology, but it's when they're combined with wireless connectivity that things get really interesting. Low power wireless multiplies LEDs' advantages by endowing the devices with bidirectional connectivity such that they can be remotely configured, controlled and monitored. That means, for example, that light output can be tuned to exactly match ambient light conditions ensuring that productivity is increased, and energy usage is minimized. "[After we installed] a smart lighting project in a school in Durham, North Carolina, a flip of a switch allows a teacher to 'edit' the mood and change the intensity of the classroom," says Trevor Palmer, SVP Digital Lighting Networks with [Acuity Brands](#), a lighting and lighting controls company headquartered in Atlanta, GA.

Wireless connectivity also allows sensors fitted to luminaires to monitor the occupancy of the workspace such that light levels (plus other services such as heating) can be automated to match the number of people using the room.

There are several competing wireless protocols for smart lighting but no clear market leader. Notable technologies include Bluetooth, Thread and Zigbee. "It's very important to support all the leading wireless technologies as a dominant protocol [is yet to emerge](#) for smart lighting," says Eirik Midttun, Technical Product Manager with wireless chipmaker Nordic Semiconductor. "Our wireless SoCs are multiprotocol devices so the OEM has complete freedom to select the protocol of their choice for their smart lighting solution, or even run Bluetooth LE concurrently with



Thread or Zigbee if the requirement arises."

A manufacturer might want to take advantage of concurrent protocol support to, for example, use Thread for wireless connectivity between the lights but take advantage of Bluetooth's interoperability with smartphones—with their familiar touchscreen—for configuration. That advantage becomes even more important for mesh networks because the topology can be tricky to configure without the aid of an intuitive interface.

A mesh topology endows a network with a number of advantages – such as allowing devices within the network to communicate with any device on the same network using radio packets relayed via other devices and without recourse to a central hub. Such a system extends the range, flexibility and redundancy of smart lighting.

"Mesh networking is extremely beneficial," says Neil Salt, Managing Director of [Goeee](#), a London-based automated building control platform developer and vendor. "It really helps in dealing with environmental interference, improves stability and provides options when installing, commissioning and running a system."

The Bluetooth SIG, promoters of Bluetooth, has developed a standard for building mesh networks using Bluetooth LE. Dubbed Bluetooth mesh, Version 1.0 of the specification was introduced in July 2017. The standard is based on expert knowledge in mesh technologies for smart lighting contributed by Krakow, Poland-based supplier of wireless lighting control systems, [Silvair](#), and other companies.

[Bluetooth mesh](#) includes functionality that allows handsets to temporarily join the mesh network (via a so-called proxy node) to aid configuration of individual nodes and communicate with all nodes directly, saving the cost



Tech Check

Nordic's nRF52 Series presents ideal solutions for smart light OEMs. The SoCs offer Bluetooth 5.1 [Direction Finding](#), [Bluetooth mesh](#), [Thread](#) and [Zigbee concurrent support](#), a stable hardware and software architecture, over-the-air device firmware updates and high temperature capability

and complexity of a proprietary hub and interface.

According to Rafal Han, CEO of Silvair, the adoption of Bluetooth mesh has come not a moment too soon. "The standard is a milestone in the development of smart lighting – especially when it comes to security, scalability and ease of use," he says. "Ease of implementation is super important for fast adoption [and that's helped by] flexible and open solutions like Bluetooth mesh. It's true it needs to prove its reliability but that's already happening now."

"Bluetooth mesh is a key development and as a major supplier of wireless solutions to the smart lighting industry, Nordic was among the first to ensure its SoCs supported the standard," says Alf Helge Omre, Nordic Semiconductor's Business Development Manager for Lighting and Indoor Positioning. "And with our technology over-the-air software updates are easy, ensuring that over a long service life the chips can take immediate advantage of software upgrades as the protocols evolve. But smart lighting is not only about the software. Nordic's hardware is mature which helps underpin smart lighting's stability. In this market such stability is especially important because product lifetimes are generally much longer than in areas like consumer. In addition, a lighting fixture is a hot environment, so the OEM needs to ensure the selected wireless chip is tested and certified for operation at elevated temperatures."

LIGHTING AS A PLATFORM

There is little argument that LEDs are the best choice for a greener future. But clean, controllable, long lasting illumination is just a tiny part of how wireless mesh networked smart lighting will influence that future. LEDs alone, while impressive, aren't smart; the intelligent part



Bluetooth mesh is a milestone in the development of smart lighting – especially when it comes to security, scalability and ease of use

Smart lighting on schedule

Bastiaan de Groot

CEO: Ingy



When I'm asked if the smart lighting industry has been slow in reaching mass adoption, I always think: how long should we expect an innovation or disruption to take before it reaches a critical mass? To paraphrase Amara's law, in the face of disruption people tend to grossly overestimate the short term possibilities of the technology, while grossly underestimating the possibilities in the long term, and this is exactly what is happening in the smart lighting world.

We have been talking about smart lighting in the true sense for more than a decade, probably longer, but people who suggest it's been slow in taking off, forget or ignore the technical readiness of the underlying technologies that needed to be ready for the disruption to take place. Although many of the required technologies for smart lighting—principally the sensors and the wireless connectivity—have been available for a long time, the performance and cost didn't necessarily support it, and only now are they readily available at performance and price level that's required to truly develop smart lighting on a mass scale. So yes, for someone who has been aware of this technology for a long time, it may seem to be going very slowly, but I believe the take-up is going exactly as expected for a disruption of this size.

The advent of scalable, self-configuring wireless mesh networks and the cost reduction of sensor technology has been crucial in reaching this point. Only with a full self-healing mesh can you get comprehensive building coverage without having to place central gateways everywhere and removing the need for a central controller is vital in achieving the necessary reliability for a solution for which no central point of failure should exist. Only a true mesh can deliver this. The next big challenge will be to deliver mesh networks that can scale and support the bandwidth necessary to deliver the full backbone for all the sensor data required for a smart building – not just lighting.

For plug and play, self-healing lighting control products and Cloud-connected lighting solutions that provide remote diagnostics of lighting-related services, we are now at a tipping point, and are really starting to see some major traction with customer projects being rolled out at scale. For products that use lighting as the digital infrastructure of the building, to offer services like indoor positioning, occupancy analytics, asset tracking, climate monitoring and the like, mass adoption will take longer, but it will be the most influential when it arrives. Lighting is everywhere, it is already powered, and if you use the latest wireless connectivity it is already connected, making it the ideal infrastructure to place sensors in your building. The value you create this way is far bigger than the value of lighting on its own. People will be stunned how quickly these solutions will get adopted, and how this will completely change people's smart lighting buying behavior.



By the Numbers
22.7%
 Smart lighting
 CAGR from
 2019 to 2025

Source: IndustryARC

75%
 Energy saving
 by using LEDs
 instead of
 incandescent
 lights

Source: U.S. DoE

of the technology is the wireless connectivity. And not just because that technology makes it easy to configure, control and monitor a lighting network.

Everywhere people go indoor requires illumination and therefore lighting fixtures. By design, these are positioned precisely to ensure even and complete coverage, they are safely out of harm's way, and typically plugged into mains electricity. That makes lighting infrastructure a perfect platform for an array of wireless sensors monitoring temperature, humidity and air quality – the things that determine whether or not a building is a nice place to be.

It's a platform that can simultaneously deliver both energy savings and additional services in the form of wayfinding, asset tracking, space utilization, and point of interest information broadcasts. According to the

From curiosity to commercial success

Briton Henry Joseph Round is occasionally credited with discovering the "light emitting diode" as far back as 1907. But what Round—coincidentally an assistant of radio pioneer Guglielmo Marconi—actually discovered was the electroluminescence from a crystal of silicon carbide when it was subjected to a voltage.

It was Russian scientist Oleg Vladimirovich Losev who did much to bring LEDs to life. In a series of papers published up to 1930, he detailed the physics of an LED—formed from a silicon diode and generating light by the recombination of electrons and holes in the depletion region of the p-n junction—before his untimely death during WW2.

