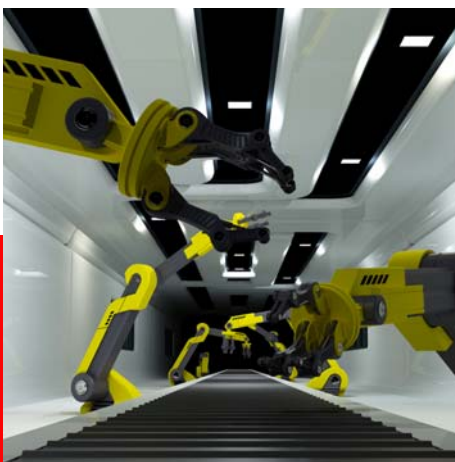Whitepaper

Why smart modules simplify development, speed time to market and make hyperscale IoT a reality

Contents

Introduction

The introduction of edge devices that combine computing, connectivity and storage in a single product have made many Internet of Things (IoT) use cases a reality for the first time. Enabled by cellular connectivity, massive cloud computing and processing power that can be accessed wherever it is needed, smart modules are empowering IoT applications, removing technical limitations and helping to accelerate time-to-market. However, discrete design of all of these functions and capabilities has created several complexities as organizations juggle edge computing, connectivity and storage and seek to integrate disparate hardware into IoT devices.

Harnessing the ability to perform multiple tasks in a single module removes the need to specify and develop function-specific modules and then ensure they integrate effectively in a unified product. This requirement led to the initial development of smart modules which bring together multiple functions required by IoT into a single module thereby removing the integration burden of bringing together multiple different functions. Further benefits of using smart modules are introduced later on in this whitepaper.

What is a smart module?

A smart module is a small form-factor, ready-to-use, computing, controlling and communication device which consists of application-agnostic hardware and software for developing an embedded product. All of this is provided in a single module which are available in several pin-to-pin compatible stock-keeping units (SKUs) for different regions, thereby streamlining product selection, design, purchasing and logistics. Smart modules also offer a wide range of interfaces so they can support a broad range of functionality, from cameras to sensors to audio and video and beyond.

The principles behind smart module design are application and software-oriented rather than hardware-focused so smart modules are more flexible and can be more readily adapted to end user requirements and the needs of vertical markets. This also means innovations can be brought to market more rapidly and customization and optimization can be completed with greater simplicity.

The smart module is an integrated solution compared with the discrete design approach that involves communication between the central processing unit (CPU), memory and modem in a printed circuit board (PCB) via buses. **Figure 1** details the different design approach and demonstrates the simplicity of the smart module approach.

Figure 1: Legacy design versus smart module design
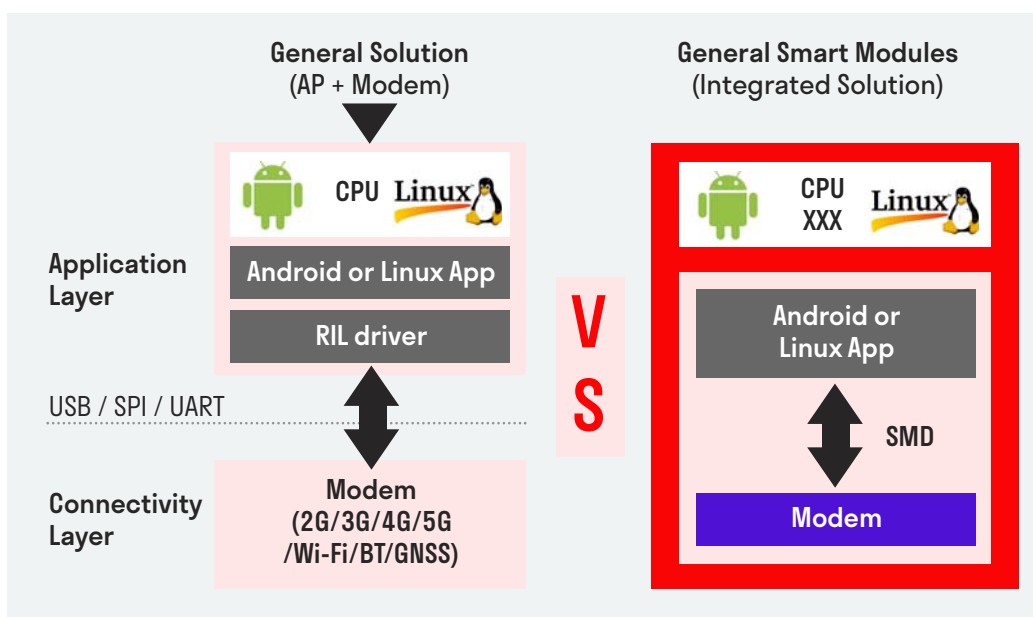
Key smart module features

