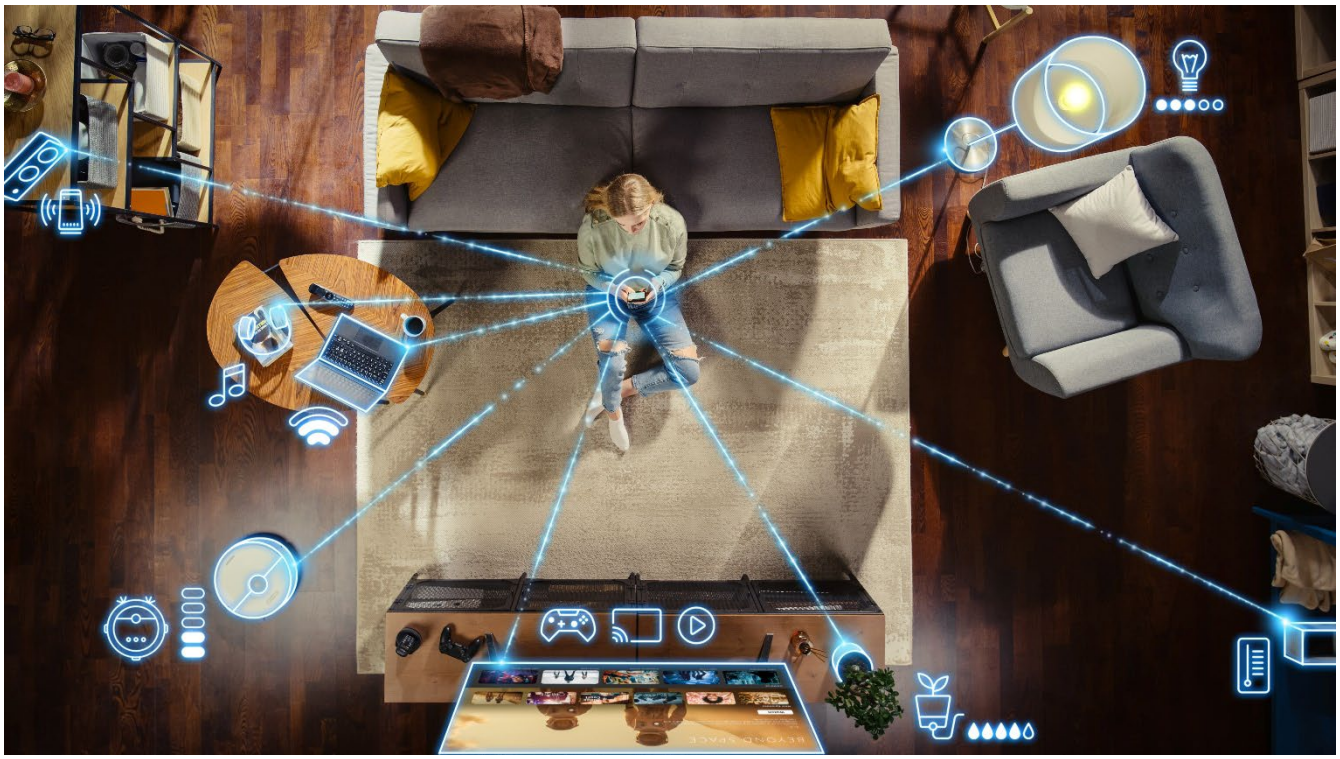
Simplifying the Connected Future: Navigating Complexity in the IoT Landscape with Renesas Wireless Connectivity

Mehmet Aras, Netherlands, November 2023



Abstract

Smart home devices, appliances, ear buds, personal medical devices, smart energy meters, POS machines, asset, and fitness trackers, … Whatever device you can think of that makes our lives more convenient, safer and more enjoyable, in today's world it's likely to be connected, often wirelessly.

Almost everywhere, connectivity is no longer an extra, it's expected. And expectations are growing – that wireless is ubiquitous, that devices interoperate seamlessly, that set-up is simple, that performance is reliable and robust, and that security is there where it's needed.

