

WIRELESS QUARTER

Q2 SUMMER 2019

POWER MAD:
HOW TO CURB ENERGY USE

FASTER FOOD:
TECH ENHANCES
QSR EXPERIENCE

Following the herd

Cellular keeps track of the Sami's most valuable asset across the vast subarctic



NB-IoT REVITALIZES
FROZEN BEVERAGES

PROTECTING POLICE
WITH BLUETOOTH TECH

WHY CELLULAR IoT
DEMANDS eSIMS



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Welcome

Svenn-Tore Larsen
CEO



When the first Bluetooth LE applications hit the market, even Nordic's engineers—who were among those that developed the specification—were amazed at the applications customers introduced. That amazement continues to this day as Nordic's products are used to power applications across industry, commerce, health, education and consumer electronics. This edition of *WQ*, for example, features applications as diverse as a fertility tracker, a cycling safety beacon and a monitor to track green sea turtles. And while we never take success for granted, the future for Nordic's solutions looks bright in a market that the Bluetooth SIG [forecasts](#) will reach 1.6 billion Bluetooth LE chips shipments per year by 2023.

Now I'm pleased to report that Nordic's customers are exhibiting the same impressive innovation with the first applications of the nRF91 Series cellular IoT module: the [nRF9160](#). The product combines Nordic's nRF91 SiP with Qorvo's custom RF front end and advanced packaging into a device so compact and battery friendly it brings LTE-M and NB-IoT connectivity to a host of applications that were previously impractical.

Apart from the advanced hardware and software, a key advantage of the nRF91 Series is that Nordic's R&D engineers have made it easier for customers to realize their designs by abstracting away the complexity of cellular via [easy-to-use development tools](#). And Nordic customers—small and large—are wasting no time in taking advantage of that proposition.

Scores of design partners have been working for months to develop and test nRF9160-based products and the first of those are now coming to market. This edition features cellular IoT reindeer trackers, smart alarms, and frozen beverage makers. Expect to read about many similar products in the coming weeks.

“Scores of design partners have been working to develop, test, and verify nRF9160-based products and now the first of those are coming to market”

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News

The latest developments from Nordic Semiconductor

Ear tag tracks location and health of herding animals

A tracking device that can be attached to an ear of herding animals and autonomously measure a location and health has been introduced by Finnish startup, Anicare.

The Anicare Healtag employs Nordic Semiconductor's multimode cellular IoT module to send data to the Cloud so that in the event a roaming animal becomes injured, it can be quickly identified for treatment.

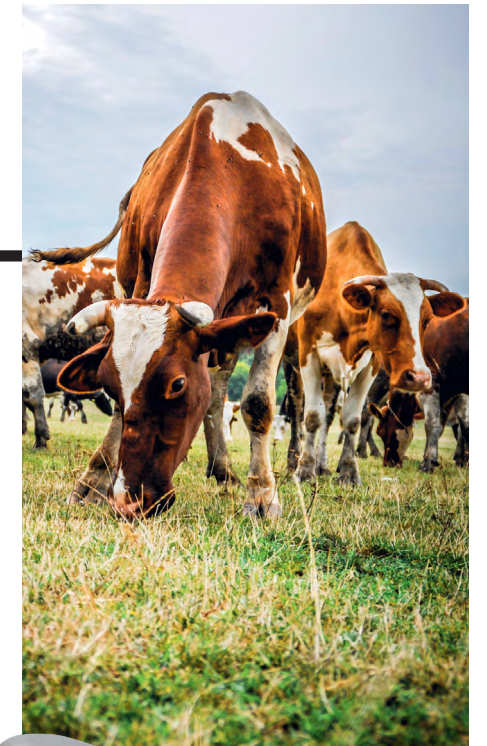
Existing herding animal trackers are so large they have to be hung from the animal's neck, and they consume so much power that their batteries have to be replaced every year. In contrast, by employing the compact [nRF9160](#) SiP, the Healtag is small and light enough (at 25g) to be attached to an animal's ear like a traditional livestock ear tag, and offers a battery lifetime of up to five years.

The device integrates an accelerometer and thermal sensor to measure the herding

animal's activity and temperature once an hour. NB-IoT cellular technology carries reports of any significant changes that would tend to indicate either illness, injury, or predator attack. This includes using the nRF9160 SiP's built-in GPS functionality to immediately send the owner the exact location of a distressed animal.

“The commercial challenge for herding livestock farmers is that they have to manage hundreds or thousands of animals and the loss of even a few of these can significantly reduce or even eliminate already slim profit margins,” says Geir Langeland, Nordic Semiconductor's Director of Sales & Marketing. “This makes IoT-enabled herding livestock management solutions particularly attractive as a way to protect profits.”

The Anicare Healtag will be commercially available from September this year.



Smart Health

Ovulation and fertility tracker helps women conceive

U.S. healthcare technology company Quanovate has released a [Bluetooth LE](#) based ovulation and fertility tracker that helps women conceive by providing hormone readings and personalized ovulation cycle predictions through the measurement of fertility hormone concentrations.

Once the user has collected a urine sample using a test wand, the sample is analyzed by the Mira Analyzer device, and the data is automatically synced using Bluetooth LE wirelessly connectivity (provided by Nordic's [nRF52832](#) SoC) to the Mira Fertility app on the user's smartphone.

The partner app then uses AI-based analysis to learn the unique hormone levels and patterns of the user. From the app display, the user can receive accurate fertility hormone data, monitor hormone patterns, and view precise, personalized ovulation predictions. The app also provides accurate insights into their fertility window to enhance the



prospects of conception. Users can also enter and store a full suite of additional fertility tracking data.

According to Quanovate, Mira is the only FDA, CE, and CDFA registered and certified, at-home diagnostic device with the capability to cover every stage of women's health testing. Mira can test fertility, pregnancy, fetal health, ovarian reserve, and the progress of menopause.

In Brief

CELLULAR IOT CONNECTIONS EXPLODE

According to a new report from IoT analyst, Berg Insight, the number of global [cellular IoT](#) subscribers during 2018 increased by 70 percent to reach 1.2 billion. The firm said the growth was driven by “exceptional adoption” in China which accounted for 63 percent of the global installed base, and has now surpassed Europe and North America in penetration. By 2023, Berg Insight forecasts, there will be 9 billion IoT devices connected to cellular networks worldwide.

NORDIC DEVELOPMENT TOOL WINS AWARD

Nordic's [nRF Connect for Cloud](#) has been named winner of the “[Most Competitive Development Tools in China](#)” category by the judges of the 2018 CEM Editor's Choice Awards. The program recognizes products that meet the needs of the Chinese market. The product is a free service for Cloud-based evaluation of products employing Nordic's Bluetooth SoCs and nRF91 Series SiPs for cellular IoT.

Smart Home

Smart alarm uses LTE-M cellular IoT to provide instant alerts

Swedish startup, Minut, is employing LTE-M cellular technology to provide the wireless connectivity for its motion, temperature, sound, humidity, and air pressure detection smart home alarm.

The device, dubbed the Point, employs Nordic's nRF9160 SiP cellular IoT module in place of the previous Wi-Fi/Bluetooth LE solution, and enables owners to receive remote notifications in the event of activation. The unit measures 85 by 46mm and eliminates the need for multiple alarms. Privacy is safeguarded by local data processing.

The Point employs patented sound-recognition technology that analyzes ambient noise in a home. This enables the device to immediately recognize out-of-the-ordinary sounds such as smashed glass or other alarms going off nearby. It can even alert neighbors, friends, and family of an intruder detection.

"With the Point you can relax safe in the knowledge that ... you'll automatically get sent a notification alert," says Nils Mattisson, CEO & Co-Founder at Minut. "Alert thresholds can also be user-specified, and the user can check-in on the status of their home."

"Cellular IoT is a natural complement to existing wireless products and is particularly relevant to security applications where it has



This smart alarm listens for unusual sounds such as a break-in and sends automatic smartphone notifications to owners via cellular IoT

often been used as the 'wireless technology of last resort' in traditional intruder alarms," says Geir Langeland, Nordic's Director of Sales & Marketing. "Unlike traditional intruder alarms that are hard-wired into the mains, low power cellular IoT supports battery-powered operation which is a bit of game changer. I suspect many previously Wi-Fi products will add or even switch to cellular."

By the Numbers

\$52.6 million in revenue

Nordic Semiconductor has reported Q1 2019 revenue of \$52.6 million and a gross margin of 51 percent, on the back of a continued strong market position in Bluetooth LE. The company has also seen an increased number of end-product certifications in the quarter, with a total of 136. This is the highest number of new certifications since Q3 2017 and represents a year-over-year growth of 33 percent. Nordic also reported \$100,000 in cellular IoT revenue in Q1 2019 as it recognized the first shipments of finished products.

36 million connected cattle

According to analyst, ABI Research, by 2024 more than two million farms and 36 million cattle will be connected by the IoT, as technology continues to transform agriculture and livestock industries. For crops, the primary driver for the introduction of connectivity and the IoT is not only to irrigate sufficiently but also to limit excess water application. For livestock, it is about collecting data relating to the health of the animals. According to the research, the technologies that will power IoT in connected agriculture will heavily rely on gateways and LPWANs.

Smart Health

Ingestible capsule controlled wirelessly



Researchers at Massachusetts Institute of Technology and Brigham and Women's Hospital have designed an ingestible capsule that can be controlled using Bluetooth LE wireless technology. The capsule, which can be customized to deliver drugs, sense environmental conditions, or both, can reside in the stomach for at least a month, transmitting information and responding to instructions from a user's smartphone. The devices could also be used to communicate with other wearable and implantable medical devices, which could pool information to be communicated to the patient's or doctor's smartphone.

Beacons

Nordic and Quuppa partner on location services ecosystem

Nordic Semiconductor has strengthened its design partnership with Quuppa, a Finland-based developer of real time location service (RTLS) solutions. The collaboration builds on Quuppa's development of its Intelligent Locating System to run on Nordic's nRF52 Series SoCs, including the latest Bluetooth 5.1 Direction Finding solutions.

Quuppa's Intelligent Locating System is a proven platform for location-based services and applications. The company has partnered with Nordic since 2016 and its firmware, which currently runs on Nordic's nRF52832 Bluetooth LE/Bluetooth 5 SoC, uses the Bluetooth LE protocol to transmit 'Angle-of-Arrival' (AoA) radio packets which in turn determine the position in space of a Bluetooth LE transceiver. The introduction of Bluetooth 5.1 Direction Finding enhances the technique by providing simplified access to the Bluetooth LE protocol's IQ signal data for the Quuppa positioning engine. The technology has been employed by major Bluetooth beacon and tag manufacturers, including Kontakt.io, BlueUp, Tatwah and ELA Innovation, for tracking applications with accuracies down to a few centimeters.

Quuppa's previous long-term experience working with Nordic's nRF52 Series will enable



leveraging of Nordic's Bluetooth 5.1 Direction Finding support to extend the ecosystem of RTLS solution providers and applications. Further expansion will be encouraged by Bluetooth 5.1 technology's interoperability between products from different vendors and smartphones. Key application sectors include asset tracking and indoor positioning systems.