Then, in the early 60s, Nick Holonyak of Bell Labs (and other researchers, notably at GEC and IBM) were working on semiconductor lasers to power optical telecommunications when they chanced upon the red LED. Today, Holonyak is generally accepted to be the first person to extract visible light from a semiconductor device.

In the late 1980s and early 1990s Japanese researchers did the heavy lifting to invent and perfect the blue LED/phosphor combination used to create the 'white' LEDs that were the precursors of the devices used in today's lighting. But the luminosity of these white LEDs was still poor compared with conventional light sources; this lack of performance resulted in LEDs failing to gain a foothold in the commercial lighting market.

The technology received a boost in 1999, when solid state lighting visionary, Roland Haitz, produced a paper that suggested LEDs could reach an efficacy of 200 lumen per Watt and reduce worldwide energy consumption devoted to lighting by 50 percent over the next few decades. The impact of Haitz's paper was to raise awareness of the energy saving potential of LEDs to a wider audience and encourage chip makers to invest in the technology.

Today, high brightness LEDs are perfectly complemented by wireless technology. Low power wireless protocols such as Bluetooth, Zigbee and Thread are now routinely incorporated into commercial lighting solutions. Supported by wireless tech, the next phase of the lighting evolution will be 'Lighting as a Platform'.

Bluetooth SIG's *Lighting as a Platform* report, while smart lighting can deliver as much as a 50 percent saving in lighting energy costs, the additional services enabled by the technology could be ten times more valuable than even the energy savings. That's got the commercial building sector seriously interested.

Because it's a simple step to transmit data across wireless mesh networks, building automation can constantly monitor and continuously make subtle changes to the environment to ensure staff are comfortable while saving money. "By analyzing occupancy data from the lighting control system, for example, you can typically save up to 20 percent of the heating by reducing the capacity of the HVAC based on the actual [number of people]," says Bastiaan de Groot, CEO of [Ingy](#), an Amsterdam-based [smart lighting](#) and building control services company.

Moreover, with the advent of technology such as Bluetooth 5.1 Direction Finding, lighting fixtures could be perfect for mounting locators for asset tracking or indoor positioning systems. While Bluetooth 5.1 Direction Finding is yet to find its way into lighting installations, Acuity has helped Giant U.S. retailer Target equip its LED fixtures with wireless beacon technology. The beacons enable interaction with shoppers who opt-in to the store's Target app, helping them navigate their way through stores.

Elsewhere, Ingy has helped a hospital implement an asset tracking scheme for its medical equipment. "Without using the lights as beacons, the hospital would have to roll-out tens of thousands of anchor nodes – now they're no longer required," says Ingy's de Groot.

Gooeee says it recently became the first smart lighting technology company in the world to win a project that connects more than 5,000 buildings to its platform. For the project, Gooeee's Building Operating System will take control of inefficient, existing building systems to optimize both building and business performance. With almost 12 million square meters being maintained and serviced just a 10 percent saving on energy alone would recoup \$132 million in costs over the decade long agreement.

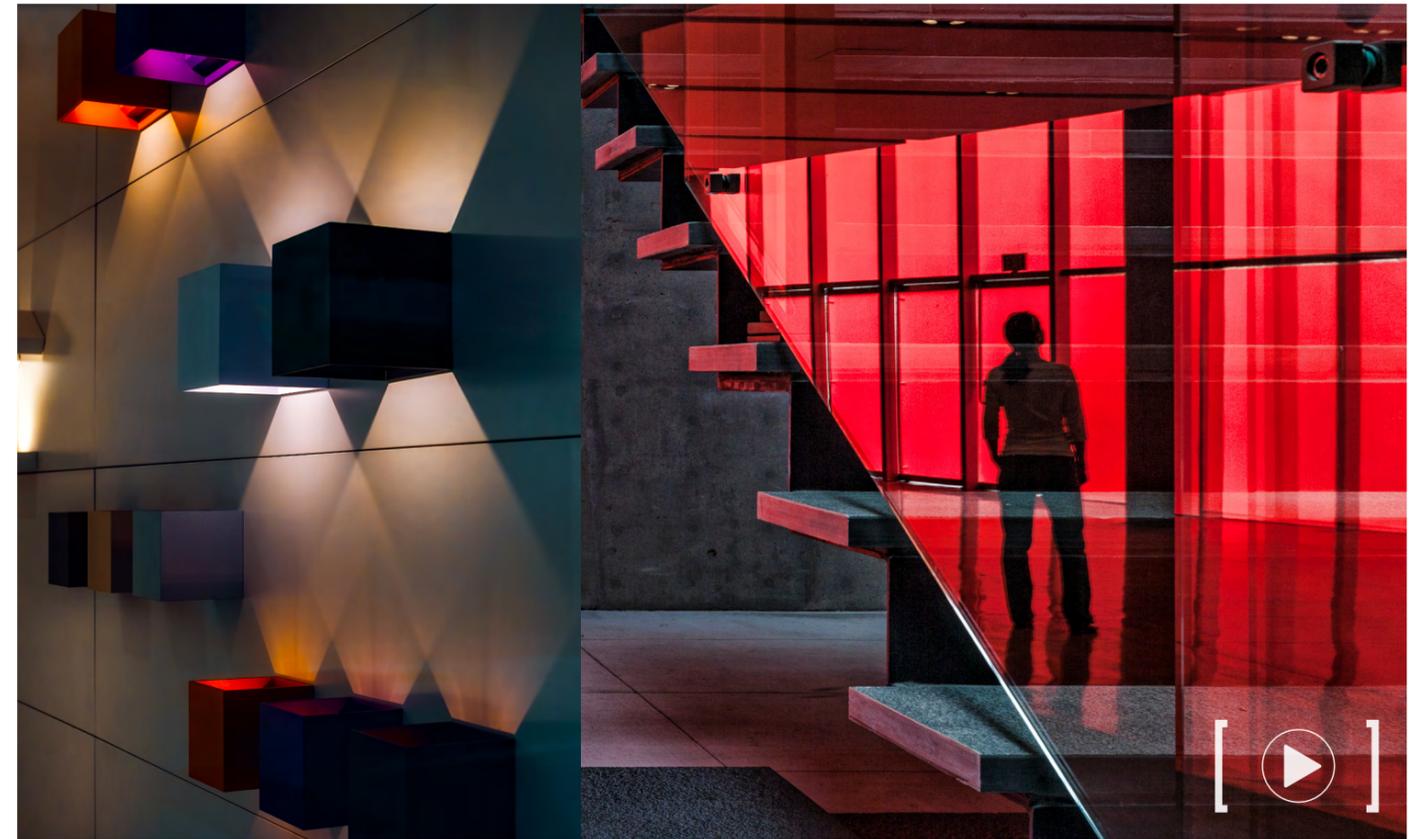
And Silvair's solution has been implemented in locations in the Europe and the U.S. Examples include an office in Brussels as well as warehouses in Sacramento, CA.

EDUCATIONAL CHALLENGE

Acuity, Gooeee, Ingy and Silvair are the vanguard of the smart lighting industry. The challenge for such companies is to impart the vision of lighting as a platform onto the mass market. And it's going to take a determined effort to educate a conservative audience.

"We shouldn't expect smart lighting to be adopted overnight," explains Gooeee's Salt. "Take up of any new technology over the past two decades has been slow. For example, when LED lighting was launched the industry took a while to move over from halogen. The key challenge is to get the right people in a business to understand and consider the benefits of a wirelessly connected lighting system, trusting it can perform to the expected demands and that it actually does what's being touted."

"The customer clearly understands the environmental aspects of LED lighting but doesn't really understand



what smart lighting promises," says François van Burk, CEO of Dutch conventional and smart lighting installer, Building Bright. "Today, a simple system whereby the lights automatically dim as daylight increases is considered smart by some. But of course, it's far from it."