The opportunities are huge – by 2028, the volume of the global Internet of Things (IoT) market could be worth 2,3 trillion USD[1]. Yet as IoT expands into every aspect of life, so does complexity.

[1] https://www.statista.com/outlook/tmo/internet-of-things/worldwide

The challenge now is to reduce that complexity, including through wireless technology solutions that make life easier for everyone: from device manufacturers and developers to the end user who wants products to work with no fuss straight from the box.

In this White Paper, we outline why complexity is a growing issue and how it can be addressed. We also give an overview of the market leading Renesas portfolio which makes life easier for developers designing for wireless connectivity for IoT.

Connecting a world of devices – Growing complexity

For billions of IoT devices Bluetooth® / Bluetooth® Low Energy, Wi-Fi or NFC (Near Field Communication) will be the wireless technology of choice. Each technology provides specific benefits to support a vast array of use cases and performance requirements.

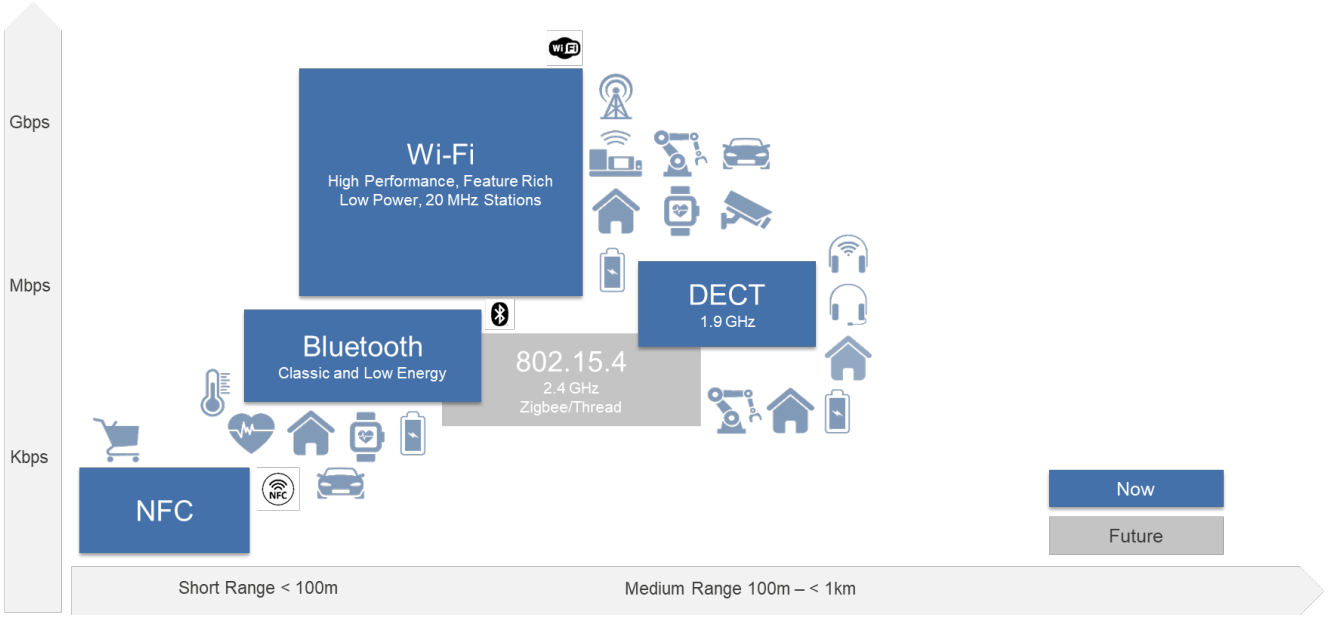


Figure 1: Wireless connectivity technologies and IoT applications

But the complexity of interconnecting billions of devices seamlessly and securely creates multiple challenges:

- **Interoperability:** designing for a market where multiple standards and protocols are in use.
- **Performance:** delivering, for example, high processing and data capacity with very low power.
- **Scalability:** maintaining large scale networks with optimal performance as billions of devices get connected.
- **Energy efficiency:** minimizing energy use and maximizing battery life for battery powered IoT devices communicating over wireless networks.
- **Security:** protecting privacy and preventing attacks and data breaches for all types of data and network.