"We place high importance on our partnership with Quuppa," says Kjetil Holstad, Director of Product Management at Nordic Semiconductor. "Combining our technologies offers developers a proven, commercialized platform which they can confidently use to build centimeter-precision RTLS solutions."

Bluetooth baseball coaches players' pitching skills

F5 Sports, a U.S. sports technology startup, has released 'pitchLogic' to help baseball pitchers and coaches at any level improve their technique.

pitchLogic is a Bluetooth LE-enabled baseball that uses proprietary algorithms employing 15 channels of built-in sensor data. The sensors provide a comprehensive set of body movement and pitch performance metrics—including spin, acceleration, launch angles, and breaking force—that help a pitcher practice more efficiently, reduce stress on the body, measure progress, and optimize overall pitching performance during a session.

The pitchLogic baseball uses Nordic's nRF52840 SoC to wirelessly send the sensor data to the user's mobile device where they can view the metrics after each pitch or review previous pitches via an iOS or Android app.

The SoC's 64MHz, 32-bit Arm Cortex M4F processor is designed to support the Floating Point (FP) and Digital Signal Processing (DSP) computations required to run the pitchLogic system's complex applications.

"The Nordic SoC provides all of the computational and wireless communication capabilities of our pitchLogic system," says David Rankin, CEO of F5 Sports. "For us, the nRF52840 SoC has enabled a combination of key advantages including fast FP operations, built-in Bluetooth LE connectivity, and of course low power requirements, that were not previously available."



In Brief

NORDIC PENS CHINA DISTRIBUTION DEAL

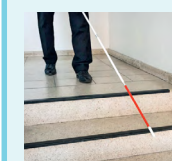


Nordic Semiconductor has signed a distribution agreement with Lierda Science & Technology Group, a Hangzhou, China-based company

focused on embedded systems, M2M solutions, and design services across China, Hong Kong, and Macau. The deal covers distribution and design support for Nordic's complete range of ultra low power wireless connectivity hardware, firmware, development tools, and reference designs. "Nordic is a Bluetooth LE leader, with high performance SoCs, development tools, and reference designs that provide a significant competitive advantage," says Kai Chen, VP IoT Business, Lierda. "This is matched perfectly with Lierda, and our focus on wireless IoT, industrial, smart home, consumer, and medical solutions," adds Chen. "There is a huge opportunity in China in building technology, automation, and smart home solutions," says Wendell Boyd, Nordic's Director of Sales and Marketing – APAC.

INTERNET CONNECTED DEVICES PASS 22 BILLION

The number of devices connected to the internet reached 22 billion worldwide at the end of 2018, according to the latest research from Strategy Analytics. Enterprise IoT remains the leading segment, accounting for more than half of the market, however the analyst predicted the home market will be the fastest growing segment over the coming years, driven by further rapid growth in smart home adoption. The report predicts that 38.6 billion devices will be connected by 2025, and 50 billion by 2030.



BLUETOOTH BEACONS HELP VISUALLY IMPAIRED

A wayfinding app and a network of Bluetooth LE beacons that can help people with visual disabilities navigate airport terminals independently and safely has been developed by researchers at Carnegie Mellon University. The NavCog app has previously been deployed in shopping malls, but has been modified for use at airports—where extremely wide corridors make users vulnerable to veering and jostling—and for use with moving walkways. The app relies on a map of the terminal with the locations of restrooms, restaurants, gates, entrances, and ticketing counters, plus hundreds of Bluetooth LE beacons, to then provide users with audio directions to their selected destination.

Smart Home

'World first' Zigbee certified thermostat for underfloor heating

Sikom, a Norway based developer of GSM IoT platforms, has released what it claims is the first Zigbee certified product for the direct control of smart home underfloor heating.

The Sikom Z3 Thermostat EP has been developed for the smart home OEM market, and employs Nordic's nRF52840 SoC to enable Zigbee wireless connectivity and mesh networking. The thermostat integrates actuators enabling the device to control floor heating cables directly, and is mains-powered, eliminating the need for battery replacement. Once installed, the thermostat can be controlled via a Zigbee Home Automation Profile-enabled control device using Zigbee wireless connectivity. The thermostat can be easily implemented in a robust and secure Zigbee smart home mesh network, where the device acts as the router to other connected Zigbee devices.

"The nRF52840 SoC is a powerful solution that gave us a lot of design freedom and functionality while keeping costs down," says Øyvind Tande Hovdsveen, a Senior Systems Developer with Sikom. "Aside from Zigbee (and Bluetooth LE) support, the most important features for us were the memory allocation and processor capacity that allows for swift development of complex applications without needing to spend time fine tuning performance or sacrificing application functionality."

The Sikom Z3 Thermostat EP thermostat complements the company's Bluetooth Thermostat EP, a Bluetooth 5/Bluetooth LE heating control solution launched in May 2018 and also based on Nordic's nRF52840 SoC.



Wireless tech helps track and conserve green sea turtles

U.K. based technology consultancy, Icotecq, in collaboration with open source conservation technology group, Arribada Initiative, has developed a solution to track and collect data on the movement and behavior of green sea turtles using Bluetooth LE wireless tech.

Collecting data on sea turtles is valuable for informing governments, directing conservation policy to designate marine protected zones, and identify turtle threats.

At the core of the solution is a platform called Horizon, incorporating a tag attached to the turtle's shell during the "arribada", the unique mass turtle nesting phenomenon where thousands of female turtles come together on the same beach to lay eggs. The tag features a nine channel motion sensor, temperature and pressure monitoring sensors, a satellite receiver, and an Insight SIP ISP1807 module, based on Nordic's nRF52832 Bluetooth LE SoC. When the turtles return to the beach the logged data is downloaded to a PC using Bluetooth LE connectivity.

Depending on the turtle species and location, turtle return to the beach can vary from weeks to months, demanding the solution operates with ultra low power consumption to conserve and extend battery life. When the battery reaches a critical state,



GPS logging is disabled, so the Bluetooth LE connectivity is still functional when the turtle does return.

The platform also supports cellular, satellite, and LoRa connectivity for remote download. The device is currently undergoing testing in the lab and in the wild.

"Historically, tracking sea turtles has been expensive, time consuming, and technically challenging," says Craig Rackstraw, Icotecq's MD. "Assembling teams of conservationists and research scientists in sometimes remote and difficult-to-access locations is not cheap and the high costs for specialist tracking equipment has meant it has been difficult to conduct large scale studies. Turtles also like to spend a long time under the water making reception of satellite navigation signals impossible for much of the time."

The device has been shortlisted for the U.K. National Technology Awards.

Bluetooth LE aids robot perception and interaction

Researchers at the University of Hertfordshire in the U.K. have proposed a technique to enhance a robot's ability to perceive and interact with people. Among its many applications is enhanced therapy for children with autism, allowing robots to act as child mediators and monitors.

According to the researchers, traditional methods using a camera or sensors are not ideal, and external proximity devices need at least three markers to be effective. As an alternative, researchers developed a technique that allows robots to recognize touch and proximity to humans using Bluetooth LE.

"When a child wears a wireless beacon, a robot can measure the signal strength and infer knowledge about [interaction or touching]," says Marcus Scheunemann, one of the research team. "The beacons can be [unobtrusive], contrary to external tracking devices."

The researchers found that observing the received signal strength between different Bluetooth LE devices significantly enhanced a robot's interactions with humans. In the future, their technique could foster more adaptive behavior in robots.

News Extra

Nordic cellular IoT powers retail sector innovations

Freezing Point is using NB-IoT to support its plan to revitalize the North American frozen beverage market

How cellular IoT will enable new business models is becoming clear as technologies such as Nordic's nRF9160 SiP LTE-M/NB-IoT module reach commercialization. One example comes from Freezing Point, a Salt Lake City-based frozen beverage company and owner of the "Slushie" brand, Frazil.

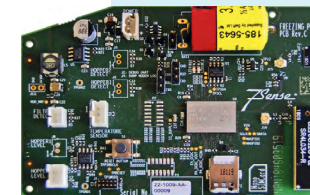
Slushie is a trade name for frozen beverages comprising chipped ice, sugar, food coloring and flavoring. The frozen beverage is dispensed by a machine that constantly stirs and refrigerates the mix to maintain a smooth consistency. That machine requires both cleaning and refilling as well as periodic maintenance.

Frazil wants its customers to sell lots of frozen beverages, frequently reordering Slushie concentrate to meet demand. But those customers don't want the financial risk of buying the dispensing machines, and they certainly don't want the hassle of maintaining or fixing a machine. Freezing Point's solution is a "Slushie as a service" model (following the scheme pioneered by Salesforce.com whose "software as a service" set the example for the subscription economy). Such a business model enables Freezing Point to provide the retailer with a Frazil machine while retaining ownership and taking care of maintenance and repair, at no cost to the retailer. The retailer can focus on their core business, instead of needing to manage the host of issues related to machine service.

Connectivity essential

Under the Slushie as a service business model, Freezing Point takes responsibility for thousands of machines situated over a wide geographical area, making it essential that it actively monitors them all. The company requires constant updates on whether the machine is on, full and working properly. It would be impractical to send a technician to each location, so connectivity is essential, enabling real time notifications to ensure each machine is in good condition and generating maximum revenue. For example, if a machine senses a low frozen beverage level for a period of a few hours, it will notify Freezing Point.

The company realized that cellular IoT—a secure, robust connection, leveraging existing infrastructure and independent of the host retailer's network—was the ideal solution for linking thousands of frozen beverage machines to its HQ. Freezing Point partnered with 7Sense, a Norwegian developer that designs IoT technology for clients that lack specific technical expertise. 7Sense has deep cellular IoT expertise having been at the forefront of the rollout of the NB-IoT version of cellular IoT in Norway while working closely with national carriers. 7Sense developed and manufactured a low-cost, retrofittable cellular NB-IoT circuit board based on Nordic's nRF9160.



Retailers have identified a strong correlation between how well they manage their Frazil program and how well they manage other aspects of retail excellence



"We've been developing cellular IoT applications using traditional cellular modules for some time," explains the company's CEO, Max Tangen. "But when the Nordic nRF9160 SiP module came along we saw it had a host of clear and unique benefits."

As the name suggests, NB-IoT is a narrowband technology standard with a bandwidth of 200 kHz, significantly boosting its range compared with LTE-M. (The trade-off is modest throughput (60/30 kbit/s downlink/uplink) compared with LTE-M.) The longer range of NB-IoT is an advantage in retail environments which often have a lot of (RF attenuating) metal on floors, walls and ceilings. However, because Nordic's nRF9160 is a multimode product, the 7Sense solution is capable of operating as an LTE-M modem if the application demands it.

IoT revelations

In addition to allowing Freezing Point to keep tabs in real time on the status of the machines, the data revealed patterns in consumer behavior; for example, Frazil machines low on Slushie content weren't used anywhere near as much as those that were nearly full. Frequent topping up boosted retailers' sales.