These are views echoed by Silvair's Han: "Educating the market is a long process which requires the commitment from all the lighting industry stakeholders. I believe many non-lighting specialists understand the benefits but are still confused about the advantages of using data generated from [the] networks." He says the key challenges preventing rapid adoption are complexity, difficult installation, reliability, scalability and security.

Caution remains the byword for the commercial sector. This is perhaps understandable particularly as wireless connectivity inevitably introduces security concerns. "There is fear of the security implications," says Building Bright's van Burk. "Customers are waiting for big companies such as Google to endorse smart lighting and say it's secure before they move forward. But then corporate customers are cautious about any connected technology, not just smart lights."

Gooeee's Salt concurs, saying security has definitely caused companies to stall the adoption of smart lighting. "It is a major concern," he says.

But there's cause for optimism. "The industry is still in the realm of educating the systems integrators," says Acuity's Palmer. "But while the conversation starts in energy savings it does progress quickly to 'what else can we do?'"

The answer is a lot more than customers might imagine. The smart capability of a wireless mesh networked lighting system endows it with almost unlimited functionality but that comes at a price: A high level of complexity.

Acuity's Palmer explains that a typical smart lighting system includes: Connected lighting (the LEDs, drivers and sensors); controls (to look after both the lights, sensors and other systems such as HVAC); edge gateways (to run IoT applications such as location services); software services (to support capabilities such as indoor navigation; and a building management platform (an OS to look after overall supervision, analytics and Cloud connectivity).

According to Gooeee's Salt, such complexity initially made the language surrounding smart lighting overly technical, but he says people now understand more, while companies like his own have found techniques to "abstract the complexity" and better ways to communicate the benefits. Further, he says: "There are now regulations and laws in place, along with standards to reassure companies and individuals alike. This is slowly helping build trust in IoT systems and connected devices [such as smart lights]."

That trust will take time to grow and the complexity is such that smart lighting will continue to suffer growing pains. But the significant change of the last several years is that, originally designed independently and decades in gestation, the underlying technologies of LED lighting and low power wireless have coincidentally matured and reached acceptance in the mass market. And now these two technologies have converged to not only revolutionize lighting but also provide a ready-made platform for data driven applications the like of which have never been seen before. To paraphrase SSL visionary, Roland Haitz, smart lighting today is where the Internet was 30 years ago. Back then we couldn't imagine what the Internet was to become and the same is true of smart lighting. But what's more certain is the future for the technology will be as much about information as illumination.

Smart lighting is not only about the software – the hardware has to be mature too because it underpins smart lighting's stability

Numbers Game

Quuppa's Direction Finding Technology is helping Bitwise satisfy ice hockey fans' love of player statistics

Ice hockey fans love numbers. And the sport serves up some impressive ones. Midfield players cover up to 9 km during the 60-minute games and hurtle across the ice at speeds of over 30 km per hour when rushing the puck forward. And the puck itself can reach speeds of around 160 km per hour when struck with a slapshot. Wireless technology is not only helping servers generate these statistics during a game but also precisely monitor, in real time, player position, speed and acceleration, as well as tracking that fast moving 160 g puck.

Bitwise, a Tampere, Finland, software company, has recently signed a five-year contract with the Finnish domestic professional ice hockey league, Liiga, ensuring the company's commercial package. Wisehockey, will monitor professional games. The player and puck tracking system is changing the game by taking all the action from inside the rink and automatically packaging it into flexible, real time, detailed Cloud-generated analytics for the enjoyment of hundreds of thousands of fans across ice hockey-loving Finland.

It might be a relatively small country with a population of only 5.5 million, but when it comes to ice hockey, Finland is a major player on the international stage, with both its men's and women's national teams currently third in the International Ice Hockey Federation (IIHF) World Rankings. Among an impressive list of past and present ice hockey exports, the original 'Finnish Flash' Teemu Selanne is the highest scoring Finn in (U.S.) NHL history with 684 goals and Jari Kurri is a five-time Stanley Cup Champion and Hockey Hall of Fame member who spent much of his career playing alongside the great Wayne Gretzky for the Canadian team, the Edmonton Oilers.

In Finland, Liiga was launched in 1975, but the country's first ever national men's league was established almost half a century earlier in 1928. These days, Liiga comprises 15 franchises including the 2019 Finnish Champions HPK and perennially successful teams Tappara, TPS and Kärpät. Last season, Tappara participated as a testing partner for the Wisehockey system.

DATA SMORGASBORD

No other sport in Finland can compete with the popularity of ice hockey for television viewership, attendance figures and media coverage. Together with fans of other sports in the modern era, Finnish ice hockey fans are increasingly interested in a smorgasbord of live player and match data to support their enjoyment of the game.

For Liiga and its television broadcaster, telco and local pay-per-view company Telia, the availability of more in-depth statistical and performance analysis during and post games has the potential to enhance overall fan engagement, whether live at the arena or watching from the comfort of home. Having initially partnered with Wisehockey three years ago on a pilot program for one team in one arena, Liiga expanded its use of the technology to five teams in five arenas the following year, and to all 15 teams in 15 arenas across the whole league for the 2019-20 season.

Wisehockey is powered by [location finding firmware](#) supplied by Quuppa, an Espoo, Finland-based developer of real time location service (RTLS) solutions. Quuppa's Intelligent Locating System, a proven platform for location-based services and tracking applications, can track the position of fast moving objects with accuracies down to a few centimeters.

"We use the direction finding technology to accurately track both the individual players and puck in real time, and then use the raw location data to generate proprietary Cloud analytics and present the information based on the context of whether the system is tracking a player (or players), or the puck," says Miska Kuusisto, Head of Sales at Bitwise. "The basic objective of the system is very simple - to provide data that enhances the viewing experience of the sport. We have successfully developed an algorithm to meet this tough analytical challenge because ice hockey it is a very fast-paced sport and precision is paramount."

In operation the system deploys around 20 locators in the arena to receive the Bluetooth LE signals transmitted from the tags and upload the positional data from each player and the puck to a server for deeper analysis via Bitwise's Cloud API. The data can be delivered over the TV stream or via a mobile app - which is particularly useful for live spectators



Tech Check

Nordic's recently launched [nRF52811](#) supports [Bluetooth 5.1 Direction Finding](#). (See [WQ Summer 19, pg.26](#).) In the Wisehockey application, a Nordic nRF52 Series SoC is mounted on a Quuppa-designed PCB inside each Bitwise tag worn by the ice hockey players. A Bitwise tag is also mounted inside the puck

wanting to engage with this extra layer of information.

"We measure the puck position roughly 100 times per second and the player around 25 to 30 times per second," says Kuusisto. "The data currently being generated is all derived from the positional data provided by the sensors. Anybody can go to the ice hockey rink and see the movements of the players and the puck, but we are making it possible to accurately measure those movements."

WIRELESS INFOTAINMENT

The Wisehockey system generates a broad array of data including player time on ice, time in possession of the puck, maximum speed, shots on goal, passing accuracy, as well as heat maps, and overall team performance and mobility statistics. Another recently introduced metric is 'game momentum', an AI-produced composite based on actions such as scoring, faceoffs, penalties and possession. In ice hockey the whole team is sometimes changed by the coach at the same time, so the system will also show the impact on the game of these mass substitutions.

"From the harmonized data, the user can access relevant and interesting information such as the possession breakdown per zone, which player has the hardest slapshot, how fast the puck is traveling, how fatigued certain players are likely to be, and so on," says Fabio Belloni, Chief Customer Officer at Quuppa. "This is infotainment that a true

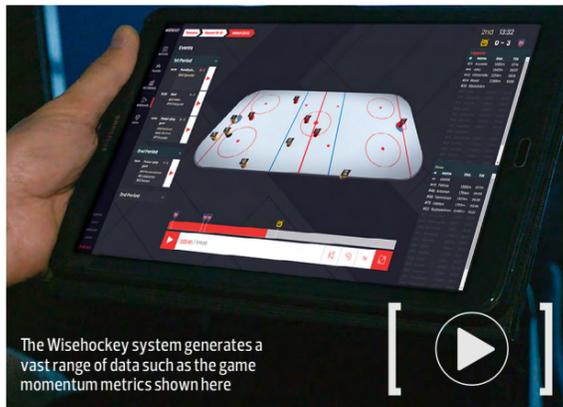
“ We use the direction finding to accurately track both the individual players and puck in real time, and then use the raw location data to generate proprietary Cloud analytics for subscriber infotainment

sports fan will really appreciate. The idea is to add to viewer entertainment at, for example, half time when pundits can review the statistics and analyze what's happening."