In this complex space, semiconductor solutions clearly need to span a range of ecosystems, standards and protocols. However, diversity must be balanced with **interoperability**. Because without interoperability,

end-users lose the promised convenience and ease of IoT connectivity. They end up struggling with incompatible devices or complicated onboarding, and network communication that is far from seamless and robust. New connectivity solutions need to assure interoperability with each other but also with the installed base which create further challenges. That's why standards and protocols like Matter, Thread, ZigBee and Bluetooth Low Energy are looking for ways to make interoperability easier.

Performance is equally vital. IoT use cases make tough demands on solutions. Battery operated smart home devices and wearables typically need to deliver ultra-low power at a highly competitive cost. Bluetooth or NFC solutions for electric vehicle battery monitoring need to be automotive qualified to fulfil performance expectations. Gaming, streaming, smart home and connected health applications call for high processing capacity and better user experience. And end-to-end security is vital for in-hospital patient monitoring, … The list of application requirements is long and growing.

Moreover, performance is the key to scalability and energy efficiency. In increasingly crowded IoT networks, solutions must deliver high performance in range, power usage and listen/receive sensitivity to maintain robust communication and long battery life.

Security is often seen as weakness in IoT. Weak authentication, unencrypted data, software vulnerability, insecure protocols and a lack of standardization can lead to data breaches, unauthorized access, and malign attacks. Wireless solutions (and the microcontrollers/microprocessor they attach to) need to offer the right level for each application. This can range from basic for many smart home devices, to end-to-end security in safety critical applications like smart metering and automotive.

Meeting the challenges: infinite possibilities, unmatched performance

Providing solutions to these challenges is part of the Renesas commitment to making life easier for device developers and manufacturers. We bring know-how as a world leader in microcontrollers (MCUs) and (MPUs) combined with 27 years of experience in wireless solutions. And over the last decade, we have enriched our in-house wireless portfolio through acquisitions of specialist market leaders to create a comprehensive product offering.

This combined experience enables us to develop solutions with a clear understanding of embedded systems and how connectivity solutions 'attach' and interface to IoT applications. Our Bluetooth Low Energy, Wi-Fi and NFC solutions are designed to work seamlessly with our entire range of MCUs and MPUs, as well as with third-party embedded controllers / processors. We also offer combined Bluetooth Low Energy/Wi-Fi solutions (increasingly important in meeting the trend towards Bluetooth onboarding and provisioning in Wi-Fi based IoT networks).

In addition, our 'Winning Combinations' bring together devices from across our embedded processing, power, analog, and connectivity portfolios. They provide complete engineering-vetted reference designs that accelerate product development and lower overall risk.

Performance, interoperability, and security

Performance is crucial to meeting IoT challenges. But not every application requires the same kind of performance. In high volume applications cost-effectiveness may be the key consideration; in others such in industrial settings, high speed processing or end-to-end security may be critical. For Renesas, the priority is high performance tailored to diverse needs. In both Bluetooth and Wi-Fi In both Bluetooth and

WiFi we deliver the absolute lowest system power consumption. This creates new opportunities to bring wireless connectivity to battery operated applications like smart door locks and in NFC, best-in-class total solutions for Point of Sale (PoS), access control and wireless charging applications.

To address the industry-wide challenge of interoperability, Renesas is active in the Connectivity Standards Alliance (CSA) and the development of Matter. Matter is a single unified IP-based protocol that enables smart devices to connect with each other, regardless of brand, and across smart home ecosystems – a ground-breaking step towards making life easier for end-users.

Renesas is committed to Matter-compliance across all our current and future Bluetooth and Wi-Fi products. Our Matter connectivity products will also feature industry-leading security protocols, including the latest hardware encryption engine and authentication standards.