But more than that, machine status proved a bellwether for the business: "Large chains are using [Frazil's] reporting dashboard as a window into their broader store operations," explains Kyle Freebairn, Frazil's CEO. "Retailers have identified a strong correlation between how well they manage their Frazil program and how well they manage other aspects of retail excellence."

Smart City

Wireless tech boosts police and public safety

Law enforcement agencies are adopting new technology to make policing more efficient and improve civilian security

The public safety and law enforcement landscape is changing as wireless technology enables the instant, automatic deployment of innovative personal protection methods and incident monitoring platforms. It's an important evolution for both those in danger and those in the line of duty.

According to data from the FBI's annual *Uniform Crime Report: Law Enforcement Officers Killed and Assaulted, 2017*, law enforcement agencies in the U.S. reported that 60,211 officers were assaulted while performing their duties in that year. Of those, around a third sustained injuries. Moreover, in the U.S. alone there were an estimated 382.9 violent crimes per 100,000 inhabitants in 2017, with aggravated assaults accounting for 65 percent of the almost 1.25 million violent crimes nationwide reported to law enforcement. Clearly, the global market for more effective self-defense technologies and connected law enforcement platforms is substantial.

Building safety networks

How can short range wireless technologies like Bluetooth LE contribute to the development of advanced solutions for handling such serious incidents? By creating secure wireless networks of people, self protection devices with multifunctional built-in sensors, and paired incident reporting smartphone apps or Cloud based alarm platforms. Such products combine to protect life and reduce the risk of serious injury in emergency situations.

Many of these networks are designed to help law enforcement agencies not only cut down emergency response times, but automatically record incidents for evidence and accountability purposes, and perhaps ultimately deter and prevent criminal activity.

Some law enforcement departments around the world have already adopted systems that allow officers to receive reliable information and updates before, during, or soon after an incident is reported. In Chicago, IL, for example, Strategic Decision Support Centers (SDSCs) bring together data from surveillance cameras and sensor based gunshot detection systems with analytics on previous crime patterns to help officers identify specific areas where violent crime is likely to occur. According to a 2019 U.S. Police Foundation report, shootings in the Chicago district of Englewood, where an SDSC was deployed for the first time in 2017, fell by 67 percent that year compared to 2016.

In the Central West End District of St. Louis, MO, an initiative using Coolfire Solutions' Ronin Platform has seen citizens report suspicious activity and request police assistance through a smartphone app, with local officers then able to aggregate data based intelligence from alarms, IoT sensors, cameras, and communication systems to quickly develop an action plan.



Axon, a Scottsdale, AZ based life protection technology specialist, has established a comprehensive network of devices, apps and people that help public safety personnel be smarter and safer when protecting their communities. "Our products impact every aspect of a public safety officer's day-to-day experience," says Annie Pratt, Director of Consumer Products at Axon. "To date, there are more than 371,100 software seats booked on the Axon network around the world and more than 216,000 lives and countless dollars have been saved with the Axon network."

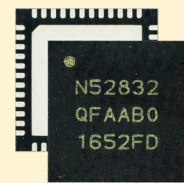
Connected TASERS

Complementing safety networks are conventional self protection devices that are enhanced with the addition of wireless technology. One such device is Axon's **TASER Pulse+**, a Bluetooth LE enabled TASER designed for civilian rather than law enforcement use. The **TASER Pulse+** can deliver neuromuscular incapacitation from a distance of 5 meters or less. According to Axon research this and other 'less lethal' solutions lower the risk of permanent injury to both target and user.

However, the true usefulness of smart personal protection devices comes from their wireless integration with app based personal safety platforms—in this case Axon's Noonlight platform—as soon as the device itself is activated. The low latency Bluetooth LE link between TASER Pulse+ device and Noonlight smartphone app ensures emergency services are automatically notified of a potentially life threatening incident along with the precise location of the alarm using real time GPS tracking. The technology means consumers don't need to retrieve

Tech Check

Low power consumption was one of the main drivers for Axon's decision to use Nordic's nRF52832 in the TASER Pulse+. The TASER achieves over one year of battery life. The nRF52832 has been engineered to minimize power consumption with features such as fully automatic power management



We see an increased need for technology that makes law enforcement officers safer, more efficient, and more effective in their roles

their phone to make emergency calls after using a TASER in self defense.

In law enforcement scenarios, an Axon TASER Smart Weapon like the TASER 7 conducted energy weapon is able to wirelessly report its status, such as in the event of a trigger pull, thus activating the officer's body worn video cameras. The device also gathers further analytics about how it has been used, such as safety activation and trigger event duration, to provide key information required by law enforcement agencies which may be useful for future investigations or court proceedings. Widespread deployment of this type of technology could one day act as its own deterrent to criminals.

Wireless technology is also instrumental in the functionality of Axon's newest law enforcement products, including the Axon Body 3, a next generation body worn camera using cellular connectivity to enable agencies to view live streaming video footage and live maps to track an officer's location during critical incidents. The product also allows officers to wirelessly view incidents and send out alerts when a gunshot is detected by the camera.

And in the unfortunate scenario where a gun is fired, technology can help limit damage. For example, Tempe, AZ based DataSoft Corporation's **Automatic Injury Detection (AID)** wearable gunshot detection system features a **wireless sensor integrated** into 'man-down' vests for law enforcement applications. The AID panel detects any piercing event to the wearer's front or back, at which point the vest automatically connects to a paired smartphone using Bluetooth LE connectivity. The smartphone then sends an emergency alert to nominated first responders or backup units via SMS, or directly to a dispatcher's console.

Future of law enforcement

Emerging wireless technologies like cellular IoT are also likely to dramatically alter crime response management and law enforcement as we know it. Within an IoT powered smart city, for example, street lights could use gunshot detection equipment, sensors, and wireless connectivity between each other and the Cloud to shine brighter when a shot is fired, or assist officers in a pursuit through a dark area. Cellular IoT networks might also have the capacity to improve the speed and accuracy of facial recognition or license plate scanning through video recorded by a city's surveillance cameras and make it instantly accessible to law enforcement.

"We see an increased need for technology that makes law enforcement officers safer, more efficient, and more effective in their roles," says Annie Pratt of Axon.

"Products and services that deliver these attributes can create savings within an agency that more than offset the additional investment."

Svein-Egil Nielsen

CTO: Nordic Semiconductor



Why the smart home needs to get even smarter

Before the industry can grow up, smart home device vendors need to learn to play nicely together

Smart home device shipments grew 55 percent in 2018 over 2017 to total 252 million units with more than 70 million homes worldwide now having one or more smart home device (according to ABI Research).

With such impressive market penetrations you could be forgiven for thinking that the smart home is doing everything right. But I don't think it is; rather I think vendors' outdated business models and product complexity are compromising growth.

Traditionally, if a consumer wanted to install an alarm system in the home, they'd turn to a professional security company. In return, the consumer would receive expert installation and remote monitoring – but also a hefty, contractually binding monthly fee. If the consumer wanted to add, for example, CCTV they'd have to go back to the same vendor and pay them to install and configure an additional set of sensors and cameras. And that hefty monthly fee would get even heftier.

Today's consumers are sending a clear message (through their investment in DIY security systems) that they don't like being locked in to contracts and they don't like being locked in to a single vendor and technology. It's a message smart home suppliers would do well to heed, because they are in danger of continuing the outdated business model of yesterday's security firms.

The second mistake the smart home device companies are making is ignoring the virtues of ease-of-use. Today it's common for a consumer to buy a device that offers the basic functionality they need but then ignore advanced features because they are daunting to configure. It's true that there are plenty of smart home installation



firms to do the heavy lifting but that hardly makes life more convenient.

The good news is that smart home manufacturers are beginning to recognize their devices are too complex for consumers to configure and access all features. For example, GE has introduced some connected light bulbs that work directly with Google Home using 'Actions on Google' for pairing and communicating. Users don't even have to pair the Bluetooth-based bulbs with the hub.

Any ease-of-use improvement is to be encouraged and will increase smart home device sales. But alone it won't be enough to deliver on the promise of the smart home.

A smart home for all

The smart home is an innovative and expanding industry sector; but right now, it's also a mess.

Consumers want smart home devices from a range of vendors that they can bring home and within minutes have up and running without recourse to an external installer.

Consumers also enjoy mixing, matching, and enhancing. This means the smart home industry needs to adopt a multiprotocol, common industry standard. One that enables devices from any vendor and using any protocol to work seamlessly together. When that's going to happen is anyone's guess. But the day it does will be the day the smart home grows up.

Following the Herd

In the harsh subarctic, cellular IoT monitoring of valuable livestock can mean the difference between boom and bust for Sami reindeer owners

In Short

Lapland's commercial reindeer herds face increasing pressures particularly from climate change, human habitat encroachment and predators

In a difficult economic environment, the indigenous people of Lapland, the Sami, are turning to technology to help them keep track of semi-nomadic reindeer. Knowing the location of the animals helps the herders reach them quickly when problems occur

Conventional GPS-based trackers are ill-suited to reindeer monitoring because the products are bulky and heavy, and battery lifetime is short

NB-IoT cellular technology, supported by Scandinavia's world-leading 4G networks, offers the answer. The products are light, compact and the batteries last for years. And the devices can be coupled with a range of sensors to provide real time information about location, movement and health of individual animals

Reindeer benefit from an enviable public image. When most people think of the animals they picture a snowy scene with a cute, healthy animal (typically with a red nose) tethered to a shiny sleigh laden with children's presents. There are even some who believe reindeer are from the world of fantasy; a figment of a Christmas card designer's imagination inhabiting the same place as unicorns, mermaids, and dragons.

Hardly. Direct ancestors of the reindeer have been around for some 680,000 years and far from being cuddly, reindeer are extremely powerful and robust animals. They have to be to survive the challenges of the alpine tundra landscapes and subarctic forests in which they live, the harsh winter conditions comprising ice, deep snow, high winds and extreme temperatures. Migrations across hundreds of kilometers between seasons to find food, avoid predators and reproduce bring further dangers.

The reindeer's resilience is derived from its evolutionary adaptations which include a compact body morphology and thick pelt to minimize heat loss; a high population of fiber-digesting bacteria in the gut flora to maximize the nutritional value of poor-quality vegetation; and unusually large deposits of subcutaneous fat laid down in late summer and fall for use when winter limits the food supply. When not migrating or running from danger, reindeer conserve energy by walking at a leisurely pace and lying down for almost half the day.

But such long periods of resting should not be confused with an easy life. While reindeer are very social animals, gathering in herds that can number up to several thousand individuals, populations exhibit large fluctuations. Extreme weather events, lack of food, predators, hunters, road and rail accidents, insect borne diseases, competition between species, and human encroachment on grazing areas all serve to erode their numbers.

Climate change is adding to the burden. Increased warming is changing migration routes and patterns of vegetation, but those aren't the major threats, rather it's rain. Traditional winters above the Arctic Circle are very cold but also very dry. Warmer winter temperatures are encouraging lower snowfall and more wet weather. Reindeer are perfectly adapted to snow; they can sniff



out vegetation with a highly sensitive nose and dig through the layers with their hooves to reach the food underneath. But when rain falls and then freezes, edible flora is locked beneath an uncrackable ice layer and starvation quickly follows.