According to Belloni, the 'infotainment' factor represents the best opportunity to monetize these kinds of location service applications in the early stages of their life cycles, but other opportunities are bound to arise. "For the time being Wisehockey is essentially an infotainment solution rather than a platform for improving the capabilities of ice hockey players, but the data could in theory be extended to the team level to enhance tactics, training and performance on the ice," he says.

"The information can be made available in seconds so there is great scope for the technology to be used for various applications beyond spectator infotainment, such as athlete performance analysis by coaching staff," echoes Kuusisto. "Because the system is fully automated, there is no need for an individual to be present at the venue collecting and organizing statistics manually during a game. This eliminates human error and creates almost limitless opportunities."

The number of applications driven by this technology is likely to be much greater than Bitwise is currently targeting, with other sports like soccer, rugby and basketball making ideal candidates given the key elements of shooting, passing and player movement are similar to hockey. In the meantime, Finnish ice hockey fans are loving Liiga in a whole new way.



The Wisehockey system generates a vast range of data such as the game momentum metrics shown here

Food Fight

Population growth and climate change are challenging crop yields. Technology promises the solutions needed to avert a food crisis

The way food is grown hasn't fundamentally changed since humans began to shift from being nomadic hunter-gatherers to farmers about 12,000 years ago. This first agricultural revolution triggered modern civilization because people stayed in one place long enough to put down roots.

But it wasn't until the second agricultural revolution—beginning in Great Britain in the mid-17th century—that things started to really heat up. Industrial farming with better tools, selective breeding, crop rotations, the development of new fertilizers and pesticides, and significant increases in farm size dramatically increased yields. Improved transportation (including better roads, canals, ships and later railways) ensured the food made it to the burgeoning centers of population.

The second industrial revolution triggered an explosion in the global population that has continued unabated. According to the UN, the world's population is expected to increase from 7.7 billion today, to 9.7 billion in just 30 years.

Feeding an extra two billion hungry people is not going to be easy. Despite heavy use of fertilizers, crop yields are already falling due to damage caused to topsoil from growing too limited a range of staples to feed both livestock and humans. Throw in the negative effects of climate change—rising temperatures, decreased rainfall, and weather extremes—and today's farming techniques won't be able to feed the world of the future. Simply scaling conventional techniques to meet increased demand would rapidly exhaust the natural resources of the planet. Worse yet, according to Barclays Investment Bank, the agricultural sector is already responsible for nearly a quarter of global greenhouse gas emissions, and striving to increase output would inevitably accelerate climate change and make the problems worse.

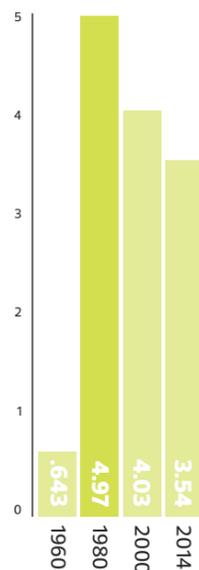
State of Play

From fighting war to combating hunger

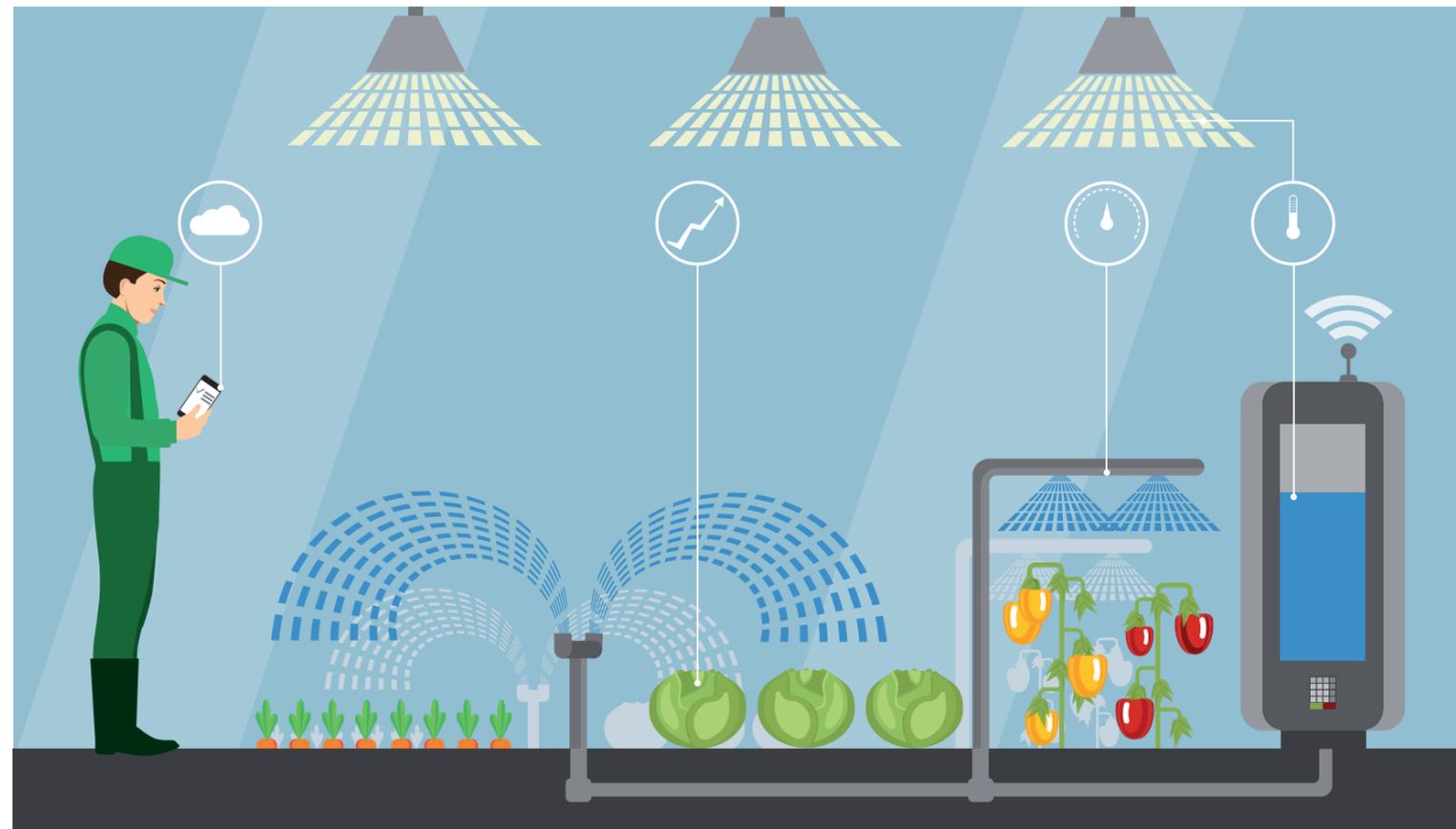
German chemist and 1918 Nobel Prize winner, Fritz Haber, invented a method to synthesize ammonia from nitrogen and hydrogen which in turn underpinned the production of modern fertilizer. Once the process was commercialized (after the ammonia stopped being sequestered to make explosives in WWII), ammonia-based fertilizer usage boomed. Since peaking in the 1980s, usage has declined as improved farming practices and selective crop breeding lessen demand.



Population growth added to the impact of climate change — mean today's farming techniques won't be able to feed the world of the future



U.S. Anhydrous Ammonia Fertilizer Consumption (million tonnes)



That means agriculture is in trouble. The world desperately needs a third agricultural revolution. "Smart farming"—with the IoT playing a pivotal role—promises quick answers. But what will the future of farming look like?

