Bringing wireless scalability to intelligent sensing applications

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Overview

There are several dimensions to the scalability of general-purpose microcontrollers (MCUs). In addition to the standard peripherals required, a product family will typically offer developers a range of device options across processor speed, memory, GPIO pins, and packaging. With the increasing need for connectivity driven by the Internet of Things (IoT), a new dimension of scalability is required: wireless connectivity technology.

One of the challenges for manufacturers designing intelligent connected applications, especially for the consumer and industrial markets, is deciding which wireless standard to adopt for a particular application. In many markets, these types of devices are an emerging technology. For example, in the smart light bulb product category, there are multiple wireless connectivity options in the market. Other applications where radio selection is a challenge include remote controls, home/building automation, smart meters, healthcare/medical, wearables, security alarms, beacons, and many others.

Because the radio is a core component of an intelligent sensing application, designers have traditionally needed to decide upon which wireless standard to adopt relatively early in the design process. Traditionally, the manufacturer would select a wireless component and build around it. Once this decision was made, many aspects of the design would be locked in, such as the transceiver technology, PCB layout, software stack, and API to access the radio.

Consider a manufacturer who has chosen ZigBee® technology for an application. As the design progresses, new market data might arise that suggests that using *Bluetooth*® Smart would substantially increase the target market for the application. It is not a trivial undertaking to switch radios at this late stage. The Bluetooth Smart radio, for example, might need to be sourced from a different vendor. All of the design work around the original radio will likely need to be scrapped. In addition, the application itself will need to be adapted to a new stack and API. Effectively, a manufacturer is looking at taking on a near-complete redesign to change radios.

Even if the Bluetooth Smart radio can be sourced from the same vendor as the original ZigBee radio, radios are typically built upon entirely different technologies. These differences can severely limit how much of the current design can be carried to the new radio. In either case, there are likely to be long delays in completing designs and bringing product to market. Added engineering costs need to be considered as well.

The decision to change a fundamental aspect of a design has never been an easy one. Manufacturers have to make the choice between bringing a suboptimal product to market on time or redesigning the right product but missing a key market window.

SimpleLink™: Meeting changing market needs

Texas Instruments (TI) understands that technology agility is crucial when entering new markets or deploying new technologies. While a lack of flexibility can result in a product's failure in the market, the

right level of configurability can play a key role in the product's success.

To meet the need of manufacturers to have greater flexibility in their choice of wireless technology, TI has created the SimpleLink™ ultra-low power wireless microcontroller (MCU) platform. The architecture is based on the ARM® Cortex®-M3 and currently offers memory configurations from 32 KB up to 128 KB Flash. It provides enough processing capacity to serve as a standalone MCU for a wide range of intelligent sensing applications.

What makes the SimpleLink platform unique, however, is its scalability across wireless technologies. Devices support a range of different radios with pin-to-pin compatible package options, including Bluetooth Smart, Sub-1 GHz, ZigBee, 6LoWPAN, IEEE 802.15.4, RF4CE™ and proprietary modes operating up to 5 Mbps.

From a hardware standpoint, it is straightforward to change the radio in use. All 2.4 GHz technologies and all Sub-1 GHz technologies are directly pin-to-pin compatible. In addition, all of the other peripherals are the same between SimpleLink devices. This gives manufacturers a great deal of flexibility in being able to select which radio to use late in the design process.

The platform is also code compatible across each of the different standards it supports. Switching radios, however, does have some impact on application software design. This arises from the differences in the radio stacks, which must be accounted for by the application. For example, interfacing to the 6LoWPAN stack is done using IP messages. With Bluetooth Smart, the application reads or modifies various attributes. These differences are captured in the APIs TI supplies with each of its SimpleLink wireless MCUs.

As a best practice, manufacturers can design the radio interface in a modular fashion. Rather than have the application directly access the radio, the wireless API can be abstracted by having the application send data to a radio function. This function can then process data to be transmitted or received as required using the appropriate API. The effect is that, to change radios late in the design process, only this radio function would require porting.

Flexibility through scalability

With the SimpleLink architecture, TI enables manufacturers to delay choosing a wireless connectivity protocol until late in the design cycle. Effectively, developers are able to design to multiple radios simultaneously since it is not a lot of extra work to put in an alternative radio once the first radio has been built in. Because designs can be easily migrated between radio technologies, manufacturers also have the option of supporting multiple radios with the same base design. This allows manufacturers to not only hedge their bets on which radio technology the market will choose but to provide multiple options in a cost-effective manner.