- Processors, memory, modem and a wide range of peripheral interfaces in a single SKU
- Ability to mitigate development risks by using a reliable, rigorously tested and certified integrated solution
- Eliminate potential design issues and mitigate future layout rework due to noise issues
- Risk mitigation in sourcing with the Quectel-provided approved list of vendors (AVL) for commonly used sensors, supported by relevant drivers and software developer kits (SDKs)
- Ready and built-in OS (Android in all Smart Modules and Linux for certain SKUs)
- Decreased device product size and weight
- Improved performance-to-price ratio and enhanced device price competitiveness
- Simplified PCB design and reduced associated time and cost
- Reduced inconvenience due to contacting different vendors for each discrete component
- Easier production ramp-up and scalability
- Simplified power supply and reduced power consumption thanks to the integrated power management unit (PMU)
- Improved performance-to-price ratio with significantly reduced total cost of ownership (TCO)
- Built-in GPU and NPU for AI applications (certain SKUs)
- Different SKUs for different regions with pin-to-in compatible design
- Wide range of smart modules extending from entry level to premium modules


Figure 2:
The smart module
ecosystem

What makes a module smart?

Smart modules are composed of hardware and software which together enable the functionality to be delivered in support of the specific IoT use case. The smartness comes from embedding many functions into a single module and ensuring these interact correctly, enabling intelligent outcomes.

Figure 3 illustrates popular smart module hardware ingredients that are needed by customers to design IoT devices. As IoT devices become more intelligent, the emergence of edge intelligence and increased reliance on this as a means to offset cloud computing and processing costs is seeing greater intelligence being accommodated on end user devices.

Figure 3: Smart module hardware building blocks
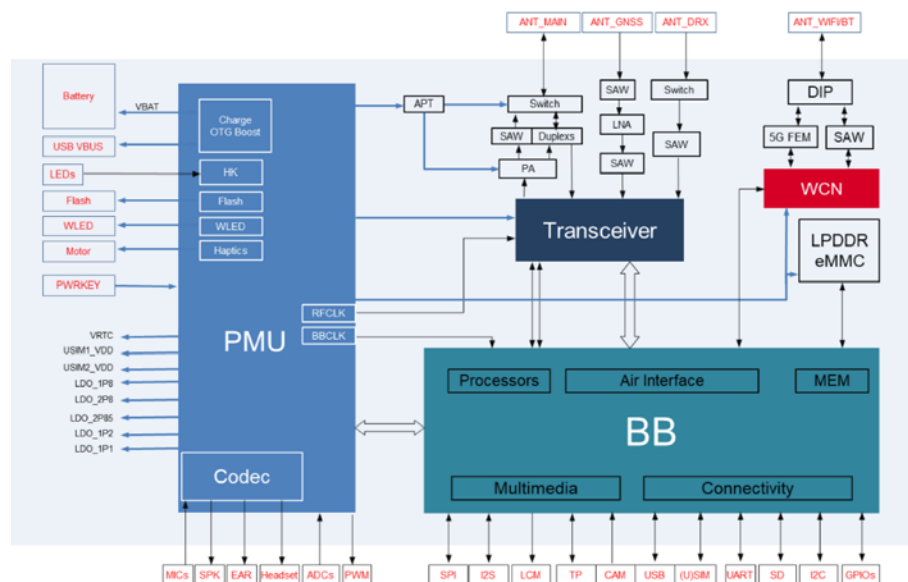
This move is seeing the smart module grow in importance and increases the available performance. Newer technologies such as neural processing engines are being added to smart modules and will help to drive greater functionality and cost efficiency, enabling smart modules to do more and interact with other systems and functions more simply.