AGRICULTURAL APPS

Just as in many aspects of ordinary life, advances in agriculture are driven by mobile technology. One of the fastest ways to adopt smart farming techniques is via a growing list of smartphone apps targeting farm businesses. When *CropLife* magazine first published a list of "top apps for agriculture" in 2011, Senior Online Editor, Matt Hopkins noted: "[The list] has turned into the most popular feature on [the magazine's website]. The column has taken on a life of its own — with nearly 100 apps featured and more than one million total views."

The 2019 list includes a weather-based pesticide apps that tell farmers when to spray; one that can recognize various forms of pest, disease, weed, and leaf damage from a digital photo; an app that allows farmers to remotely monitor and control their entire irrigation operation from anywhere; and a drone flying app that allows farmers to use auto-piloting drones to fly above fields and map a whole range of parameters including plant health and population.

"There are weather apps that suggest the best time to plant crops, robot fruit-pickers that use sensors to cut waste, apps to measure crop development, manure-management apps [including the imaginatively named 'Farm Crap App'], machines that can electronically 'zap' weeds from the root up; and drones that can survey land and track livestock," noted *MoneyWeek* magazine. "Firms are working on devices with face-scanning technology to

locate dairy cows that look unwell and special wearables (think Fitbits for cows) to detect problems." (One such example of the latter is the Healtag from Finnish startup, Anicare. This product tracks reindeer via Nordic NB-IoT cellular wireless technology to monitor their position, grazing patterns, health, and location if the animal is injured or dies due to a predator attack. (See [WQ Summer 2019, pg10.](#))

PRECISION FARMING

But apps represent just the start of the third agricultural revolution. Networks of low cost wireless sensors allied with powerful Cloud-based servers mean for the first time it's commercially viable to collect, process, and analyze vast amounts of data to enhance farming techniques. (See [WQ Spring 2019, pg18.](#))

This technology is a game changer. Overnight it allows farmers to apply more scientific techniques to the business of agriculture and move into "precision farming"; focusing on each animal and each square meter of arable land.

"The essence of precision farming is to produce more with less," stated a report on precision farming by the European Commission (EC). "Simply put, [precision farming] allows farmers to increase yields while reducing use of water, pesticide, fertilizer, etc. This in turn reduces costs — both financially and in terms of health and environmental impacts. Using connected tools—such as satellites, GPS, drones and sensors—farmers can monitor and respond to their crops and animals' precise needs."

The report mentions two EC-funded projects that are working to make precision farming in the EU a reality. One is the called Internet of food and farm 2020 and aims to

improve the competitiveness and sustainability of the EU farming sector through precision farming and the IoT. The other is being conducted by the European Network of Broadband Competence Offices and aims to expand the reach of high-speed broadband to all citizens in the EU with a particular focus on rural and remote areas.

Another smart farming initiative worthy of note is vertical farming. The technique involves growing food in stacked layers in indoor controlled environments (using, for example, LED lighting to accelerate growth and hydroponics (whereby soil is replaced by nutrient-enriched water)). "Vertical farming is a revolutionary and more sustainable method of agriculture than its counterpart as it lowers the requirement of water by up to 70 per cent and also saves considerable space and soil," noted Kashyap Vyas in an article published on the *Interesting Engineering* website.

Vertical farming is being shown to work; for example, Robotics farming pioneer, Iron Ox, claims its robots and vertical farming system can grow a wide range of vegetable greens using 90 per cent less water than traditional farms while producing around 30 times the crops per unit area. This is done by optimizing the entire planting and growing process from seed to harvest.

Since the industrial revolution, the global agricultural industry has coped with the demands of feeding an exploding world population by throwing more chemicals, bigger machines and more land at every problem, becoming a major source of greenhouse gas emissions in the process. A sustainable future for agriculture producing yields sufficient to feed ten billion people will require yet another revolution — a revolution based on the IoT.

Need to Know

Tomorrow's vertical farm installations will rely on low maintenance wireless sensor networks to monitor light levels, humidity and temperature. Data will be sent to Cloud servers via cellular IoT for analysis. Algorithms will then tune the farm environment to maximize yield while optimizing use of resources

Sports & Fitness

Unlimited Electric Skateboard Powertrain

This Bluetooth LE modular powertrain makes any conventional skateboard electric and wirelessly remote-controlled

According to analyst, Technavio, the global smart sports equipment market will grow by \$14.49 billion between 2019 and 2023, at a CAGR of over 37 percent. Factors driving growth include increasing use of sports equipment to improve gaming performances, health concerns and the rapid innovation in technology and consumer electronics

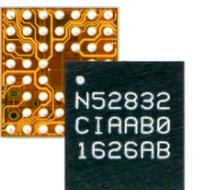


Unlimited's powertrain can achieve a range of up to 24 km between recharge, which is likely enough for almost anyone save Spaniard [Andy Andras](#). In February 2016, Andras set the world record for distance traveled on a skateboard in a day, clocking up a phenomenal 497 kilometers in 24 hours at the Homestead Miami Speedway circuit

Any skateboard fitted with the [modular powertrain](#) can be wirelessly controlled over Bluetooth LE using the handheld remote controller featuring a throttle to accelerate and brake, an OLED screen displaying key information like speed, battery level, and riding mode, and buttons for features such as cruise control and 'nitro' power boosts

While a skateboard fitted with Unlimited's 'R Kit' can reach an impressive 42 km/h top speed, this is still some way off the fastest speed recorded on a skateboard. That record is held by British man [Peter Connolly](#), who hit 146.73 km/h in a standing position at a gravity sports event in Quebec, Canada in 2017

Skateboarding was born at some point between the late 1940s or early 1950s, when Californian surfers wanted something to do when the waves were flat. The maker of the first board is unknown, but surf shop owner Bill Richard made a deal with a roller skate company to produce sets of wheels to attach to square wooden boards, and the sport of 'sidewalk surfing' was invented



Tech Check

The Unlimited modular powertrain and remote controller employs Nordic's [nRF52832](#) Bluetooth LE multiprotocol SoC to provide robust wireless connectivity between remote controller, powertrain, and the user's smartphone. In addition to supervising the remote controller's connectivity, the SoC's 64MHz, 32-bit Arm Cortex M4 processor with FPU supervises the rest of the device's functionality

Connected Health

Ring-based smart pulse oximeter provides continuous key health data

Using Bluetooth LE connectivity and MegaHealth's Medical Pulse Oximeter, patients can access blood oxygen and heart rate updates day and night

Leading manufacturers in the rapidly developing connected health market are looking to innovative solutions for medical analysis and health monitoring challenges using low power wireless technologies. One company, Hangzhou, China-based MegaHealth Technologies, has its finger firmly on the pulse of contemporary patient and medical practitioner needs. Following extensive research and development efforts, the company has successfully launched a smart pulse oximeter which is now being widely adopted by hospitals in China. The oximeter has been certified by the country's National Medical Products Administration (NMPA, formerly CFDA).

MegaHealth designed the [ZG-P11D Medical Pulse Oximeter](#) to provide all the key functionality of a standard pulse oximeter including heart rate measurement, blood oxygen saturation (SpO₂) and pulse rate (PR). At the same time, the smart ring offers unique features that the company believes differentiate it from competitive solutions traditionally employed in the healthcare space.

For one, the Medical Pulse Oximeter's lightweight, waterproof ring-based form factor allows for extended wear on the finger. "In contrast to traditional finger-clip oximeters, the device's one-piece housing is designed for better biocompatibility making it comfortable to wear and secure from falling off during sleep, while the low power design allows for continuous use over long periods of time," says Jan Wang, Cofounder of MegaHealth.

Powerful hardware

The Medical Pulse Oximeter detects changes in the wearer's SpO₂ and PR using built-in proprietary signal processing algorithms driven by the absorption rate of different wavelengths detected by sensors.