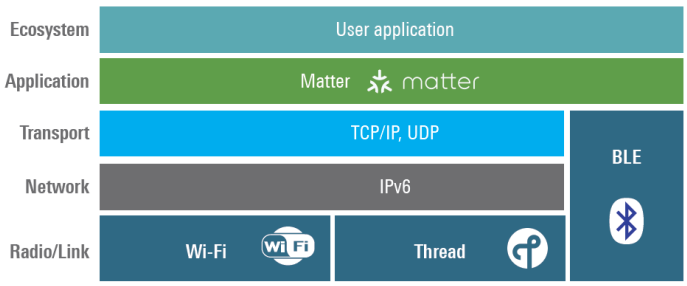


Figure 2: Matter architecture

As Matter is an application layer solution it can be implemented over all key wireless technologies including Wi-Fi, Bluetooth Low Energy, ZigBee and Thread. Plus, as data from devices can stay within the home network, Matter can help improve latency, security and response times, and ensure continuous operation even if internet connection to the cloud is interrupted.

Time to market

Meeting the challenges of IoT also means ensuring fast time to market. Here, Renesas' strength in MCUs/MPUs enables us to offer complete solutions that simplify integration of wireless connectivity and networking stacks. These solutions are backed by a mature ecosystem of software and hardware tools including the Renesas Quick-Connect IoT Platform for rapid evaluation, design and production ramp-up. They are also complemented by a growing library of complete reference designs (our Winning Combinations) and support from the Renesas Engineering Community.

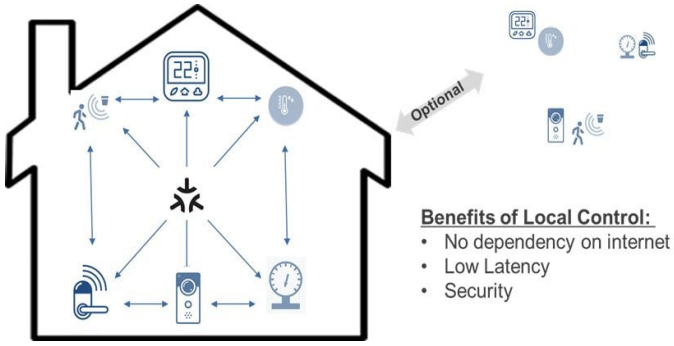


Figure 3: Matter in a smart home

Renesas: a portfolio for easier wireless connectivity

Making Bluetooth ubiquitous

Shipments of Bluetooth products are expected to reach 7.6 billion by 2027[2], backed-up by a vibrant standards body, the Bluetooth SIG, and an ambitious roadmap promising to enable many new applications. Recent announcements such as Auracast™, enabling audio transmission over Bluetooth Low Energy to power novel applications such as audio broadcasting and sharing or the Periodic Advertisement with Response leading to Bluetooth-powered Electronic Shelf Labels (ESL) to improve retail operations and customer experiences are just some examples of how this low power technology is evolving to reach these numbers. Bluetooth will also be part of the Matter standard, in particular for ease of onboarding and provisioning Bluetooth devices.

Figure 4: Bluetooth applications

As one of key Bluetooth Low Energy market players, Renesas offers mature solutions, a software stack proven in over 600 million shipped devices, and comprehensive engineering support. Today, we are helping make Bluetooth ubiquitous in all kinds of devices, many of them battery operated. Our low power

high-performance solutions provide unrivalled versatility, spanning the widest range of price points and applications from feature rich SoCs for high-end products to low-cost simple ones suitable even for disposable products.

Plus, with the lowest power, smallest size and lowest cost solutions, the Renesas portfolio is ideally suited to Bluetooth Low Energy. Our solutions adapt to numerous form fac=tors, including extremely small sizes for applications such as styluses, ECG patches and medical devices. Developers can choose from a large variety of MCU configurations for applications from simple wireless sensors to complex IoT devices with graphic interfaces. And where cost and form factor are a consideration, Renesas offers highly integrated solutions that reduce the system Bill of Material - depending on the SoC selected, a charger, a display driver or a complete power management unit with Lithium-Ion battery charger has been integrated into a single chip).