Important smart module hardware

The transceiver is the communication part of a smart module and ensures a reliable 2G, 3G, LTE or 5G link with the cellular network. The transceiver can also include GNSS, Wi-Fi and Bluetooth connectivity, offering connection flexibility to end users.

The power management unit (PMU) is a microcontroller based unit that governs power functions of the smart module. It provides a stable power supply to entire smart module units, which otherwise have to be designed discretely. In addition, the PMU handles battery charging, driving LEDs, power key control and audio codecs, if required.

Smart modules can support a rich set of peripherals and need minimized effort to integrate them into the application. This helps R&D to speed up the development process and reduce time and associated costs significantly. Popular peripherals include: cameras, LCMs, Wi-Fi, Bluetooth and GNSS capabilities, memory and SD cards and eSIM and embedded universal integrated circuit cards (eUICC).

Smart modules offer a wide choice of interfaces with peripheral components on a customers' PCBA, such as USB2.0/3.0, USB type-C, I2C, UART, GPIOs, and support PWM and ADCs.

In terms of software, smart modules contain the operating system (OS), device driver and associated SDKs. For Industrial IoT, Linux is preferred while for other commercial purposes, Android has greater advantages.

The clear separation between the OS and application layer through standardized application program interfaces (APIs) means a smart module development team can have a separate group working on APIs and carry on with testing or adjusting the user interface with the target users, while an embedded team works on implementation of all others functional IoT features.

Figure 4: Smart module software building blocks
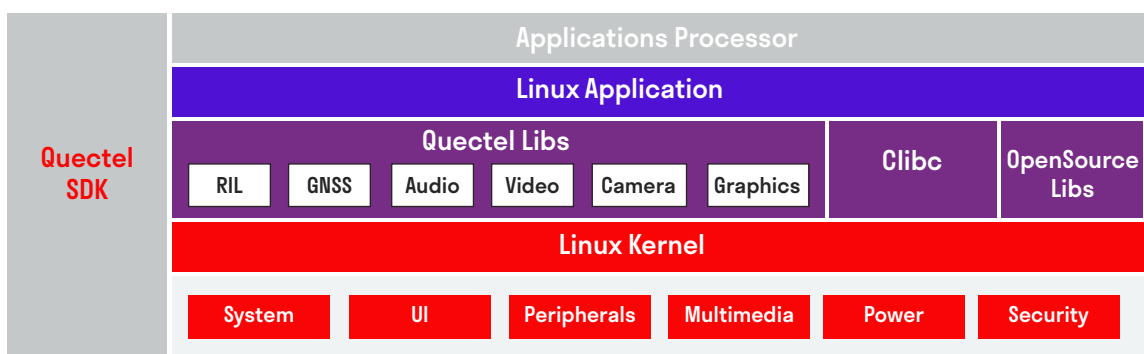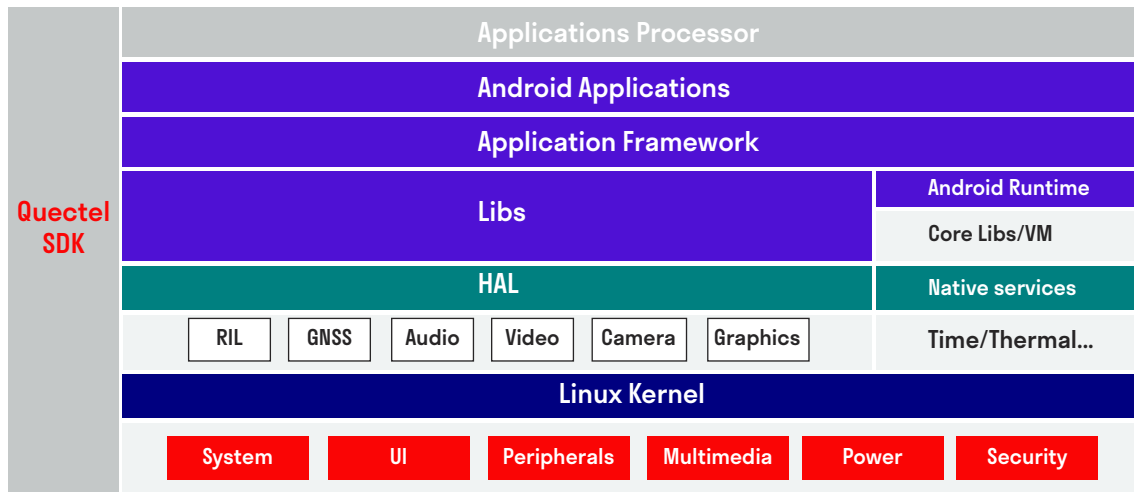
Security has been and will always be a matter of concern to all players in the IoT value chain, especially the end users. Secure boot refers to the bootup sequence that establishes a trusted platform for secure applications. It starts as an immutable sequence that validates the origin of the code using cryptographic authentication so only authorized software can be executed. The bootup sequence places smart modules in a known secured state and protects them against malicious software and cyber-attacks.