SpO₂ is an important physiological parameter reflecting respiration and ventilation function and a key indicator of the total oxygen status of the body.

To gather useful individual health metrics, MegaHealth's pulse oximeter uses LEDs of two wavelengths: A red LED with a wavelength of 660 nm ± 10 nm; and an infrared (IR) LED with a wavelength of 940 nm ± 20 nm.

"The percentage of blood oxygen and pulse rate is calculated by measuring the different absorption rates of the two light wavelengths as they pass through the body," explains Wang.

The complexity of the device's software demands powerful hardware. Nordic's [nRF52832](#) SoC's 64 MHz, 32-bit Arm Cortex M4 processor with FPU runs the pulse oximeter's complex applications including the SpO₂ signal acquisition and algorithm operation. The SoC's 512 kB Flash memory is sufficient to record and store the health data at defined intervals, while the 64 kB RAM allocation



In contrast to traditional finger clip oximeters this device is comfortable to wear and secure from falling off during sleep



Need to Know

SpO₂ represents the percentage of oxygen-bound oxyhemoglobin in the blood compared with the total hemoglobin. The normal blood oxygen saturation of human arterial blood is 98 percent, and that of venous blood is 75 percent. Medical professionals generally consider the arterial saturation should be no less than 94 percent - anything less signals danger

is ample for the algorithm filtering requirements of the pulse oximeter.

In addition, the Nordic SoC provides the low latency Bluetooth LE wireless connectivity that enables personal health data to be periodically transmitted from the smart ring to MegaHealth's iOS- and Android-compatible partner app on the user's smartphone. Whether at home or in transit, the user can then easily access daily, weekly and monthly reports detailing their key health metrics such as blood oxygen and heart rate, as well as update selected medical professionals with relevant information.

"Nordic's SoC uses a Bluetooth LE protocol stack that superbly balances power consumption and real-time performance," says Wang. "The [architecture's] clear message-driven model provides a convenient means of programming, allowing our developers to put as much energy as possible into application development."

The small ring form factor of the Medical Pulse Oximeter made the selection of extremely power efficient electronics essential. "The oximeter device itself is small so the battery must also be very compact. This means battery-life management is definitely an important factor in selecting [the SoC]," explains Wang. "We use a custom-made arched soft-pack lithium battery which paired with the Nordic solution means we now have a product in which the battery lasts for more than 20 hours.

The nRF52832 has been specifically engineered for ultra low power consumption with features such as the 2.4GHz radio's 5.5 mA peak RX/TX currents and microamp average currents over long periods.

A development focus

Looking ahead, MegaHealth is focused on the continuing development and operation of [smart medical monitoring and health management](#) hardware, and systems and data platforms, along with providing medical and health management services based on mobile Internet platforms.

"MegaHealth has core technologies and intellectual property rights in the fields of ultra wideband radar sensors, HRV biofeedback, ECG, optoelectronics and other biomedical electronics," says Wang. "We have cooperative relations with nearly 100 renowned local hospitals and MegaHealth products have been included in the list of China's key R&D programs."

But for now, MegaHealth hopes the ZG-P11D Medical Pulse Oximeter will continue to gather momentum in the connected health market. Not only from medical professionals and hospitals in China and around the world, but also by patients themselves, as wireless technology increasingly enables consumers to take control of their own health outcomes.

Nordic People

Former intern embraces work and life challenges

Hi, I'm Marjeris Romero and I'm a Nordic Application Engineer based in Trondheim. Having previously worked with Nordic as a summer intern and again when completing part of my masters thesis, I am now working full time in the tech support department. My main responsibilities are to help customers with any technical queries or problems they encounter to ensure they get their products to market. A typical workday involves getting to the office and grabbing a coffee before checking [Nordic's DevZone](#) to see what new customer questions have popped up. For anyone who doesn't know about DevZone, it is our dedicated forum for Nordic Q&As and our main communication channel with customers. We try to provide answers in a timely manner.



Profile

Name: Marjeris Romero

Job Title: Application Engineer

Joined Nordic: August, 2018

Based: Trondheim, Norway

Interests: Horse riding, fitness, reading, wool knitting, socializing

I enjoy the responsibility of working closely with product development. You can see how much your ideas and suggestions have the potential to impact the result of a product, and it's very satisfying to find good solutions for our customers. Some days I work on hardware queries, others I work on embedded software debugging, but I always feel like I am learning something new because customers' requests can be so broad. Either way it's always rewarding to receive positive feedback from customers after helping them solve an issue or

to go horse riding whenever I have the opportunity. It's so relaxing and I get to see the beautiful Norwegian landscape from a better point of view. Horses are also great companions.

Two years ago, I took a pole dancing and aerial fitness class at the student sports organization and I found it to be a really good way to combine dance, strength and flexibility training. It also gave me new motivation to work out and improve my overall fitness level. I try to switch between strength training at the gym, yoga, pole and aerial hoop in my weekly workout schedule. This year, thanks to NoVel, I also tried downhill skiing for the first time. We spent three days in a cabin up in the mountains of Trysil where I took a beginner course with some other colleagues. It was a really good experience and I am already looking forward to taking my skis out again next winter.

“My overall goal is to keep challenging myself and continuing to learn new things

improve a design. I feel our customers really appreciate what we do.

I like working in such a positive environment and this year I joined Nordic's social committee, 'NoVel', where I help organize events and social activities outside of work for all Nordic employees. I always like to learn new things and I must say that Trondheim is a great city for trying different activities. As a student at the Norwegian University of Science and Technology (NTNU) I enrolled in a horse riding course and it immediately became one of my passions. Now I like

My overall goal is to keep challenging myself and continuing to learn new things. The best feeling in the world is when you manage to do something you didn't know you were capable of. I think the same attitude towards embracing challenges can apply to work as well. Looking ahead, I hope I can help more Nordic customers to shape new solutions that make it easier for us all to live better and more sustainable lives.

[Tech Zone]

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

Industrial IoT

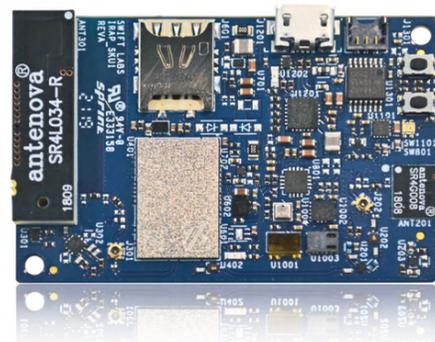
Cellular module speeds fail safe IIoT development

Canadian wireless hardware design specialists, Swift Labs, has launched its C1DI module based on Nordic Semiconductor's nRF9160 SiP, designed to help rapidly develop fail safe IIoT applications, for example in oil and gas refineries, as well as energy-, utility- and chemical-plants.

According to Swift Labs, the module has been designed to reduce development time to between three and six months for high reliability applications. The module is suitable for applications where components have to perform 100 percent reliably, require long battery life and, in the event of failure scenario such as being crushed, fail safely so as not create a fire, overheating or sparking risk, particularly in explosive and flammable environments.

"[The demand for high reliability] really 'ups' the design complexity," says Swift Labs' Senior Director of Solutions Architecture, Mike Brown. "There's no room for error in any [part] of the design from the fail safe components on the PCB to trace width sizing, to the unique anti-ESD enclosure. [These] are all designed with the utmost scrutiny in terms of operational reliability and fail safe predictability."

The Swift Labs Design Blocks PCB measures just 55 by 36 by 4.9 mm, includes GPS and LTE antennas, plus an extended list of customizable sensing options including nine-axis absolute orientation, air pressure and humidity, time-of-flight and air quality. By using the onboard capabilities of the nRF9160 SiP, the Design Blocks platform also



offers an accelerometer and temperature sensor as standard, multimode LTE-M/NB-IoT capabilities, GPS and a powerful Arm Cortex-M33 application processor.

"The time for cellular IoT has arrived and in the industrial IoT sector the ability to automate what was once laborious, costly, and time consuming in safety critical operations is now technologically and commercially viable for the first time," says Swift Labs CEO, Paul Wilson.