The first devices available in the SimpleLink ultra-low power platform are the CC2640 wireless MCU for Bluetooth Smart, the CC2630 device supporting 6LoWPAN and ZigBee and the CC1310 wireless MCU for Sub-1 GHz. Additionally, the platform supports ZigBee RF4CE with CC2620 wireless MCU (see Figure 1 on the following page). Each of these devices has been optimized for ultra-low power designs enabling multi-year operations over a coin cell battery or even battery-less with energy harvesting, giving manufacturers flexibility and innovation to connect many sensors and things.

Figure 1: The SimpleLink ultra-low power wireless MCU platform is the industry's first family of devices delivering wireless scalability for intelligent sensing applications. Each technology offering has been optimized for both cost and power, giving manufacturers flexibility with the competitive pricing of an application-specific part.

For the ultimate in flexibility, TI is also announcing the CC2650 multi-standard device. This "superset" device can be dynamically configured in both hardware and software to support one of several different 2.4 GHz radios. Designs built with the CC2650 can go to production without locking in a selection and be configured at the time of installation in the field. This allows manufacturers to truly wait until the last minute to decide on which radio to implement without changing the antenna design.

The CC2650 also enables applications to support multiple radios with a single chip since the radio a device supports can be changed. Thus, by reprogramming the CC2650 in the field, a system could communicate with both ZigBee- and *Bluetooth*-based devices.

The Sub-1 GHz CC1310 wireless MCU, for operation in 315 MHz, 433 MHz, 470 MHz, 500 MHz, 868 MHz, 915 MHz and 920 MHz ISM bands, offers up to 20 years battery life for building and factory automation, alarm and security, smart grid and wireless sensor network applications. With the CC1310 solution plus the CC26xx devices, the SimpleLink ultra-low power platform can meet the needs of any design.

Multiprocessor efficiency for the lowest power

Many intelligent sensing applications have to operate for years in an always-on state from just a single coin cell. Other designs don't have a battery, so they must be able to operate on the limited capacity of energy-harvesting technology. Wearable applications are especially sensitive to power consumption.

Part of the innovation behind the SimpleLink platform is how it integrates multiple processors to provide the different levels of computational capabilities required for the variety of tasks an

intelligent-sensing application performs. By using the right processor for the task at hand, SimpleLink wireless MCUs are able to operate at the lowest possible power:

Application Processor: An ARM Cortex-M3 serves as the main processor of the SimpleLink ultra-low power platform. It provides the performance needed to serve as a standalone MCU that can intelligently manage a sensor-based system. The Cortex-M3 provides plenty of processing power to handle the application and high-level stack processing, and is extremely energy efficient with 48 MIPS processing power. According to **EEMBC's ULPBench**, the CC26xx/CC13xx platform has a best-in-class low-power score of 158.

Radio Processor: The SimpleLink platform also integrates a Cortex-M0 dedicated to managing all low-level radio tasks for the system. This offloads timing-critical tasks from the main CPU.

Sensor Controller: This ultra-low power integrated MCU handles sensor monitoring quickly and efficiently. It is designed to provide just the right level of processing required for sampling data and making simple sensor decisions. In addition, it has limited memory and no extraneous peripherals. This makes it extremely power efficient for tasks such as regularly polling a sensor output and determining if a threshold event has occurred, and avoids having to wastefully wake up the main CPU when this is not needed.

TI has simplified design using SimpleLink wireless MCUs by providing the software needed to operate and interface to the wireless radio. This simplifies radio design to the degree that developers can drop in the appropriate SimpleLink device and quickly begin using the radio without a lot of configuration or tuning. To this end, the radio controller is provided with production code that has been optimized to achieve the most efficient radio operation.

Because the sensor controller needs to monitor sensors, make decisions, and take action based on the particular application, developers need to be able to configure its operation. TI provides a software development tool, Sensor Controller Studio, which allows users to configure the sensor controller. It is possible to configure the sensor controller to perform common tasks without having to write any code, while for applications that require custom code, this is supported through a C-like scripting language. Sensor controller studio speeds up development by using the sensor controller for testing and debugging functionality. This allows for live visualization of sensor data and algorithm verification.