A secure boot system adds cryptographic checks to each stage of the bootup process. This process asserts the authenticity of all secure software images that are executed by the smart module. This additional check prevents any unauthorized or maliciously modified software from running on the module. For the code to be executed, it must be signed by the trusted entity identified in the hardware fuses.

To sign the images, a trusted vendor uses their private key to generate a signature of the raw code that they want to use and adds this to the device alongside the software binary. The device contains the corresponding public key of the vendor, which can be used to verify that the binary has not been modified and that it was provided by the trusted vendor in question.

Smart module communication

For original equipment manufacturers (OEMs), there has never been a greater need or opportunity to connect their products. Critical smart module functions that require connectivity include: over-the-air (OTA) OS updates, application layer improvements, remote maintenance and troubleshooting, performance monitoring, innovative payment methods (such as device leasing), and reporting for business intelligence purposes.

An unconnected product cannot be remotely maintained and its performance in the field cannot be checked. The total value of an unconnected product resides in the product itself, whereas the total value of a connected product includes both the product and all the services created by it which are connected via the smart module.

Quectel's smart module range

Quectel offers a comprehensive range of smart modules with product families that contain an extensive range of variants to address deployment regions and a range of interfaces and connection options.

SC20

The SC20 family comprises new-generation multi-mode LTE Cat 4 smart modules measuring 40.5mm × 40.5mm × 2.8mm with built-in Android OS. The SC20 is suited to both industrial and consumer applications requiring high data rates and high-speed internet access. It delivers data rates of up to 150Mbps downlink and 50Mbps uplink on LTE networks and supports wireless communication via IEEE 802.11a/b/g/n and BT 4.2 LE. It is also backward-compatible with EDGE and GSM/GPRS networks, ensuring connection even in remote areas without 3G or 4G coverage. It supports MIMO and offers a multi-constellation GNSS receiver. The SC20 is a cost-effective module for a wide range of IoT use case and application such as smart PoS, cashier, display and signage, industrial PDAs and patient home monitoring to name a few. As a mature and well-established product, it supports the richest global carriers' certificates.

SC200

The SC200 is an upgraded version of the SC20 which while it retains cost advantages, can also support Android 10. This family comprises new generation multi-mode LTE Cat 4 smart modules measuring 40.5mm × 40.5mm × 2.8mm with built-in Android OS, based on Qualcomm's ARM Cortex-A53 64-bit quad-core processor and built-in Adreno™ 308 GPU. This high-performance module supports various multimedia functions, making it ideal for both industrial and consumer applications which require high data rates. The smart modules weigh 10.2g and offer maximum speeds of 300Mbps downlink and 50Mbps uplink utilizing LTE. Operating temperature range is -35°C to +75°C.

SC600

The SC600 series is Quectel's new generation of multi-mode smart LTE Cat 6 modules with built-in Yocto Linux (Kernel 4.9) OS, in an LCC+LGA package measuring 43.0mm × 44.0mm × 2.85mm. Based on Qualcomm octa-core ARM Cortex-A53 64-bit high-performance processors with built-in Adreno 506 GPU, the modules offer leading performance and various multimedia features, and are ideal for both industrial and consumer applications requiring high data rates and multimedia functions. The modules offer maximum speeds of 300Mbps downlink and 50Mbps uplink utilizing LTE. Operating temperature range is -35°C to +75°C.