A report by *New Scientist*, a U.K. magazine, described the impact of two major rain events on the Yamal Peninsula in Russia which caused mass starvation of reindeer in November 2006 and 2013. After the 2013 rainfall, over 20 percent of a herd numbering 275,000 animals died. The rain froze into a thick ice sheet for months, preventing the animals reaching vegetation underneath.

"Reindeer are used to sporadic ice cover, and adult males can normally smash through ice around 2 centimeters thick," Bruce Forbes at the University of Lapland in Rovaniemi, Finland, told *New Scientist*. "But in 2006 and 2013, the ice was several tens of centimeters thick."

Despite the suffering, the life and death of reindeer would be little more than an academic curiosity if the animals were wild, but for thousands of years the herds have been a critical source of nutrition, clothing and income for

polar indigenous cultures. "Caribou [the North American name for reindeer] are not just what we eat; they are who we are ... without caribou we wouldn't exist," explains a spokesperson for the Gwich'in, an Alaskan Indian people.

COMMERCIAL ENTERPRISE

Dependence on reindeer has led indigenous peoples to semi-domesticate what were formerly wild, nomadic animals. According to *reindeerherding.org*, reindeer farming is a traditional way of life in Eurasia, carried out by more than 20 different ethnic indigenous Arctic peoples in Norway, Sweden, Finland, Russia, Mongolia and China, involving close to 100,000 herders, 2.5 million semi-domesticated reindeer, and covering some four million km² of land. The organization says that reindeer herding in some parts of Russia dates back over two millennia.

In Lapland, northern Finland, while the sector has deep historical roots it's now run like a modern industry by the indigenous people, the Sami. For starters, the reindeer are no longer free to wander where they wish; as far back as 1898 Finland divided the area in which reindeer herding is



The tracker demonstrates how cellular IoT can be used for general animal farming. Versions for sheep and cows are next on the company's list

permitted into *paliskunta*, a defined herding area. Today there are 54 such regions and each herd must keep to its own area to avoid overgrazing. Nonetheless, each paliskunta covers vast tracts of remote, harsh terrain. So remote that Salla, a settlement well north of the Arctic Circle and in the center of one of the regions, bills itself as "the town in the middle of nowhere".

Reindeer meat is a popular delicacy in Scandinavia and demand is steady. According to U.K. based publication *The Economist*, 71,580 reindeer were slaughtered in 2014 with the meat from each being worth \$1100 to \$1700. That makes protection of the valuable animals critical. The Russian rain events, for example, caused long-lasting socio-economic impacts for the local reindeer herders.

DANGER EVERYWHERE

Decimation of a herd due to disease or starvation is only one concern for the owners. Although reindeer prefer to stick together, stragglers often become separated. That makes them easy pickings for predators, particularly wolverines, which since 1995 have been protected by

Finnish hunting regulations. According to *The Economist*, a family of wolverines can get through 90 reindeer a year.

Because the forests are vast and remote, if an isolated animal is attacked by predators, starves or falls ill and dies in the in the dark frozen trees, it is often never found. And even if it is located the carcass is typically mutilated by scavengers. In as little as a day, the scavengers can do so much damage that not only can the cause of death be impossible to determine but even proof of ownership can be erased. Unidentifiable dead animals are not only distressing but also, in Lapland in particular, costly, because if the herder is unable to prove the reindeer was killed by a predator, they miss out on a compensatory payment from the Finnish government. (4,126 such payments were made in 2014.)

One such unfortunate beast led to the 2012 foundation of Anicare, a company whose mission is to help reindeer herders look after their animals. The company's CEO, Aki Marttila, chanced upon the dead reindeer in the forest and it set him thinking. "I own reindeer myself," he says. "And I wondered if there might be a device for tracking the animals from which all herders could benefit."

It's not a completely original idea; some reindeer have been equipped with satellite tracking devices for over a decade. But they're expensive, costing hundreds of dollars, heavy (mainly because of the large batteries which still only last about year) and bulky.

The heft of the tracking devices dictated that they are attached via a collar. This is far from ideal, partly for practical reasons—young reindeer grow quickly so the collar quickly becomes uncomfortable and collars worn by adults can snag on tree branches—and partly for aesthetic reasons. "Bright colored and wide collars on reindeer don't give a very good experience for tourists," says Marttila. The tourism industry provides supplementary income for herders so it's important to cater to their tastes. "They hope to see wild animals, not reindeer in 'dog collars'."

Instead, Marttila decided to base his company's product on NB-IoT, an LPWAN technology that leverages existing cellular infrastructure. As a pioneer of cellular technology, Scandinavia is blessed with extensive coverage of the LTE networks needed to support the NB-IoT technology,



even in the sparsely populated regions frequented by the reindeer. And Scandinavia's telecoms firms are among the first in the world to offer commercial NB-IoT support. (See sidebar *Leading the world in NB-IoT*.)

The narrowband tech lends itself to long range (tens of kilometers) while throughput is limited to tens of kilobits per second. That matches the requirement of the reindeer application where the animals roam over long distances and the volume of data is small, amounting to hourly updates of location, movement and body temperature.

PROTECTED SPECIES

Dubbed the Healtag, the Anicare product integrates Nordic Semiconductor's nRF9160 NB-IoT modem, GPS, an accelerometer and a temperature sensor into a device small and light enough to attach to a reindeer's ear like a traditional livestock tag. The Healtag's low power consumption offers a battery life of up to five years.

"The component integration and small size of Nordic's solution—the module is the smallest NB-IoT solution on the market with GPS—meant we could fit the product into a package measuring just over 3 by 2 by 2 centimeters and weighing only 25 grams," says Marttila. "And because the Nordic product is certified for global cellular networks, we didn't have to worry about gaining any regulatory approvals." (See *this issue* pg3.)

As the reindeer moves across the tundra, its location is monitored and transmitted by the NB-IoT device to the Cloud. Herders can use a browser dashboard to check each animal's unique position, as well as where and how far it's traveled since the last update. An app supports a smartphone version of the dashboard. Over time, positional data can help build up grazing patterns to help herders better manage the reindeer.

Key to the product's success is an alert function that triggers a notification if a problem is detected with a particular animal. The accelerometer and temperature sensor monitor movement and body heat, and the alert is sent immediately (rather than waiting for the next periodic transmission) if the algorithm calculates something is amiss. For example, if the animal is lethargic

and its temperature rises, it could be an indication it has an infection. Or if the reindeer is lying down and its temperature drops it could be that it is injured or dead. "A rapid alert enables the herder to reach the reindeer as soon as possible and hopefully take it to a vet or at least end the animal's suffering. And in the worst case it can ease the identification of the cause of death," says Marttila. "If it's due to predation, the herder can initiate a claim, but if it's due to, for instance, starvation or disease, the herder can take measures to protect the remainder of the herd."

WHAT'S NEXT?

Healtag is still under development and an updated version of the device is due for release soon. The tech has been tested across Lapland for over 12 months and the units fixed to reindeer last summer are still working well. More herds will be added in other geographical areas around Finland to continue to test, among other things, that cellular coverage is adequate to cover the reindeer's wandering range. Marttila expects the technology to be commercially available by year end when the solution will be available to herders for the cost of a software license fee.

"While the product is designed for reindeer, we consider it to be a demonstration of how cellular IoT can be used for animal farming in general," explains Marttila. "Versions for sheep and cows are next on our list." Marttila's ambition extends beyond domesticated animals; he also suggests a version for the very wolverines that attack the reindeer. "If we know where they are, we can at least limit the number of reindeer they take," he says.

Life in the subarctic is never going to be easy. Winters have always been harsh and global warming is changing weather patterns in a way that adds to the already tough challenge of feeding for the north's reindeer herds.

And an increase in the number of hungry wolves, not to mention Scandinavian cars and trains, is killing more animals. But three things provide hope for the future; the reindeer demonstrate a tremendous capacity to adapt, the herders are clever and resourceful people, and cellular IoT technology can help them better protect and nurture their animals.

Tech Check

Measuring just 10 by 16 by 1 mm, the nRF9160 includes everything a cellular connection and IoT application needs beyond an external battery, SIM and antenna. The nRF9160 is capable of delivering class-leading output power (+23 dBm) and sensitivity, vital for its GPS support



Nordic's compact nRF9160 SIP enabled Anicare to develop a product measuring just 35 by 22 by 23 mm and weighing only 25 g

Leading the world in NB-IoT

While it's remote, sparsely populated, and bleak, northern Scandinavia doesn't want for cellular coverage. Nordic countries have routinely set a world-class benchmark for cheap access to mobile data and a competitive telecoms landscape has driven an early and comprehensive roll out of LTE (4G) networks. According to analyst, Opensignal, for example, when it comes to 4G availability, the Nordic countries are in an elite class. The company says that in Finland, Norway and Sweden, 4G subscribers are able to access an LTE signal more than 80 percent of the time. And coverage is impressive too, with analyst Tutela noting that Norway, Sweden and Finland boast 4G across most of the land area, including their remote rural regions.

Scandinavian telecoms firms are also among the first in the world to provide network access for NB-IoT cellular IoT devices. Norwegian mobile operator, Telia, for example, commissioned the first NB-IoT network in the Nordics as far back as 2016. In 2018, the company was the first to offer NB-IoT on its entire Swedish network. The network provides NB-IoT coverage to over 95 percent of the country's area and commercial deployments have commenced, including a deal to NB-IoT connect 900,000 electricity meters for Swedish electricity distributor, Ellevio.

NB-IoT is an LPWAN technology standard developed by the 3rd Generation Partnership Project (3GPP), a standards organization for mobile telecom, to enable a wide range of low power cellular devices and services including those for the IoT. The NB-IoT specification was adopted in the organization's Release 13 in June 2016.

The technology is designed to meet the demanding requirement of extended rural and indoor coverage but with minimal device complexity and low power consumption. Because the underlying technology is simpler than 2 and 3G modems the cost of the devices is expected to decrease rapidly as volumes rise. NB-IoT can coexist with 2, 3, 4 and 5G and the technology benefits from the mature security and privacy features of mobile networks.

As the name suggests, NB-IoT employs a very narrow frequency band typically 200-kHz wide. That limits throughput to 60 kbps downlink and 30 kbps uplink. But the technology benefits from greater range and the ability to penetrate far into difficult radio environments compared with alternatives such as LTE-M. And NB-IoT is a good choice for dense deployments with each LTE base station able to support in excess of 100,000 connections.



By the Numbers

in Lapland,
200,000
 reindeer roam across an area of
98,984 km²

Source: Anicare;eastnorth.fi



Power Mad

Every year consumers pay power bills for energy they never use, but smart wireless technology is helping turn the tide on waste

In Short

Roughly a third of energy consumed in U.S. homes is wasted

Wirelessly connected smart home devices can help curb this waste but consumers need to be convinced of their merits

The data generated by smart home devices allows consumers to identify inefficient equipment and energy wasting behavior

AI enables smart energy devices to suggest appliance schedules which reduce energy usage

When the Deepwater Horizon drilling rig started spewing crude oil into the Gulf of Mexico following a catastrophic explosion at the BP operated platform in April 2010, the world looked on in horror as an appalling environmental disaster unfolded. By the time the leak was finally contained 87 days later, the U.S. government estimated more than 4.9 million barrels—or 795 million liters—of oil had been spilled into the sea.