Firmware beefs up Bluetooth LE smart lock security

Germany-based BlueID has released security firmware for Nordic Semiconductor's nRF52840 Bluetooth 5/Bluetooth LE SoC. The firmware forms part of a complete Cloud based access rights management platform that turns smartphones, tablets and smartwatches into secure digital keys, and now includes support for the Nordic SoC's Arm CryptoCell functionality.

Hardware manufacturers can purchase a Ready2Go license for the ACCESS firmware enabling them to easily integrate it into their nRF52840 based electronic lock and reader designs using Nordic's nRF5 SDK. The Nordic SoC's secure OTA-DFU capability also allows existing nRF52840 SoC-based locks and readers using previous versions of the firmware to be securely updated in the field.

The ACCESS firmware allows facility managers to provide Cloud based authorization and authentication of a user's

access credentials, enabling effective and secure facility access control. Once authorized, the user can open a door fitted with an nRF52840 based lock or reader using their smartphone.

To ensure the highest level of security the BlueID solution takes advantage of the nRF52840's advanced security features including an Arm TrustZone CryptoCell-310 cryptographic module and an AES 128-bit hardware accelerator that provide cryptographic functions and include a true random number generator.



Module offers full Bluetooth 5 suite

Laird Connectivity has released two new products in its BL654 Series, the power amplified BL654 PA module and the BL654 USB Adapter, both employing Nordic's nRF52840 Bluetooth 5/Bluetooth LE SoC.

The BL654 PA module enables OEMs to use Bluetooth 5 for secure, extended range in IoT product designs. The integrated nRF52840 SoC provides full Bluetooth 5 support including 2x on-air raw data bandwidth (2Mbps); 4x range; 8x broadcasting ability with advertising extensions and an improved channel coexistence algorithm. The SoC's sensitivity is boosted by Skyworks' PA/LNA to -98.5 dBm (at 1Mbps in Bluetooth LE mode) with maximum output power of +18 dBm for a link budget of 116.5 dBm.

The BL654 USB Adapter is a production packaged and fully certified version of Laird's standard BL654 module. The module supports designs created with either Nordic's nRF5 SDK or the Zephyr development environment.

Tech Briefing

IoT growth increases demand for trusted execution

Technologies such as Arm's TrustZone offer proven solutions for protecting valuable and sensitive data from the clutches of determined hackers

The IoT is rapidly gathering momentum; estimates of the number of devices connected to the network vary from 20 billion (according to Gartner) to 30 billion (statista) by the end of next year. The exact number is of little consequence, what's far more important is the value of the data those connected devices accumulate. The higher the value of that data—be it, for example, financial, medical, commercial, or personal—the more it attracts the attention of the bad guys. But that doesn't mean if a device handles no sensitive data security can be ignored. By connecting devices together life is made easier for the hackers because they can concentrate their efforts on the weakest link in the chain – especially if that link is defenseless. Once hacked, the compromised device offers an unlocked back door into more secure devices elsewhere on the network.

A key challenge for engineers tasked with the protection of hardware and software architectures is to secure valuable data without compromising the flexibility and convenience of a solution by locking down everything. One established solution is to create 'Trusted Execution Environments' (TEEs). TEEs are secure areas inside the processor that run in parallel but are isolated from (and often invisible to) the main operating system. Code and data inside TEEs are maintained with the highest level of integrity and confidentiality while elsewhere things can be a little less constrained. Such a system protects the valuable code and data while enabling less valuable code and data to run unencumbered on the main operating system. Commercial implementation of TEEs included TrustZone from Arm, a silicon IP vendor. The company explains that TrustZone technology provides "system-wide hardware isolation for trusted software".

Flexible and secure

TrustZone represents a flexible approach to high levels of security by enabling an Arm processor to be used as a freely programmable 'trusted platform module'. This is achieved by adding a "secure" processor operational mode (establishing a "secure world" or a TEE within the processor) in addition to the regular normal mode. By implementing the secure mode, things like security functions and cryptographic credentials can be hidden from the normal processor functions.

When operating in the secure mode, for example to perform a secure boot, the processor runs code from secure memory and can interface with secure peripherals. Upon completion of the boot up, the processor attends to user software such as the application and protocol stack in normal mode. The processor is never simultaneously in secure mode and normal mode.

John Leonard, Nordic's Senior Product Marketing Manager advises developers to firstly use TrustZone to build a "root-of-trust" for the system comprising everything needed for a secure boot and system recovery. Once that root of trust is established, the



elements in normal mode can make function calls to the functions that exist in the secure world. However, the normal mode function calls can only access that which has been exposed for such purposes in the secure code.

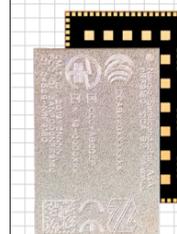
To understand how TrustZone works in practice, consider the design of a smartwatch for both collecting exercise data and performing mobile payments. The smartwatch will need a secure mechanism for identifying the user so that payment details can be securely released to the vendor. With TrustZone handling the user identity and payment systems, it becomes very difficult to hijack sensitive data. As soon as a need to use the payment system is triggered, the processor switches from the normal to the secure mode and enables the payment app. Authentication could involve a secure PIN entry or biometric check to ensure the device can only be used by the trusted owner and the payment details are safe from hacking.

While Trustzone does provide a secure basis to protect the most important aspects of the system, Leonard advises "TrustZone isn't the last word in security and is no substitute for a secure-by-design product development process". To assist in building protected products, Arm offers its Platform Security Architecture (PSA) which it describes as a framework for securing connected devices. PSA provides a step-by-step guide to building in the right level of device security, reducing risk associated with data reliability.

In addition, Arm TrustZone CryptoCell IP complements TrustZone by enabling greater separation of assets through hardware. CryptoCell will be described in more detail in WQ issue 4; 2019.



With TrustZone handling the user identity and payment systems, it becomes very difficult to hijack sensitive data



Tech Check

TrustZone technology integrated into Arm Cortex-M33 based systems (through Arm's Armv8-M architecture) protects Nordic's LTE-M/NB-IoT cellular IoT solution, the nRF9160 SiP. The SiP is also among the first products to receive PSA Certified Level 1 certification under the Arm PSA initiative

Cellular IoT PoC points the way for smart meter connectivity

An open source proof-of-concept developed by Finnish smart meter specialist, Gurux, based on Nordic's cellular IoT solution, simplifies smart meter communication. Lorenzo Amicucci explains

Utilities are looking to smart meters to minimize operating costs and keep consumer bills down. But existing smart meter connectivity technologies offer limited performance and flexibility. And the widespread deployment of proprietary solutions severely limits interoperability and lock utilities into niche communication technologies that can be expensive to install and maintain.

Consequently, the smart utility meter industry is demanding a standardized solution that, through economies of scale, is relatively low cost to both deploy and operate. The most widely accepted international standard for utility meter data exchange, the DLMS/COSEM ("DLMS") standard offers the most promise. The major impediment to realizing DLMS's potential is the lack of convergence on the communications used to connect DLMS meters to back-end utility infrastructure. However, because DLMS is based on the Open Systems Interconnection (OSI) model, it is able to employ a wide range of communication media. That includes cellular IoT, a wireless technology based on established, robust, and highly secure LTE ("4G") networks.

Cellular IoT presents a very real opportunity to globally standardize smart utility metering connectivity to the Cloud. But the underlying technology is complex and daunting to the inexperienced. Now, a collaboration between Finnish smart meter experts, Gurux, and Nordic Semiconductor, promises to simplify development of DLMS smart meter communication via cellular IoT. With the help of Nordic, Gurux has produced an open-source proof-of-concept (PoC) smart electricity meter, based on Nordic's nRF9160 SiP, that directly addresses the engineering challenges typically encountered when using cellular IoT for smart meter reading.