SC66

The SC66 family offers new-generation multi-mode LTE Cat 6 smart modules measuring 43.0mm × 44.0mm × 2.85mm with built-in Android OS, based on Qualcomm's ARM Kryo™ 260 64-bit octa-core processor, with built-in Adreno™ 512 GPU. This high-performance module series supports various multimedia functions, making it ideal for both industrial and consumer applications which require high data rates. The smart modules weigh 12g and offer maximum speeds of 300Mbps downlink and 50Mbps uplink utilizing LTE. Operating temperature range is -35°C to +75°C.

SA800U-WF
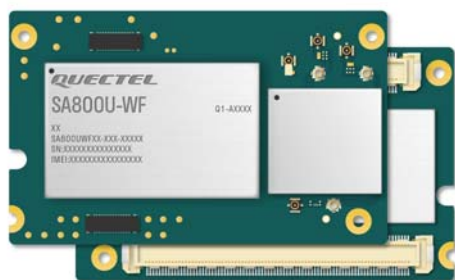
The SA800U-WF is Quectel's high-end smart module based on the SDA845, 10nm SoC. The module comprises Octa core 64-bit application processors (Kryo 385) as well as the Adreno 630 GPU. The SA800U-WF is considered as non-cellular module hence connectivity is established via WiFi, supporting 2.4&5 GHz, 2 × 2 MIMO 802.11a/b/g/n/ac as well as BLE 5.0. HDMI IN/OUT 4K connectors, one Gigabit Ethernet RJ45 interface and an M.2 interface for the external 4G/5G module, are among features of this powerful module, which makes it suitable for emerging use cases such as AR/XR, robotic, gaming consoles, live video steaming devices and smart home interactive gyms.
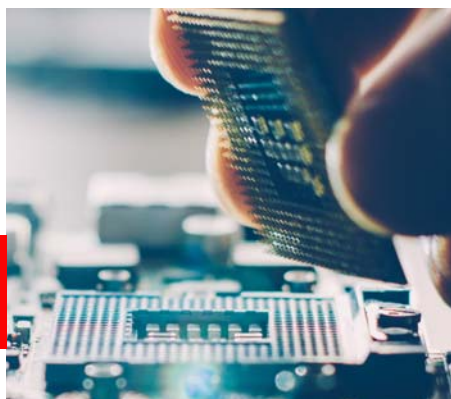
EVB kits

Quectel evaluation board (EVB) development kits allow users to get started to develop applications based on Quectel smart modules. Quectel's extensive Smart EVB G2 and Development Guides will help developers learn how to customize software to accomplish the design phase quickly.

The Quectel EVB is designed for original equipment manufacturers, hardware/software vendors and developers which can help accelerate the development and testing of devices. Developers can utilize the Quectel EVB to get a head start on the competition by creating solutions optimized for the latest device designs.

Figure 5A: SC20 EVB kit

Figure 5B: SC600Y/T EVB kit

The EVB kit comprises hardware for SC600 family smart modules, including:

- DC Power Supply: 4.75V~6.0V (typical: 5.0V)
- Two 5-inch HD LCM, Touch Panel, Camera, USB, Audio, (U)SIM, UART, SD card interfaces
- Vibrator and status indication LEDs
- Sensors (Support three sensors including ALS/PS, accelerometer/gyroscope and compass)

Figure 5C: SA800U-WF EVB Kit

Antennas

YB0007AA

YB0015AA

YC0003AA (SMD)

YF0006DA (FPC)

YE0001BA

Quectel also offers a wide range of antennas so customers can take advantage of its huge engineering resources and buy antennas as well as modules. Integrating antennas with IoT modules into IoT devices, which are often space-constrained and affected by location in devices that limits signal propagation or shortens battery life, is a common challenge for IoT device makers. To streamline development and enable optimized integration of embedded antennas, Quectel has assembled a comprehensive range of antennas and modules and offers support to design and integrate antennas into customers' solutions and devices.

In addition to this simplification of the embedded antennas integration process, Quectel is also offering a wide range of external antennas. These have fewer integration challenges but can also be purchased alongside appropriate Quectel IoT modules, enabling streamlining of the supply chain and easier purchasing. Alternatively, customers can simply buy just the antennas on their own from the wide range available in Quectel's new portfolio.