[2] Bluetooth SIG - 2023 Bluetooth® Market Update

Wi-Fi: delivering outstanding performance

The rapid growth of IoT and increasingly demanding applications is spurring uptake of Wi-Fi 6/6E. Wi-Fi 6 provides higher performance, faster data rates (from gigabits per second to 1 Mbps) and lower latency, and extended communication range indoors. It can also support a large number of coexisting devices in a dense environment (even in the 2.4 GHz spectrum).

Additionally, Wi-Fi 6 incorporates numerous features to maximize IoT performance in environments from homes to large-scale enterprises and industrial applications. These include 'Target Wake Time' that improves spectral efficiency, reduces connectivity congestion and increases battery life, particularly in crowded networks with many sensors and always-connected battery powered devices. Wi-Fi 6 also enhances security with the new 'WPA3 certification (stronger encryption, protection against password guessing, …), and devices can be connected via QR codes for simpler, safer end-user set-up.

Hot on the heels of Wi-Fi 6 is Wi-Fi 7. It will enable speeds up to four times faster, and deliver advances to reduce latency and network congestion, increase capacity, and boost stability and efficiency.

Renesas offers an extensive range of Wi-Fi 6/6E solutions. These enable feature-rich, high-throughput Wi-Fi 6/6E station devices (with integrated dual-mode Bluetooth if required) through to industrial automation and access points. Right across the portfolio, developers can find the best characteristics for diverse requirements like high RF performance, robust security, ease of application development, and ultra-low power to extend battery life.

Indeed, Renesas' portfolio includes the industry's lowest power Wi-Fi SoC that delivers multi-year battery life while maintaining industry-leading range and security capabilities – performance that makes it a confirmed market leader. And right across our Wi-Fi portfolio, our fully integrated SoCs include the processor, SRAM, security, ROM, OTP, Wi-Fi (b/g/n) support, and provide industry-leading range (119.5 dBm) as well as end-to-end security features. Plus, our 'Wi-Fi Ready2go' solutions reduce development time and effort, from first idea through concept and development to production.

Figure 5: Wi-Fi applications

We are also constantly innovating to meet evolving market needs. For instance, our DA16200 Wi-Fi SoC is Matter compatible and offers dynamic power management, consuming virtually no power in sleep state. All our upcoming Wi-Fi solutions will support Matter, and we will be ready with solutions as Wi-Fi 7 takes off.

Moreover, the Renesas Longevity Program ensures that our Wi-Fi solutions receive continuous support including software updates, security patches, and technical assistance for an extended period.

NFC: total solutions with best-in-class performance

NFC is present in a vast array of applications from payments, authentication and user identification to building access control and smart home devices. And the NFC roadmap is set to bring advances such as increased power for wireless charging, greater range (for faster, easier contactless transactions) and enhanced device-to-device communication for PoS in NFC-enabled smartphones. These will take NFC into new areas such as healthcare and electric vehicles.

Renesas has been developing ground-breaking NFC technology and products since 2014. Our solutions target the most demanding applications in NFC wireless charging, and PoS, and incorporate advanced features such as higher sensitivity and output powers. They enable sleek designs, reduce BOM and minimize costs, and simplify integration. For instance, developers can implement NFC for brand protection, authentication and payment with limited NFC experience required.

We simplify integration through higher reading distances and smaller antennae, with output power up to 2W and best-in-class receiver sensitivity, along with Direct Antenna Connection (DiRAC) for easy antenna matching and best interoperability. And in software, development is facilitated through optimized APIs and on-chip handling of time critical protocol operations that free up host MCU computation power and memory.