Configuring a prototype

The PoC is designed for use with a DLMS meter and comprises four elements: A cable that connects the nRF9160 DK to the meter (via optical probe or direct serial port connection); the nRF9160 DK itself flashed with Gurux MQTT Bridge example; an MQTT Broker and the client application based on GXDLMSDirector (which is simple to install on a PC for product demonstration).

It is straightforward to configure the PoC for a prototype. First the engineer programs the nRF9160 DK with the example provided by Gurux, which implements a MQTT bridge, and connects it to the smart meter via the cable, and then uses GXDLMSDirector to select the meter manufacturer and set the MQTT parameters. The PoC is then able to use the MQTT Broker to send data across the LTE-M link and receive information back from the Cloud-based client application. Although primarily designed for DLMS, the PoC can support alternative smart meter protocols across the LTE-M link. The PoC can also be used



as a prototype Network Interface Card (NIC). NICs are plug-in boards that can bring connectivity to a meter. The architecture is popular since it introduces modularity enabling the meter to support different types of connectivity by swapping out the NIC. By using nRF9160, no extra microcontroller is needed on the NIC. A single chip architecture can be implemented, with nRF9160 managing both connectivity and edge processing.

By experimenting with the meter data collection interfaces, the developer can configure the nRF9160 DK to operate as a NIC for most kinds of meters. Thanks to the simplicity of software development on the DK (in part because the application processor and modem are integrated on the same chipset) building prototype NICs is relatively straightforward.

The NB-IoT option

The PoC currently uses LTE-M cellular IoT because it supports the low latency and high data rate demanded by the most challenging metering applications. However, for many applications, an alternative cellular IoT technology, NB-IoT, would be satisfactory. And for advanced electricity meters, where both latency and coverage are important, it would make sense to incorporate a solution that supports both versions of cellular IoT to cover the widest range of applications with a single design.

The Nordic nRF9160 SiP at the heart of the PoC can switch autonomously between LTE-M and NB-IoT using a simple AT command triggered by the onboard Arm Cortex-M33 processor. That makes it simple for the engineer to modify the PoC to optimize smart meter wireless connectivity automatically. The majority of cellular IoT connectivity challenges can be resolved by switching between LTE-M and NB-IoT to establish which works best in the specific operational environment.

Lorenzo Amicucci is a Business Development Manager with Nordic Semiconductor



The smart utility meter industry is demanding a standardized connectivity solution that through economies of scale is low cost to deploy and operate

Need to Know

Gurux has serviced the smart meter industry for over 20 years and offers globally licenced products. Nordic is a leader in the global Bluetooth chip market and is set to become a major player in low power cellular IoT with its nRF9160 SiP

Product Guide	nRF 91 SERIES		nRF 52 SERIES			nRF 51 SERIES		
	nRF9160	nRF52840	nRF52832	nRF52811	nRF52810	nRF51822	nRF51422	nRF51824
ICS								
WIRELESS PROTOCOL	LTE-M	•						
	NB-IOT	•						
	GPS	•						
	BLUETOOTH 5.1 DIRECTION FINDING				•			
	BLUETOOTH 5 - 2 Mbps		•	•	•	•		
	BLUETOOTH 5 - LONG RANGE		•	•	•			
	BLUETOOTH MESH		•	•	•			
	BLUETOOTH LOW ENERGY		•	•	•	•	•	•
	ANT		•	•	•	•	•	•
	THREAD		•	•	•			
	ZIGBEE		•	•	•			
	802.15.4		•	•	•			
2.4 GHZ PROPRIETARY		•	•	•	•	•	•	
NFC		•	•	•				
IC TYPE								
SYSTEM-ON-CHIP	•							
SYSTEM-IN-PACKAGE	•							
ON-CHIP								
LTE-M/NB-IOT/GPS MODEM	•							
CPU	Arm Cortex-M33	Arm Cortex-M4	Arm Cortex-M4	Arm Cortex-M4	Arm Cortex-M4	Arm Cortex-M0	Arm Cortex-M0	Arm Cortex-M0
FPU	•	•	•					
DSP INSTRUCTION SET	•	•	•	•	•			
ARM TRUSTZONE	•							
MEMORY	1 MB Flash 256 kB RAM	1 MB Flash 256 kB RAM	512 kB or 256 kB Flash 64 kB or 32 kB RAM	192 kB Flash 24 kB RAM	192 kB Flash 24 kB RAM	128 kB or 256 kB Flash 32 kB or 16 kB RAM	128 kB or 256 kB Flash 32 kB or 16 kB RAM	256 kB Flash and 16 kB RAM
MAXIMUM TX POWER	23 dBm	8 dBm	4 dBm	4 dBm	4 dBm	4 dBm	4 dBm	4 dBm
MPU	•	•	•	•	•	•	•	•
ANTENNA INTERFACE	50 Ω single-ended	Single-ended	Single-ended	Single-ended	Single-ended	Differential	Differential	Differential
PERIPHERALS								
CLOCKS	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	64 MHz / 32 kHz	16 MHz / 32 kHz	16 MHz / 32 kHz	16 MHz / 32 kHz
TWI, SPI, UART	•	•	•	•	•	•	•	•
HIGH SPEED SPI	•	•						
QSPI	•	•						
USB	•	•						
PWM	•	•	•	•	•			
PDM	•	•	•	•	•			
I2S	•	•	•					
AES	•	•	•	•	•	•	•	•
ARM CRYPTOCELL	•	•	•					
ADC/COMPARATOR	•	•	•	•	•	•	•	•
TIMER/RTC	•	•	•	•	•	•	•	•
TRNG	•	•	•	•	•	•	•	•
TEMPERATURE SENSOR	•	•	•	•	•	•	•	•
APPLICATIONS								
PC PERIPHERALS		•	•	•	•	•	•	•
SPORTS & FITNESS		•	•	•	•	•	•	•
GAMING / VR + AR		•	•	•	•	•	•	•
MESH NETWORKS		•	•	•	•	•	•	•
CONSUMER ELECTRONICS		•	•	•	•	•	•	•
AUTOMATION		•	•	•	•	•	•	•
INDUSTRIAL SYSTEMS	•							
AGRICULTURE	•							
HEALTHCARE		•	•	•	•	•	•	•
TOYS		•	•	•	•	•	•	•
WEARABLES	•	•	•	•	•	•	•	•
SMART HOME		•	•	•	•	•	•	•
SMART BUILDINGS	•							
SMART CITY	•							
DIRECTION FINDING				•				
ASSET TRACKING	•			•				
METERING	•							
BEACON		•	•	•	•	•	•	•
AUTOMOTIVE GRADED								•
REF. DESIGNS			PC Desktop, Smart Remote, Smartphone Demo Apps			PC Desktop, Smart Remote, Smartphone Demo Apps, Beacon	Smartphone Demo Apps	Smartphone Demo Apps
DEV TOOLS	nRF9160 Dev Kit, Nordic Thingy:91	Single Board Dev Kit, Power Profiler Kit	Single Board Dev Kit, Power Profiler Kit, Nordic Thingy:52	Single Board Dev Kit, Power Profiler Kit	Single Board Dev Kit, Power Profiler Kit	Single Board Dev Kit, Dongle	Single Board Dev Kit, Dongle	Single Board Dev Kit, Dongle
PACKAGES	LGA	aQFN, WLCSP	QFN, WLCSP	QFN, WLCSP	QFN, WLCSP	QFN, WLCSP	QFN, WLCSP	QFN



NORDIC[®]
SEMICONDUCTOR

Kickstart your
LTE-M/NB-IoT development

NORDIC te_{ch}TOUR

Nordic Tech Tour is a series of technical seminars hosted by Nordic Semiconductor in EMEA, US and APAC. Each seminar is free-of-charge and all attendees get a free development tool.

COMING UP NEXT

INDIA - NEW ZEALAND - AUSTRALIA - SINGAPORE
VIETNAM - CHINA - TAIWAN - SOUTH KOREA - JAPAN

November 4 - December 19, 2019

For full agenda, cities and registration: nordicsemi.com/ntt