The environmental cost remains incalculable, but the energy cost of the spill, according to U.S. utility service provider, EnergySavvy, was, in relative terms, a drop in the ocean. To put it in context, the company said the energy contained in the biggest oil spill in U.S. history was roughly equal to the energy that just 75,000 American homes—or 0.05 percent of the estimated 127 million households in the country—waste in a single year. Echoing this finding, the U.S. Energy Administration, in 2014, the latest year for which data is available, reported that roughly a third of all energy consumed in U.S. homes was wasted.

Extrapolate the numbers out globally and the problem of lights left on, incandescent bulb use, appliances and electronic devices needlessly drawing power, and inefficiently heating and cooling our homes, to name but a

few culprits, is put into sharp focus. At our current trajectory, according to the World Coal Association, coal deposits have 150 years to run. Oil, BP itself claims, will be exhausted in about 47 years. Natural gas has larger reserves, enough to last for another couple of hundred years. But one day all fossil fuels will be depleted.

New technology, in the shape of renewable energy and energy-saving devices promises to delay that day. However, that promise will only be realized if catalyzed by a fundamental change in consumer behavior.

ACCELERATING CONSUMER ADOPTION

According to Jen King, a Senior Research Analyst at the American Council for an Energy-Efficient Economy's (ACEEE) Buildings Program, technology is moving faster than consumer mindsets when it comes to adopting energy-saving smart home solutions. "People have been slow to adopt smart home technologies for several reasons," King said in the ACEEE report *Energy Impacts of Smart Home Technologies*. "Some are just not aware of them. Even if they are, they may never have used these technologies and may view them as too complex or expensive ... current adopters tend to be tech-savvy, upper-middle-income households.

To realize the full potential of smart technologies, consumer acceptance must evolve beyond early adopters and reach the broader population."

It's a view backed by recent research from analyst, Parks Associates. "Roughly 46 percent of U.S. broadband households currently have no intention to purchase any smart home devices," says Patrice Samuels, Senior Analyst, Parks Associates. "Delivering on the promise of saving money is among the key factors that will drive purchase intentions among these consumers." To prove the point, the company said of those who had invested in smart energy-saving devices, 70 percent believed the technology had helped them reduce energy consumption.

If it's a case then of seeing is believing, then smart energy device manufacturers will need to tap into the drivers of consumer demand for this technology, foster up-take, and enable households to see the benefits for themselves through the reduction in energy use and in turn the cost savings that come with it. "The true potential for energy savings in the smart home lies in reducing energy consumption through better management," King said in the ACEEE report. "And better management lies in optimizing our home's energy-consuming systems. We can align their

operation to our preferences and reduce unnecessary energy use. Smart technologies can yield higher overall efficiency through better controls, communication, and response ... in short, smart technologies that target major end uses can change the picture of household energy consumption."

However, smart homes are less about individual devices than about their interaction with one another. "The key to the smart home is connectivity," King said. "Wireless protocols—Wi-Fi, Bluetooth, Zigbee, Z-Wave, Thread, and others—allow smart devices to share their status and data with one another."

THE POWER OF CONNECTIVITY

Which wireless protocol will come to dominate the smart home space for energy-saving devices is unclear; each option has inherent advantages as well as drawbacks. Wi-Fi is popular because it is already widely available in almost every home in the developed world, offers good data throughput and reasonable range, but it is power hungry. Bluetooth LE's enormous advantage is its presence in smartphones as well as its ultra low power consumption. While range was Bluetooth LE's Achilles heel, the arrival of Bluetooth 5 and the extended range that came with it has gone some way to addressing the issue. Zigbee is well established and effective particularly for mesh applications, but requires a gateway and offers limited throughput. Thread has been developed specifically for the smart home and is simple to install, secure, and scalable, but like Zigbee is not present in smartphones. Cellular solutions meanwhile offer range aplenty, but come with a higher price tag and a relatively higher power requirement.

"What is the perfect connectivity option? The answer is simple – it depends," says Eirik Midttun, Technical Product Manager at Nordic Semiconductor. "The ideal choice would consume low power, have long range capability, and high bandwidth capability. Unfortunately that doesn't exist in one solution. It's unlikely one low power wireless protocol will win out." And other than to chipmakers and developers, it hardly matters; the issue of wasted energy in the home is protocol-agnostic. But connectivity of some form is key.

Smart thermostats, smart lighting, smart meters, and any other smart power-saving device for the home rely on wireless connectivity to not only communicate with one another, but also to proactively communicate with the



To realize the full potential of smart technologies, consumer acceptance must evolve beyond early adopters and reach the broader population

By the Numbers

Each year in the US,
\$350bn
 is spent on electricity and
\$260bn
 of it is wasted

Source: EnvironmentalDefenseFund



Currant's Smart Outlet turns any wall socket into an energy consumption monitor

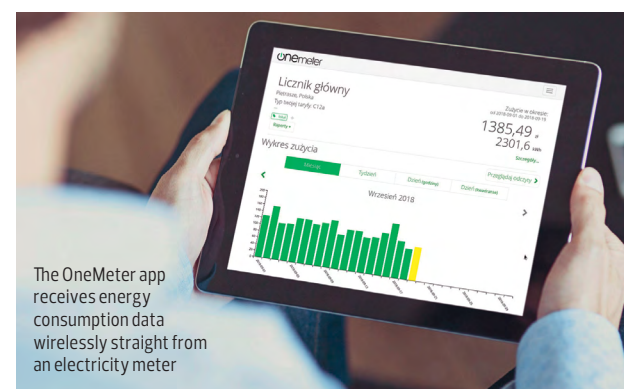
"Devices with analytic capability generate copious amounts of data that can provide insight into a home's activities," said King. "These data create new opportunities and mechanisms for identifying equipment inefficiencies and energy wasting behaviors. Third-party solution providers have entered the smart home space to make sense of the data and engage residents in their energy use."

The data holds value to utility providers who can use the information to engage in demand response programs; in effect a technology enabled economic rationing system for electric power supply wherein consumers are incentivized for allowing the utility company to automatically reduce their energy use during peak times of the day. For example, for consumers that have opted-in, on a particularly hot summer's day, during peak load, the utility could remotely turn off a customer's AC unit, or raise the temperature setting on their smart thermostat.

POWER TO THE PEOPLE

An example of a third party solution providers. In the smart home space is Currant, a California based company, which last year released its [WiFi Smart Outlet](#). The device is a Bluetooth LE and Wi-Fi connected product which employs AI to enable users to monitor and manage their power usage, reduce energy consumption, and cut electricity costs. Any household appliance can be plugged into the device and once paired with a smartphone or tablet the product enables the user to review their energy consumption by appliance, as well as create customized rules to manage their energy usage. The Nordic SoC-powered device uses AI to recognize patterns in energy usage and suggest changes to cut down consumption. Once the device has been in operation for a week it will learn the user's schedule, the devices that are plugged in, and the associated energy usage. Using this information—and data gathered from thousands of other devices—the partner app will recommend a schedule for appliance use to minimize energy consumption. The user has ultimate control over the schedule, which in turn enables Currant's proprietary algorithm to continue to learn and improve.

"Some smart outlets have rudimentary energy monitoring, but none use AI to suggest schedules based on energy usage," says Hasty Granbery, the CEO of Currant. "There are



The OneMeter app receives energy consumption data wirelessly straight from an electricity meter

“ “ The examples of smart energy saving devices are numerous, but the principle in every case remains the same – knowledge is power

some basic handheld energy monitors that show real-time usage but don't aggregate data over time, and there are whole house monitors that have trouble identifying specific devices, especially those that draw a small amount of idle power. [This is] the first AI-powered smart outlet to help people take control of their homes, and their energy bills."

Another company working hard to curb power waste is Polish IoT startup, OneMeter, which recently released its [OneMeter Beacon](#), a device that also allows users to monitor and manage their energy usage. While currently designed for use in industrial and commercial environments, the company is looking at the domestic market and integration via Amazon Alexa, Google Home, as well as Apple HomeKit. The OneMeter Beacon is plugged in to an existing electronic electricity meter via an optical port interface, enabling the beacon to receive energy usage data from the meter using the IEC 62056-21/IEC 1107 protocol. Once installed, the beacon is paired to a smartphone or tablet using Nordic Bluetooth LE wireless connectivity, and allows the user to review the data including active and reactive energy consumption parameters, as well as daily, weekly, and monthly energy usage charts. From the accompanying OneMeter Cloud platform a company can not only monitor its metering data, but also perform accurate energy usage cost estimation, conduct effective energy audits, avoid penalties for exceeding contracted power by defining power parameter alerts, as well as manage its photovoltaic infrastructure. Certified measurement data can be shared with energy vendors enabling invoices to be settled based on actual usage instead of forecasts.

The examples of wirelessly connected smart energy saving devices are numerous and varied, but the principle in every case remains the same – knowledge is power. If technology can tell us as it happens that we are wasting energy or can save money, then it's a technology with a huge future. As Currant CEO Granbery puts it: "Our target market is anyone who cares about reducing their energy usage, either for environmental reasons or cost-savings." In other words, every single one of us.

Need to Know

The smart home market was valued at \$76 billion in 2018 and is forecast to reach \$151 billion by 2024 according to B2B research company, MarketsandMarkets. The analyst said the increasing cost of electricity is a major concern for household consumers and was driving households towards investing in smart home appliances in an effort to make energy savings. The firm added that smart meters and lighting controls were in particular expected to see significant growth over the forecast period



Domestic energy saving is made easy by a smartphone app and wireless connectivity

How solid are the smart home's foundations?

Many [1960s visions of the smart home](#) of the future focused on robots and other labor saving devices, and while certain prophecies were wide of the mark, others were eerily accurate. Intelligent lighting, robotic vacuums, and smart blinds were all dreamt up in Hollywood long before the technology to make it a reality arrived. Sci-fi writer Arthur C. Clarke was also on the money when he predicted in 1964 that wireless tech would allow us to be in instant contact with each other, wherever we may be. He did however caution that "predicting the future is a discouraging, hazardous occupation", and as such forecasting where today's [smart home tech](#) will be in 10 years, let alone 50, is a risky game. Is the smart home going to work, is it a gimmick, will it deliver the promised savings in money, time, energy?

First the good news. At face value consumers appear enthusiastic about the potential of smart home technology, more so than they are about other technologies including wearables, the Cloud, or 3D printing for example, at least according to research from analyst GfK. Gartner concurs, predicting the average home will feature 500 smart connected home devices by 2022, while a report by the *Singapore Business Review* claims Asia's smart home market is expected to reach \$115 billion by 2030. These are big numbers, and developers have not been slow to react to anticipated demand. However, at present, the smart home is more potential than mainstream success. By far the most common smart device found in homes—aside from the smartphone itself—is a smart TV, which is hardly the grand vision of a fully networked home comprising appliances, lights, security, and HVAC solutions that the technology is capable of.