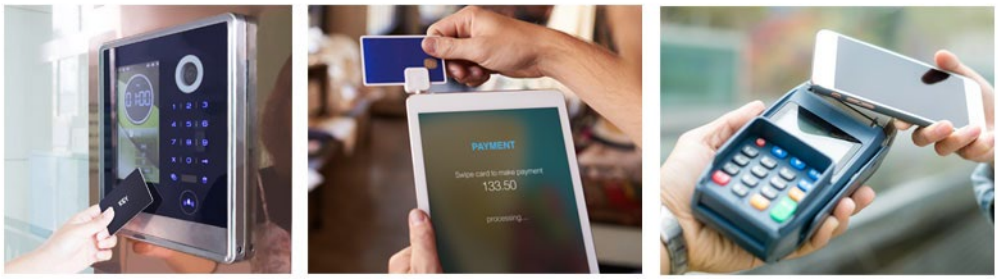


Figure 6: Typical NFC applications

Plus, for the growing SmartPoS terminal market, the Renesas solution features a unique architecture that allows placement of the NFC antenna near or behind the display, making it the only NFC controller that enables EMVCo 3.0/3.1 in a mobile environment.

The way ahead: infinite possibilities, unmatched performance

In the coming years, IoT will take convenience, safety, security, automation and enjoyment to even higher levels. The opportunities are exciting and challenging. That’s why our focus is unceasingly on performance. Renesas is committed to delivering solutions that combine everything our customers need for the IoT of tomorrow. We are constantly strengthening our market-leading MCU and wireless connectivity portfolios, for increased intelligence and data processing in IoT end points. And we are expanding our ecosystem to

integrate AI, for instance with our Reality AI technology for edge AI software development. In a world of infinite possibilities, unmatched performance will be key to unlocking the promise of IoT that's truly interoperable, easy to use, and always reliable – making life easier for everyone.

Renesas Winning Combinations for IoT applications

Renesas offers over 400 Winning Combinations featuring mutually compatible devices that work together seamlessly for optimized low-risk design and fast time to market – many for IoT applications, such as:

A **Matter-Ready Wi-Fi Sensor Solution** for easy interoperability in applications such as measuring light levels, humidity, and temperatures in smart home, building and industrial environments. With a battery/solar-powered design and Matter connectivity, it allows for independent, stand-alone operation (no wiring) and a fast/reliable system, as well as user-friendly IoT development.

A solution for wearable / **portable health monitoring devices**, with regular checking of vital body indicators for early warning of health risks. Based on an ultra-low power **Bluetooth Low Energy** SoC it incorporates a real-time ECG monitor and can be equipped with fast battery charging for high-end application.

For the growing trend for **smart locks** for home appliances, a fingerprint based solution enabled by **NFC**, capacitive touch, or low power Bluetooth for communication with mobile or smart home routers. An optional Narrowband IoT modem can directly support WLAN and send an alarm condition to the cloud.

A **solution for smart tracking labels** which enable container and device tracking while also providing environmental data during transit. The solution allows for reporting of a container's or device's presence via **Bluetooth**, either at a depot or via a tablet or phone app. The Renesas design is optimized with ultra-low power devices and several standby options for minimal current draw.

A solution that provides a cost-effective, low-power **smart controller for any heat pump**. A feature-rich MCU and various wireless communication options (including **Wi-Fi** and **Bluetooth**) enable the end user to change the thermostat, set temperature schedules, review energy consumption and air quality.

A **CO_2 detector solution** with wireless connectivity. The solution uses Renesas' RTD120D dual thermopile to detect the ambient CO_2 concentration. It has a Non-Dispersive Infrared (NDIR) thermopile-based gas sensing circuit, and the concentration of CO_2 gas is measured based on the intensity of the NDIR radiation.

A battery-operated stand-alone system to **detect leakage of flammable gas** in industrial and household applications. The system can detect Liquefied Petroleum Gas (LPG) / Piped Natural Gas (PNG), and issue an alarm via a single MCU with built-in low power **Wi-Fi**. This communicates with the nearest router and sends updates via push notification over the user's phone through a dedicated mobile app.

A **blood glucose monitor** (BGM) that design utilizes the high-performance Renesas RA2 MCU series, a complete solution in a single chip. Its high-performance ADC provides an optimal fit for BGM applications where precision is required and with its **Bluetooth** module, the system can be easily extended to intelligent connections and control via mobile devices.

A real-time **tire air pressure and temperature monitoring solution** based on SmartBond TINY™, the world's smallest and lowest power **Bluetooth Low Energy** SoC. SmartBond TINY and a PCB pattern antenna reduce BoM and costs, and no dedicated receiver is required in the vehicle infotainment system.