Another key advantage of the sensor controller is that it is integrated with the main CPU. Traditionally, sensor controllers are implemented using a second, less powerful MCU to offload the main application processor. The primary power advantage arises from the fact that the application processor can drop into a sleep mode, letting the more power-efficient controller monitor and manage the sensors.

Because these secondary MCUs are external to the application processor, developers have to design and manage communication between the processors. They also have to implement interrupt capabilities if the controller is to be able to wake the application processor.

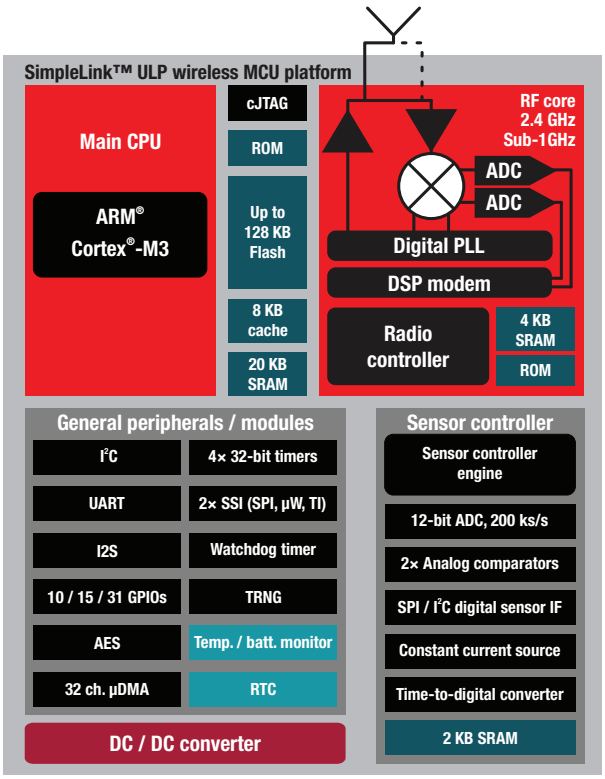

Figure 2: By integrating a sensor controller, radio and MCU within the same package, hardware design is greatly simplified and greater power efficiency is possible.

The SimpleLink platform is unique in how it has integrated the sensor controller (see Figure 2). This provides all of the advantages of power efficiency without the disadvantage of complicating design. Because the sensor controller, radio MCU, and application processor are integrated on the same silicon, hardware and software design is greatly simplified. Greater power efficiency is possible as well.

Of course, developers have full access to the programmable capabilities of the Cortex-M3 for their application development. TI also provides an API for each of its radio technologies so developers can quickly implement wireless connectivity in their applications with a minimal learning curve.

TI's vision has been to create a wireless MCU that is easy to program and avoids the challenges associated with trying to integrate PHYs and stacks. Application code runs on the ARM Cortex-M3, a standard MCU that many designers are already familiar with. RF and antenna design have been simplified as well without compromising reliability or performance. Robust security is built-in, and the protocol stacks are ready for production.

The SimpleLink platform is also the easiest to use and to design with with TI's extensive development tools and third-party ecosystem. Developers can choose from full-featured design environments like Code Composer Studio™ Integrated Development Environment or IAR Embedded Workbench. In addition, comprehensive evaluation kits for the platform are available that can be used to jumpstart design.

SimpleLink wireless MCUs will be available in a variety of package sizes to address the I/O needs of each application. Devices in the 4×4-mm package offer 10 GPIOs while the 5×5-mm package has 15 GPIOs. For applications needing a higher level of connectivity, the 7×7 mm package provides 31 GPIOs.

TI has created the industry's only multi-standard wireless MCU platform that operates at the lowest power and is the easiest to design with. The availability of an MCU platform that is scalable across wireless technologies brings a whole new dimension to market agility for manufacturers. This builds on the flexibility of selecting the optimal amount of memory, number of GPIO, and packaging of the device to active the lower power and cost.

TI's SimpleLink ultra-low power wireless MCU platform enables developers to choose the radio standard their system supports much later in the

design cycle. This gives manufacturers more time and tremendous flexibility to determine how to best address current market demand. And, by offering the optimized performance and power consumption of an application-specific device, the SimpleLink ultra-low power platform helps developers more easily meet the strict requirements of many intelligent-sensing applications.

For more information, visit **www.ti.com/simplelinkulp**

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