Up-front purchase cost, perceived complexity, security fears, and a lack of interoperability between devices are the key barriers to adoption, and the grayer the age bracket of consumer, the more pronounced those barriers are. That is where developers must focus their attention if the predictions for the smart home are to bear out. The foundations of the smart home are solid though, and as consumers become more familiar with the technologies, and satisfied they can deliver not just comfort and convenience, but energy and money savings as well, then uptake will follow. The technology is clever, the price barrier will come down, and the population will increasingly become tech native. The smart home of the future is just around the corner.



Faster Food

Quick service restaurants face a cut throat battle for business. Wireless tech is aiding customer retention by enhancing the consumer experience

Ever since the McDonald brothers, Maurice and Richard, opened their first restaurant in San Bernardino, CA, in 1948, the fast food business has made its money by offering low price products in high volumes. The brothers pioneered the technique by rationalizing their restaurant menu to relatively few simple-to-prepare items such that the customer's order was delivered in a matter of minutes.

A basic hamburger cost about half the price charged by competing restaurants and the self-service counter eliminated the need for waiters and waitresses. Food was delivered quickly because the burgers were cooked ahead of time, wrapped, and kept warm under heat lamps.

The model attracted the attention of appliance salesman, Ray Kroc, who was intrigued by McDonald's need for eight malt and shake mixers. Kroc visited the shop and saw it was shifting so many milk shakes because of the rapid customer turnover. He offered to extend the McDonald's model through a franchise program, bought out the brothers in 1961, and had opened 1,000 restaurants before the end of the decade. Today, McDonald's has 38,000 outlets in 100 countries, serves 69 million customers a day, and generated \$37 billion in the U.S. alone in 2017.

But the company also faces tough competition. Rivals, including Yum! Brands (owners of KFC and Pizza Hut), Burger King and Starbucks fight to carve up an industry which, according to analyst, IBISWorld, is worth \$856 billion per year. And the key to keeping prices down and moving lots of products remains efficiency; every aspect of the business, from raw ingredient ordering through preparation, cooking, customer interaction, packing, and delivery has been finely honed.

But now a new trend is rising—summed up by the sector's official classification of "Quick Service Restaurants" (QSR)—driven by the belief that it's not just rapid food delivery that's important, rather the entire customer experience. And that new trend is being driven by the IoT.

Today's connected consumers are used to instant gratification. That means any sector billing itself as "quick" needs to be, and more. Where a few decades ago a ten-



A new trend is rising, driven by the belief is that it's not just rapid food delivery that's important, rather the entire customer experience

minute wait might trigger mild annoyance, today it prompts a move to the competitor down the street. And that could well be the competitor that's striving to implement exactly the kind of user experience that builds long term loyalty.

CREATE YOUR OWN

Starbucks is one firm doing just this. The company's embrace of technology allows consumers to use their smartphone to identify the Starbucks outlet closest to their location and pay for their order in advance. The order will then be ready and waiting at the store. Elsewhere, Starbucks has connected its coffee makers, fridges, cold storage systems and lighting to the IoT. Such systems allow baristas to find out in advance, for example, when the products in a fridge are going to be out of date, or when coffee machines will need cleaning.

Next up is the hyper-personalized ordering system. Customers can create their own meal, choosing individual ingredients to get just the right balance of proteins,

carbohydrates, fats and overall energy. The flexibility endowed on the restaurant's processes by the IoT enables the outlet to order and stock the ingredients that meet current demand and then prepare and cook the personalized order without slowing down delivery.

Other leading QSRs have been just as quick as Starbucks in seizing the opportunity afforded by wireless connectivity. For example, according to QSR magazine, a leading trade industry journal, key among McDonald's core objectives is "exploring new technology and its effect on how customers experience the brand".

CUSTOMER ENGAGEMENT

Typical of the new breed of companies bringing such technology to the QSR sector is Radius Networks. The company builds a platform that uses machine learning to help companies conduct location based transactions with their customers, including table service and curbside pickup. The wireless location based platform allows a customer to place a food order via a mobile app or in-store, and relays their exact location to the restaurant for order delivery.

Introducing a robust, flexible and scalable wireless network into a crowded restaurant is no mean feat as it must compete with a barrage of interference from Wi-Fi and smartphone Bluetooth transmissions. However, Radius Networks turned to low power wireless system integrator Rigado to solve the engineering challenges. The company specializes in commercial Bluetooth LE solutions built on Nordic Semiconductor's nRF52 Series [Bluetooth 5 SoCs](#).

"Using a standard protocol such as Bluetooth makes things less complex, which makes it easier to install and run apps," Kevin Tate, Chief Revenue Officer with Rigado told *asmag*.

com. "We're trying to make it so that customers only have to worry about the data and what to do with it, and we'll take care of getting that data to them."

To meet the specific needs of the Radius Networks project, Rigado used its [Bluetooth gateways](#)—which support multiple IoT applications and are capable of over-the-air updates as new use cases arise—typically four to five per retail location, to deliver wireless sensor and device data to the Radius Networks location engine and platform.

Customer location and order details, and other incoming data, trigger real time notifications for restaurant staff. Staff in turn use a tablet running the Radius Networks dashboard to identify customer location for order delivery. Other data integration introduces capabilities in areas such as in-store and curbside pickup, asset tracking, and pay-at-table functionality.

Early results after installing the systems are impressive, with an average decrease of 50 percent in customer problems, complaints and incorrect orders. Meanwhile, overall customer satisfaction—the name of the game—has increased by 20 percent, the amount spent on each order has gone up by about 15 percent, while overall guest count has risen by 4 percent.

More than seven decades since the McDonald brothers came up with their formula for fast food, the same basic principles still apply. Combining those principles with modern commerce techniques has allowed the QSR sector to become almost ubiquitous across most of the globe, and it looks set to become a trillion-dollar industry in the not-too-distant future. And now wireless connectivity is poised to supercharge fast food restaurant efficiency while at the same time bringing greater convenience, comfort and choice to hungry consumers.



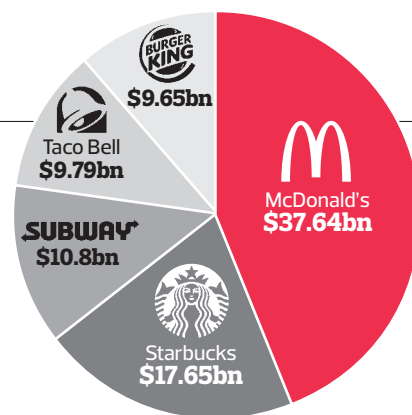
Tech Check

Rigado's Cascade edge data network is a device-to-cloud solution for reducing cost and risk of commercial IoT in the QSR sector and elsewhere. The product includes Rigado's Cascade Gateways with Nordic nRF52 based [modules](#), secure edge computing and cloud integration, and a service for managing large-scale installations

State of Play

Top five QSRs by U.S. revenue

The fast food business was worth \$199 billion in the U.S. alone in 2018 and is set to exceed \$223 billion next year. In 2016, there were 186,977 QSRs in the U.S., up by 28,000 from a decade ago. 20 percent of Americans dine at a QSR once per week and 79 percent have visited a McDonald's in the last year



Wearables

ATMOS Mission One Dive Watch

This Bluetooth LE diving watch records detailed dive information and wirelessly transmits sensor data to a user's smartphone app to enhance the underwater swim experience

The worldwide market for wearables grew more than 31 percent during the fourth quarter of 2018, reaching a new high of 59.3 million units according to analyst International Data Corporation (IDC). Wrist worn devices, including those for sports and fitness activities, accounted for more than 64 percent of total shipments

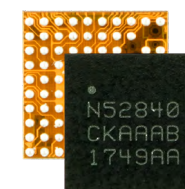


The record for the deepest ever SCUBA dive was set by Egyptian Army special forces officer Ahmed Gabr in 2014. Gabr descended 332 meters in the Red Sea off the coast of Egypt. The pressure at that depth is 32 times that on the surface, so while it took 12 minutes for Gabr to reach maximum depth, it required nearly 15 hours for him to resurface to ensure safe decompression

SCUBA divers can hear better and at a greater distance underwater than they can on land, as sound travels at 1480 meters per second in water, more than four times faster than it does in the air. However, underwater, divers can't determine the direction of sound due to the high speed that sound travels. When underwater, to the human ear all sound appears to come from overhead

The Mission One dive watch features a digital compass, gyroscope, accelerometer, thermometer, barometric altimeter, depth sensor, and GPS, allowing the watch to precisely track and calculate decompression, as well as record specific dive information. The watch also integrates a haptic vibration motor, enabling the user to receive vibration alarms for ascent and descent rates

While French seaman Jacques Cousteau is credited with the 1943 invention of the first Self Contained Underwater Breathing Apparatus (SCUBA)—a device he dubbed the 'aqualung'—records suggest Italian polymath Leonardo da Vinci sketched such equipment 450 years earlier. Da Vinci's device was designed to enable sneak attacks on enemy ships around Venice



Tech Check

The ATMOS Mission One dive watch employs Nordic's nRF52840 Bluetooth 5/Bluetooth LE advanced multiprotocol SoC to act as the main control chip, as well as provide the device with Bluetooth LE connectivity. The SoC's powerful 64MHz, 32-bit Arm Cortex M4F processor provides ample computational power to run the watch's complex sensor algorithms

Sports and Fitness

Smart ski boot 'digital coach' improves skiing technique

Through Bluetooth LE connectivity and Atomic's Hawx Connected ski boot platform, skiers can track their own performance metrics and make improvements on the slopes

As inevitable as an avid skier hitting the slopes the moment conditions become favorable, so too has a market emerged for connected ski gear and skiing performance analysis platforms built on low power wireless technology. Runners wirelessly monitor their performance metrics, cyclists do likewise, so why shouldn't skiers do the same?

Among the innovative companies leading the race to develop the most advanced solutions for the global winter sports enthusiast community is Atomic, an Austrian ski equipment manufacturer that's been at the forefront of the industry for over six decades. With a goal to revolutionize skiers' ability to track and review their own skills and techniques, Atomic—in conjunction with biomechanics experts from Salzburg University and Salzburg Research—has developed [Hawx Connected](#), a Bluetooth LE ski boot. The boot is complemented by an iOS or Android compatible smartphone app designed to deliver direct, onslope sensory feedback to enhance the overall skiing experience. The platform effectively acts as a skier's 'digital coach' and training log, not only providing real time analysis of each individual ski run but also archiving results from a full season of skiing and setting targets for improvement.

Hawx Connected is based on sister company [Suunto's 'Movesense' platform](#), an open environment for developers of wireless motion sensing solutions incorporating a nine-axis Inertial Measurement Unit (IMU). The smart ski boot features eight embedded force sensors that measure pressure at key contact points inside the boot liner, while the IMU's built-in accelerometer and gyroscope simultaneously detect turns and ski edge angles through the orientation of the boot.

Immediately following either a single run or full session on the mountain, the skier can use their smartphone to access the Atomic CTD app, which via Bluetooth LE connectivity retrieves the performance metrics gathered by the ski boot's various force and motion sensors.