A highly integrated low-power **mobile POS terminal**, supporting **NFC-enabled** contact and contactless payments. It implements advanced security functions, including anti-tamper, secure boot, and secure authentication, with USB-C and wireless charging for fast charging for always on-the-go mobile terminals.

A smart NFC **access control system** that can authenticate access and store user information through an **NFC card**, camera, or manually entered user information. Capacitive buttons avoid mechanical key failure over extended periods of use and haptics enable active response to user touch. There are options for porting a Linux or Android operating system for flexibility in meeting user interface experiences.

Renesas Wireless Connectivity in action

Carnival cruise ships: Elevating the guest experience

The **Carnival Medallion™ device** connects passengers on Princess Medallion Class cruise ships into its Experience Internet of Things (xIoT™) intelligent, shipboard ecosystem to enhance crew-passenger interactions with unprecedented levels of personalized passenger services. Featuring Renesas' DA14697 Bluetooth Low Energy SoC for optimum processing performance and Wireless Ranging (WiRa™) technology, the medallion enables touchless embarkation and disembarkation, frictionless commerce, and keyless stateroom entry, as well as service on demand; dynamic way-finding; family and friends locator; first-run movies on the go; an interactive events and activities planner; and interactive fun.

KAIFA: Small size, high performance solution for AMI

KAIFA, a global leader in smart meters and Advanced Metering Infrastructure (AMI), was looking for a solution for Bluetooth module that would be compatible with its smart electricity, water and gas meters, and handheld terminals. It chose the Renesas DA14531 SmartBond™ Ultra-Low Power Bluetooth® 5.1 System-on-Chip which, despite its small size and power consumption, delivers excellent performance thanks to its powerful 32-bit Arm® Cortex®-M0+ processor.

BilliCom: Cheaper and better meters

BilliComm, a subsidiary of GoldCard (China's largest gas meter company), helps customers create high-performance, low-cost gas meters, water meters, and gas alarms through reliable, low-power, feature-rich communication solutions. Today, meters go beyond simply measuring flow. For example, they use wireless connectivity to warn of leakages, cut the gas supply, and alert safety authorities and fire departments. BilliComm chose the Renesas DA14531 Bluetooth chip for its low power consumption, microcontroller resources, ease of adaption to different application scenarios through software modifications, competitive price.

Fi: Low power Wi-Fi for smart dog collars

Fi's GPS tracking collar has empowered millions of dog parents with insights about their dogs' location and behavior, saving thousands of dogs' lives through real-time escape notifications and accurate GPS tracking. The latest version features Renesas DA16200 Wi-Fi SoC and RA9530 Wireless Power Transmitter/Receiver, solutions rugged enough to be round a dog's neck, while offering exceptionally low power consumption, small size, reasonable cost.

Stripe/BBPOS: Rapid NFC implementation for payment terminal

Stripe provides payment technologies used by some of the world's biggest retailers, as well as smaller businesses and consumers worldwide. Aiming for a fast time to market, it chose a Renesas **NFC solution** for its BBPOS terminal. This solution combines Renesas's unique hardware and software architecture that allows fast integration and EMVCo 3 certification with the antenna behind the display.

Prevent Biometrics: Reliable NFC charging of new & smaller impact-sensing mouthguard

Minneapolis, US-based Prevent Biometrics manufactures the Prevent Impact Monitoring Mouthguard (IMM). Prevent's head impact monitoring system is the market leading solution for accurately tracking head impacts in sports and the military. Worn by athletes in contact sports such as rugby, hockey, lacrosse and football, and by soldiers in training activities, the mouthguard measures the intensity, frequency, location and angle of impacts to the head. By choosing Renesas NFC offering, Prevent Biometrics is able to maintain optimal charging performance when the coils are misaligned, even if they are as much as 13mm

apart. minimize the charging system’s board footprint. In addition, the elimination of the filter reduces losses, enabling the device to provide higher Transmit (output) power, and the listener to harvest up to 1W.

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