Visit the new Quectel Antenna Selector and let us help you find the ideal antenna for your IoT deployment.

Apps and use cases

Smart modules theoretically can be deployed in multiple IoT verticals, some popular examples of which are detailed below:

AIoT

The coming together of artificial intelligence and IoT – now commonly known as AIoT – is creating further new use cases for which smart modules are vital enablers. These include:

- Robotics and Smart Factories
- Face and Voice Recognition
- Health Care Assistants and Medical Diagnosis
- Industrial Digital Assistants

Mobile payments/Smart POS

Increased adoption of mobile payments is creating huge demand for smart POS and cash register devices. The change is happening now in China as well as global markets because smart POS is one of the main verticals which heavily utilizes smart module features.


Electronic cash registers

An electronic cash register combines a secure cash box, barcode scanners, credit and debit card processing, mobile payment scanner, tracking staffs, receipt printer and many other functions into one operating unit. It's hard to find a small business owners or retailer that doesn't have a cash register.

Smart vending machines

Thanks to their cost-effective embedded computing power as well as abundant interfaces, smart modules can contribute to the rapid adoption of vending machines globally. Vending machines use large digital touch displays, internet connectivity, cameras and various types of sensors, a wide variety of advanced payment systems, digital signage and identification technology such as near-field communications (NFC), radio frequency identification (RFID) and facial recognition. Smart vending machines enable a more interactive user experience and reduce operating costs while improving the efficiency of the vending operations through remote manageability and intelligent back-end analytics. Integrated sensors and cameras also provide a source of such data as customer demographics, purchase trends, and other locality-specific information.
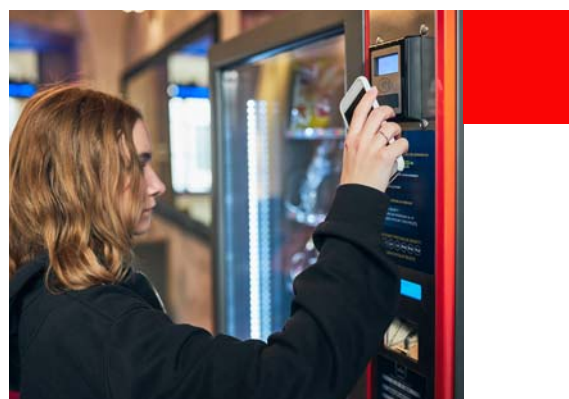
Industrial PDAs and tablets

Industrial PDAs are known for their combination of high performance and strength to handle the most demanding field applications. All rugged handhelds and tablets have ingress protection such as IP65 or higher. Handhelds are built to withstand tough environments and rough industrial settings. Quectel supports business partners to accomplish their mission in supplying complete mobility solutions for businesses working within demanding industries, helping the end users to improve productivity and efficiency in the field. Major applications/end users include:

- Retail and Wholesale
- Logistics and Warehousing
- Government
- Industrial Manufacturing
- Healthcare

e-Mobility, After Telematics and Infotainment

The cost-competiveness of SC20 and SC200R have enabled a new range of devices which were previously only available in premium vehicles. These include dash cams, multimedia cellular infotainment, smart mirrors, in vehicle DVR and advance dashboards for two wheels, to name just a few.

Conclusion

Smart modules are smart because they bring together previously discrete functionality into a single product, with a single SKU. Developers that select smart modules to meet their deployment's requirements no longer have to specify and purchase multiple modules that only address discrete functionalities of the IoT device and this speeds development and time-to-market by simplifying design.

Further benefits accrue because smart modules typically offer pre-integrated functionality and have been tested to ensure high quality by their makers. In addition, there are fewer security concerns because smart modules have been tested and there are fewer points of weakness than with the multiple different modules that need to interact.

With comprehensive portfolios, such as Quectel's, now widely available, OEMs can easily identify the right smart module for their particular deployment regardless of region, cellular technology, interfaces, operating system and processor choice.

> Smart modules are simplifying IoT deployments, saving costs and accelerating the IoT revolution. To find out more about how Quectel can help you experience the benefits, visit:
> **www.quectel.com**