The metrics allow the user to instantly view comprehensive information about their skiing performance and technique including balance and edging, turn count, run count, average speed, top speed, slope angle, total distance, total vertical distance, G-force, and more. Over time, the on-demand notifications and readily available performance reviews help the user improve their overall technique for "smarter, safer, and stronger skiing" claim the developers. In addition, the app makes it easy for skiers to set personal goals, challenge fellow skiers from the same ski resort and right around the world and even compare their own performance data against professional athletes.

"The Hawx Connected platform allows the skier to know



precisely how to adjust their skiing technique for higher performance by refining their balance, pressure control, and edging skills," says Jussi Kaasinen, General Manager of the Emerging Businesses Unit at Suunto. "The ski boot transmits its Movesense data seamlessly via Bluetooth LE to the Atomic CTD app through the user's smartphone, and this data can be reviewed instantly on the intuitive skier's dashboard in the app and used to aid learning on the run as well as long-term development of skiing technique."

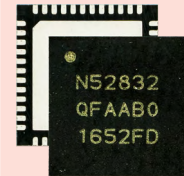
The 'brain' of the ski boot

The Hawx Connected relies on Nordic's tiny [nRF52832](#) Wafer Level Chip Scale Package (WL-CSP) SoC for its Bluetooth LE wireless connectivity. The SoC's powerful 64MHz, 32-bit Arm Cortex M4F processor also functions as the main microcontroller for the ski boot, providing ample computational capacity to run the complex sensor algorithms.

"The availability of the nRF52832 SoC in a WL-CSP was hugely important for us due to the size constraints we were facing," explains Kaasinen. "On the other hand, the Arm M4F processor is essential for running our cutting edge signal processing algorithms. Nordic's nRF52832

Tech Check

Nordic's nRF52832 WL-CSP SoC measures just 3.0 by 3.2mm while offering all the features of the conventionally-packaged chip, including the 2.4GHz radio's 5.5mA peak RX/TX currents and a fully-automatic power management system that reduces power consumption by up to 80 percent compared with Nordic's nRF51 Series SoCs



The Hawx Connected platform allows the skier to know precisely how to adjust their skiing technique for higher performance by refining their balance, pressure control, and edging skills

SoC is the 'brain' of the implementation. The SoC handles the Bluetooth LE protocol stack, the Movesense platform operations, and the highly application specific tasks related to the skiing use case."

The Hawx Connected ski boot employs a Li-Poly battery that provides up to 4.5 days of operation in typical usage between recharge, thanks in part to the ultra low power consumption of the nRF52832 SoC. Extended battery life of this kind makes the product even more valuable for highly active skiers as they don't need to worry about the ski boot losing power, and therefore performance data, during long days on the ski fields.

Looking ahead, Atomic has begun to shift its product development focus increasingly towards solutions that go beyond the scope of traditional ski equipment. "We have a long and proud history of making the best race skis in the world," the company explains. "In the spirit of being the best we are aiming for more. And to do that, we have changed our focus—from the skis, to the skier. We have gone from being a ski equipment manufacturer to a skiing experience provider."

Would this vision for a connected skiing community be achievable without the low latency wearable-to-smartphone connectivity made possible by low power Bluetooth LE technology? As the contemporary skier would agree, not a snowball's chance in hell.



Nordic People

Old-school gamer helps develop modern products

Hi, I'm Karl Helmer Torvmark and I'm a Technical Product Manager based in Oslo, Norway. Before joining Nordic in 2018, I had worked in the electronics industry for almost 19 years. For the majority of that time I worked with wireless ICs in various roles including Field Application Engineer.

My main responsibility at Nordic is to ensure we develop great products. I talk to customers to understand their needs, analyze the information I gather, and together with the R&D team turn it into specifications for future products. Unfortunately, I can't say too much about the project I'm currently working on but I can say there are some really exciting things in progress at Nordic!

The best parts of my job are working with some very smart people, being exposed to new ideas and technology, and seeing what our customers are able to do with the tools we provide. I've really come to love the Nordic company culture—very little bureaucracy, willingness to take risks, a flat company structure, and colleagues being passionate, engaged, and upfront with their views. Decision making seems to be quick and efficient at Nordic. I think these are all key elements to the company's success.

Outside of work, I like to spend time with my family: my wife, my two sons, a dog, and a cat. As a family, we

"The best parts of my job are working with smart people and being exposed to new ideas and technology

enjoy playing board games, watching movies, or just hanging out together. Going for a walk in the woods near my home is a great way to get some exercise, relieve stress, and clear the mind. Over the last few years I've read up on mushrooms, and I enjoy hunting for chanterelles, boletes, and other edible sorts, which I then incorporate into our home cuisine.

I have been homebrewing beer for almost three years now, and I'm especially fond of British bitters and various Belgian types. While the



Profile

Name: Karl Helmer Torvmark

Job Title: Technical Product Manager

Joined Nordic: August, 2018

Based: Oslo, Norway

Interests: Family, homebrewing beer, playing classic videogames, performing on synthesizers and the guitar

brewing process is interesting and enjoyable in itself, as a bonus I usually end up with 20 liters of beer to be shared with friends and family.

I also love collecting and playing retro videogames and arcade games from my childhood in the 1980s. This hobby provides an opportunity to learn about old embedded electronics and brush up on troubleshooting skills. Although my sons play a lot of modern games, they also like to play some of the classics, which I appreciate a lot. A few years back, while working in the Bluetooth SIG, I met one of the people who designed the chips for the Atari 2600 back in the late 1970s. It was really interesting to meet someone who was there when videogames (and indeed computers) were emerging. I've enjoyed playing around with synthesizers since I got my first one at aged 12, and I started learning to play electric guitar a couple of years ago. Making weird noises is lots of fun, but I'm not giving up my day job just yet.

From a work perspective, my main focus is ensuring Nordic has exciting products coming up in the future, which our customers can then use to make some fantastic products for their own customers. It's always very interesting to see how our products are being used, often in ways that we had never even thought of!

[Tech Zone]

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

Industrial Automation

OS maintains robust link in challenging RF environments

Swedish company LumenRadio has released a new version of its [MiraOS](#) embedded operating system (OS), firmware that enhances ultra low power wireless tech's interference immunity while delivering mesh support for networks of up to 5,000 nodes. Such support enables IoT mesh-networked applications to be rapidly deployed and commissioned.

MiraOS is specifically targeted at applications operating in challenging RF environments. The OS includes a 'cognitive' algorithm that builds a millisecond-by-millisecond predictive model of the RF environment to project how the allocated frequency spectrum will be used in the near future. The use model then selects the least

congested frequencies for network devices.

This technology, which the company calls 'Future-Proof Coexistence Connectivity' (FPCC) enables low power wireless networks to adapt as greater use is made of the license free RF spectrum. MiraOS is also suitable for applications where consistent low power consumption is critical, high integrity communication important and large wireless networks are needed.

Nordic's [nRF52840](#) SoC's Arm Cortex M4F processor offers ample computational power to run MiraOS and the company's MiraMesh communication stack, as well as providing Bluetooth and NFC support for commissioning. When running on the Nordic SoC, MiraOS enables concurrent



communication through LumenRadio's MiraMesh networking stack and Nordic's Bluetooth protocol stack.

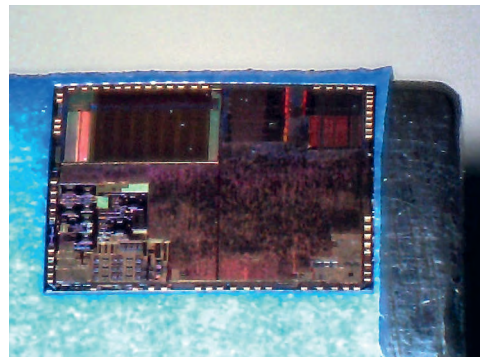
"For low power applications, it's critical RF spectrum is used efficiently, to ensure energy is not wasted on retransmissions," says Michael Karlsson, R&D Manager at LumenRadio. "Collaborating with Nordic has allowed us to bring the benefits of cognitive coexistence to large wireless networks."

Flexible IC offers Bluetooth LE in world's thinnest form factor

American Semiconductor has launched a flexible IC that supports Bluetooth LE connectivity, in what the company claims is the world's thinnest and smallest Chip Scale Package (CSP).

The AS_NRF51 Flex-BLE is an ultra-thin version of Nordic's [nRF51822](#) SoC wafer-level CSP, employing American Semiconductor's 'Flex Semiconductor-on-Polymer' (Flex SoP) process to reduce package size to approximately 35µm - half the thickness of a human hair. Front and backside polyimides from HD Microsystems provides mechanical strength to allow the IC to bend without breaking.

The result is an IC with a robust, thin, and physically flexible form factor designed for solutions that demand ultra thinness, physical flexibility, and high reliability in applications ranging from wearables and logistics, through to the IoT.



"We were looking for an advanced Bluetooth Low Energy solution that was rich in features and available in wafer format for conversion through our Flex SoP process," says Richard Ellinger, VP Sales and Marketing at American Semiconductor. "The nRF51822 SoC's Arm microprocessor, large Flash memory, low power consumption, and excellent 2.4 GHz radio performance made it the ideal choice."

"The availability of an established suite of support software was also essential, as we want our end customers to be able to quickly deploy the products. This chip will allow entry into markets demanding an ultra thin, conformable, and flexible solution."

Dongle delivers M2M IoT product

Taiwan-based Raytac Corporation has released a dongle that once programmed with a developer's application software, provides designers of M2M IoT applications with an precertified and compliant multiprotocol connectivity solution, negating the need for RF design expertise and time consuming development work.

The compact 43.1 by 18 by 9.3mm MDBT50Q-RX dongle, employs Nordic's nRF52840 advanced multiprotocol SoC to provide Bluetooth 5/Bluetooth LE, ANT, Thread, Zigbee, IEEE 802.15.4, and 2.4GHz proprietary wireless connectivity for use in Industrial IoT (IIoT), smart home and smart city sensor mesh networks, as well as in personal area networks (PANs) for health and medical monitoring applications.

Raytac says the dongle offers a working range of up to 250 meters in open space at a data rate of 1Mbps, or up to 120 meters at a data rate of 2Mbps. The dongle also provides GPIO, PWM, and USB interfaces for connecting peripherals and sensors.

Tech Briefing

Why cellular IoT needs eSIMs

eSIMs address the inherent drawbacks of conventional SIM cards and encourage rapid, out-of-the-box scaling of the IoT

A key advantage of cellular IoT is that the infrastructure to support global deployment is already in place. The installed cellular network comprises robust, proven network technology that covers most of the populated regions of the globe.

Because cellular spectrum allocations are licensed and regulated, devices must be identified and authorized before accessing these networks. Most mobiles use a Subscriber Identity Module (SIM) for this purpose. SIMs were originally developed by the European Telecommunications Standards Institute (ETSI) for GSM networks. Today, SIMs are used by almost all mobile devices that connect to LTE (4G) networks.

Future cellular IoT devices will also require identification and authorization, but alternative technology is required because the conventional physical SIM is not a practical solution for billions of remotely deployed devices.

SIMple connection

A SIM securely stores an International Mobile Subscriber Identity (IMSI) number, a 15-digit code uniquely identifying the card (and mobile) on the operator's network. SIMs are typically associated with the company that issued the card and that operator deals with the access request even if the user wants to use a different operator's network in, for example, another country.

When network access is requested, the IMSI and a one-time-use 128-bit authentication key (Ki) are relayed to the network for operator verification; the operator then authorizes the connection.

There are two major disadvantages of this system for cellular IoT deployment. The first occurs because conventional SIMs are discrete cards that plug in to the mobile device; that means they take up space, the mobile device needs a port (increasing costs and providing an ingress for dust and water), and if a SIM upgrade is required each card must be replaced - something that's hardly practical for potentially millions of devices, many of which will be in inaccessible locations.

The second problem arises because of the SIM's association with a single operator: While a SIM covered by a roaming contract can theoretically provide near global coverage by accessing local networks, the actual coverage depends on the number of roaming relationships the "home" operator has negotiated.

It also means paying the high data charges incurred while roaming. Because it stores only a single set of operator credentials, a conventional SIM becomes impractical for a cellular IoT device that is required to operate anywhere in the world. For example, in some regions, permanent roaming authorized by a remote operator is not allowed under local regulations, limiting the cellular IoT device's usefulness.

An embedded SIM (eSIM) overcomes these problems. The device is no longer a separate, relatively large external plug-in; rather, as the name suggests, it comes



in the form of a chip (known as an embedded Universal Integrated Circuit Card (eUICC)) that becomes part of the cellular device's electronic assembly. That means it can be made tiny - an important consideration for compact cellular IoT devices - and removes the cost and vulnerability of an external port. (An eSIM can also be supplied in conventional micro- or nano-SIM card formats allowing use in older devices that feature a port and don't have a built-in eSIM.)

An eSIM holds multiple local network operator credentials (in contrast to a conventional SIM card that can only hold one). An eSIM can also be "remotely provisioned" (reprogrammed over the air). Such capabilities not only allow for future technology enhancements but also repeated updates with profiles suitable for the local network - eliminating the regulatory challenges that come from constant roaming and allowing the connected device to take advantage of local (typically cheaper) data charges.

Network benefits

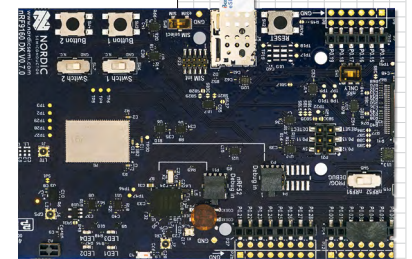
There are advantages for the networks too: Remotely provisioned eSIMs enable mobile operators to seamlessly add cellular IoT devices and apply data charges that would otherwise be directed to the home operator.

Cellular IoT solution providers such as Nordic Semiconductor are embracing eSIMs, and as a result, cellular IoT customers receive global connectivity without the considerable hassle of negotiating and managing relationships with network operators around the world.

Further, eSIMs also ensure local network connectivity out-of-the-box, resulting in operational efficiency and rapidly scalable IoT deployments.



Because it stores only a single set of operator credentials, a conventional SIM becomes impractical for a cellular IoT device that could be used anywhere in the world



Tech Check

Nordic's nRF9160 Development Kit incorporates an eSIM from iBASIS which includes 10 MByte of free data. By registering at Nordic's nRF Connect for Cloud users can connect to iBASIS's network and gain access to configuration, monitoring, and connectivity services

Tech Perspective

Bluetooth 5.1 takes real time location systems to the next level

The latest update to the Bluetooth Core Specification provides access to RF phase data making it easier for developers to build accurate position location applications

While Global Navigation Satellite Services (GNSS) works well outdoors, the loss of satellite signals makes the system unsuitable for indoor position location applications. Engineers are looking to other wireless technologies for an alternative. Bluetooth technology's Received Signal Strength Indication (RSSI) can be used to estimate the distance of a transmitting device from a known fixed point such as a beacon. However, the technique is limited to proximity applications because variable signal attenuation and lack of information about the direction of the signal prevent an accurate positional estimate. This lack of capability limits implementation in applications such as real time location systems (RTLs) and Indoor Positioning Systems (IPS).

The recent introduction of Bluetooth 5.1 Direction Finding offers a basis for centimeter precision positional estimates in two- or three- dimensions by using 'Angle-of-Arrival' (AoA) and 'Angle-of-Departure' (AoD) methods.

Estimating the angles

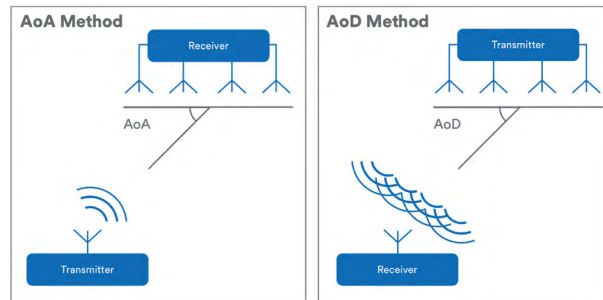
The AoA method forms the foundation of a system for tracking a transmitting Bluetooth LE device. The transmitter sends Bluetooth 5.1-compliant packets using a single antenna which are then received by an antenna array-equipped device locator. As the transmitted signal crosses the array, the receiving device monitors the phase difference at the wavefront caused by the difference in distance from each array antenna to the single transmitting antenna. This data can be used to compute the angle from which the signal comes and hence the direction of the transmitter.

The situation is reversed for the AoD method. In this scenario, the device with the antenna array sends a signal via each of its antennas. As the signal from each antenna in the array arrives in turn at the receiver's single antenna, it is phase shifted from the previous signal due to the different distance it has traveled from the transmitter. The receiving device's antenna monitors this phase difference and then determines the angle from which the signals were received and hence the direction of the transmitter.

Exposing IQ data

Bluetooth 5.1 Direction Finding is far from a complete suite of RTLs firmware, rather it simply makes the protocol's "IQ" signal data (in-phase and quadrature-phase information) easily available to developers via a Bluetooth LE SoC's API.

The IQ signal data is a fundamental requirement for performing RF direction finding. However, to realize a full RTLs implementation requires intensive processing using complex algorithms. It is possible for



The AoA method features a simple mobile transmitter whose signal is monitored by a receiver with an antenna array. The receiver computes the direction from which the signal was sent. The AoD method reverses the roles, with the mobile receiver calculating the direction of a signal sent from the transmitter's antenna array. (Image: Bluetooth SIG)

the ambitious developer to code these algorithms but commercial 'positioning engines' (for example, Quuppa's Intelligent Locating System) are available. And a new generation of these firmware products, adhering to the Bluetooth 5.1 specification, are already in the works. The Bluetooth SIG is also working on its own AoA and AoD direction-finding profiles for early release which could form the basis of future positioning engines.

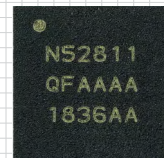
The other area requiring careful consideration from the developer is system hardware. First, the selected Bluetooth LE SoC must of course be Bluetooth 5.1-compliant and it will typically need a powerful onboard processor (paired with ample Flash and RAM) to handle the complex direction finding algorithms. Second, designing an antenna array for 360-degree coverage is not trivial and the inexperienced might prefer a commercial option. Third, Bluetooth LE SoCs typically don't have multiple antenna ports so a peripheral device will be needed to feed the signal from multiple antennas to the SoC's single antenna port.

The AoA system is suited to asset tracking where the transmitter is a mobile item such as a simple, low cost tag, while the receiver is a fixed reference point incorporating the complex hardware and software required to perform the angle calculations.

In the AoD implementation, the (fixed) transmitter requires an antenna array. The (mobile) receiver, while requiring only a single antenna, also needs the hardware and software to perform the angle calculations. In IPS applications the receiver could be a next generation (Bluetooth 5.1) smartphone or wearable.

The Bluetooth SIG says direction finding capability was added in response to market demand for Bluetooth-based location services solutions. By adding direction finding, Bluetooth positioning systems can improve location accuracy down to the centimeter level. The SIG is bullish about the future, predicting annual shipments of over 400 million Bluetooth 5.1 products by 2022.

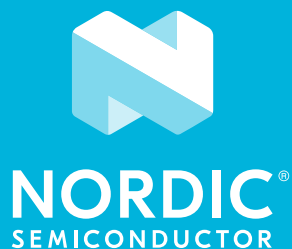
Bluetooth 5.1 Direction Finding offers a basis for centimeter precision positional estimates in two- or three- dimensions



Tech Check

Nordic's nRF52811 is one of the first Bluetooth 5.1-compatible commercial solutions and incorporates a powerful 64MHz, 32-bit Arm M4 processor which provides ample overhead for supervising both the Bluetooth RF protocol software and the RF profile positioning engine firmware

Product Guide	nRF 52 SERIES				nRF 51 SERIES				
	nRF9160	nRF52840	nRF52832	nRF52811	nRF52810	nRF51822	nRF51422	nRF51824	
ICS	LTE: 1,2,3,4,5,8,9,12,13,17,18,19,20,26,28	2.4GHz	2.4GHz	2.4GHz	2.4GHz	2.4GHz	2.4GHz	2.4GHz	
OPERATING BAND									
WIRELESS PROTOCOL	BLUETOOTH 5.1								
	BLUETOOTH 5								
	BLUETOOTH LOW ENERGY								
	ANT								
	THREAD								
	ZIGBEE								
	802.15.4								
	2.4GHZ PROPRIETARY								
	LTE-M								
	NB-IOT								
GPS									
SYSTEM-ON-CHIP									
SYSTEM-IN-PACKAGE									
ON-CHIP	CPU	Arm Cortex-M33	Arm Cortex-M4	Arm Cortex-M4	Arm Cortex-M4	Arm Cortex-M4	Arm Cortex-M0	Arm Cortex-M0	
	LTE MODEM								
	FPU								
	DSP								
	ARM TRUSTZONE								
	MEMORY	1MB Flash 256kB RAM	1MB Flash 256kB RAM	512kB or 256kB Flash 64kB or 32kB RAM	192kB Flash 24kB RAM	192kB Flash 24kB RAM	128kB or 256kB Flash 32kB or 16kB RAM	128kB or 256kB Flash 32kB or 16kB RAM	256kB Flash 16kB RAM
	MPU								
	PA								
	ON-CHIP BALUN								
	CLOCKS	64MHz / 32kHz	64MHz / 32kHz	64MHz / 32kHz	64MHz / 32kHz	64MHz / 32kHz	16MHz / 32kHz	16MHz / 32kHz	16MHz / 32kHz
PERIPHERALS	GPS								
	NFC-A TAG								
	2-WIRE								
	ADC								
	AES								
	ANALOG COMPARATOR								
	I2S								
	PDM								
	PWM								
	REAL TIME CLOCK								
	ARM CRYPTOCELL								
	TRNG								
	SPI								
	QSPI								
	TEMPERATURE SENSOR								
	UART								
	USB								
	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	
WLCSP									



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