Reducing the cost, power and size of connectivity in industrial gateway designs

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Internet of Things (IoT) developers are continuing to chase this lucrative $70 billion market, focusing their energy on improving and differentiating their IoT nodes, whether with smarter sensors or cloud services.

The continuing evolution of microcontroller (MCU) architecture has led to increased intelligence in embedded designs, while cloud connectivity introduces a whole new world of capabilities for businesses and users alike, including a superior user experience, remote operation, automated control and intelligent networking. In many cases, connectivity substantially enhances the utility, serviceability and versatility of embedded systems.

The value of the IoT comes from its interconnectedness. An IoT system must often be able to connect in two directions: down to its sources of data, such as sensors or other IoT devices, and up into the cloud, such as to a data aggregator or centralized control point. Connecting to data sources requires support for a wide range of machine-to-machine (M2M) protocols running over interfaces such as I^2C, Serial Peripheral Interface (SPI) or universal asynchronous receiver transmitter (UART). For many applications, the industry and application define the types of M2M interfaces a system requires.

Connecting to the cloud through the internet requires an Internet Protocol (IP)-based interface, typically Ethernet for wired connectivity and Wi-Fi® for wireless applications. The ubiquity of 10/100 Ethernet makes it a compelling option when you need secure connectivity to a wired product line. The challenge is to implement this connectivity at the lowest cost and power without compromising performance or reliability.

The PHY integration

Traditionally, integrating the Ethernet media access controller (MAC) onto MCUs reduces cost and design complexity. The Ethernet physical layer (PHY), on the other hand, was implemented as a separate component due to analog integration challenges, even though many applications could benefit from integrating the PHY as well.

With the introduction of the SimpleLink™ MSP432E4 MCU from Texas Instruments (TI), the advantages of an MCU with integrated MAC/PHY are now available. TI developed the technology necessary to overcome the challenges of analog integration to bring its industry-leading Ethernet PHY and 10/100 MAC technology together with an Arm® Cortex®-M4 MCU core. The SimpleLink MSP432E4 MCU provides an effective solution for developers needing to connect their systems to the cloud so that they can take full advantage of the capabilities enabled by the IoT.

Figure 1a shows a traditional Ethernet-enabled system built around an external PHY. In addition to the PHY, the system also requires numerous passives and other components. **Figure 1b** shows an equivalent system using an integrated PHY. Integrating the PHY eliminates the need for many of the supporting components.

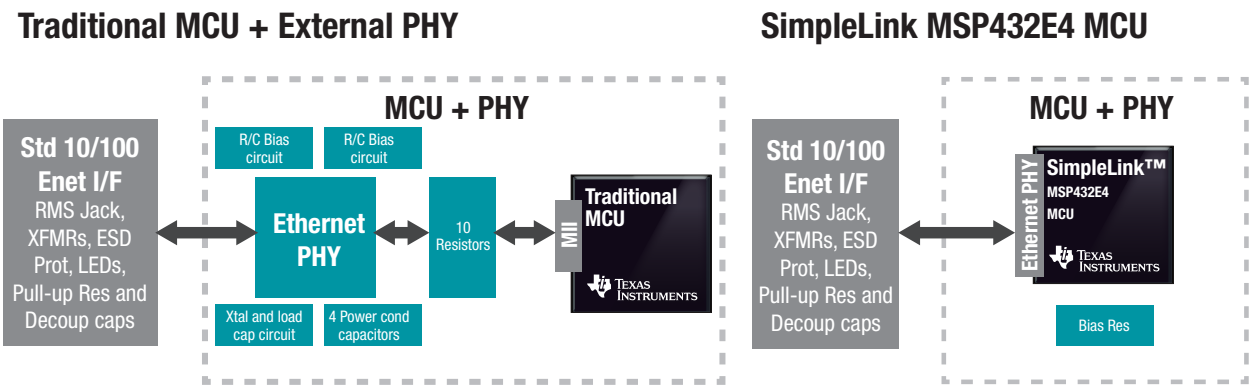

Figure 1. *A traditional Ethernet-enabled system is built around an external PHY requiring numerous passives and other components (a); when integrating the Ethernet PHY into the SimpleLink MSP432E4 MCU, board space requirements drop substantially, as do power consumption and system cost (b).*

As you can see in **Figure 2**, integrating the PHY yields savings and benefits similar to those that became possible when the Ethernet MAC was first integrated onto an MCU:

- **Cost savings**. The number of external and passive components required drops substantially when integrating the PHY (see **Figure 1b**). This results in both bill-of-materials (BOM) and assembly cost savings of as much as 91%.
- **Power savings**. Active power savings can reach up to 58 mA, or a 76% reduction. Standby power savings are highly dependent on the implementation and can range from no benefit up to 10.2 mA, or a 74% reduction. Reducing power consumption increases the power efficiency of systems, in turn reducing operating costs for line-powered devices and increasing operating life for battery-powered systems.
- **Board space savings**. An integrated PHY still requires a few external components, such as a transformer and some form of electrostatic discharge (ESD) protection to protect the MCU from external shock. The overall board space savings, however, are still on the order of a 93% to 96% reduction. This frees up printed circuit board (PCB) space for additional features and functionality.
- **Reduced noise**. Extraneous system noise is reduced because of the removal of several external signals and the elimination of a crystal. This provides greater signal margin for developers, easing routing constraints and design complexities.
- **Accelerated design**. Integrating the PHY simplifies design, enabling faster implementation and troubleshooting.
- **Increased reliability**. As a complete interface, the integrated MAC/PHY of the SimpleLink MSP432E4 MCU is a proven and reliable implementation. Eliminating external components also reduces the number of potential points of failure in the system, further increasing reliability and reducing overall costs.

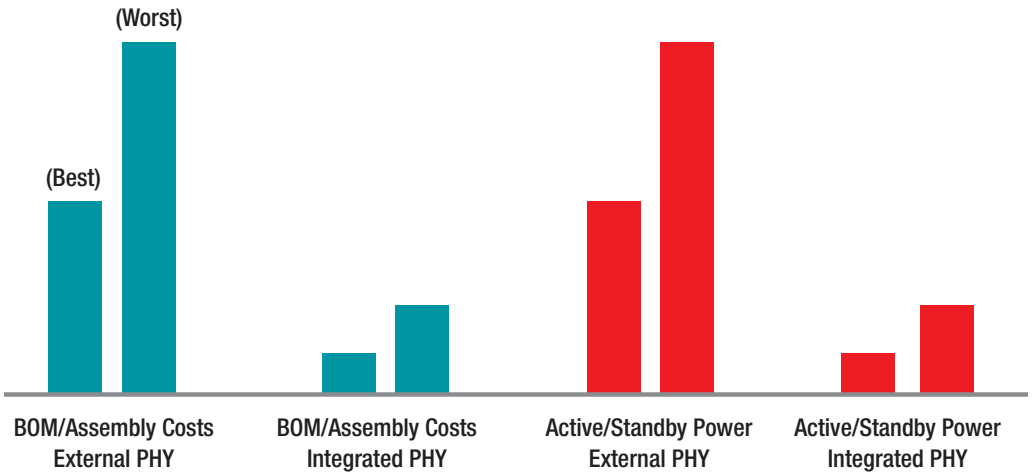

Figure 2. *Integrating the Ethernet PHY onto the MCU, as opposed to a traditional Ethernet implementation using an external PHY, achieves significant cost, power and board space savings.*

Figure 2 highlight the comparisons of the PHY portion of the design only and are dependent on the application, actual implementation, product volume and other factors. To help you estimate the savings you might see in your own applications, TI offers several product evaluation options:

- Heating, ventilation and air conditioning (HVAC) system controllers
- Building zone controllers
- Building security system controllers
- Energy data concentrators
- Industrial human machine interface (HMI) control panels/displays
- Networked residential/commercial building systems
- Networked industrial inverters/motor drives
- Security access systems
- Industrial automation
- Networked industrial meters/controllers/gateways
- Communication adapters/concentrators

Beyond the PHY

The advantages of the SimpleLink MSP432E4 MCU for IoT applications go far beyond just the PHY savings it offers (see **Figure 4**). After all, the Ethernet interface is only one part of a system. Today's IoT devices need a fully integrated processor capable of providing:

- Advanced HMI capabilities.
- High-speed data aggregation.
- Greater reliability.
- Elevated data protection.
- A reduced target footprint for board-space-limited systems.
- Integrated industrial control capabilities.

Industrial & Factory Gateways

Challenges:
- Cross-network synchronization
- Data protection
- Product longevity
- Retrofit wireless into industrial
- Communication interface options

Solutions:
- Precision synchronized timing
- Secured data & protection mechanisms
- Extended temp grade & memory reliability
- Portable software across wireless & ETH
- Many connection options

SimpleLink MSP432E4 MCU benefits

Key Features
- IEEE1588-2008(v2) PTP
- Cryptography accelerators & Tamper IPs
- –40 to 105°C, 100K Flash, 500K EE
- SimpleLink SDK with wireless plug-ins
- Ethernet, 2 CAN, 8 UART, 4 QSPI

Building Automation Gateway: HVAC & Security Systems

Challenges:
- Board space/cost
- User interface
- Extensive I/O control
- Retrofit wireless into wired infrastructure

Solutions:
- High integration
- Display control with supporting software
- Over 20 serial interfaces: UART, I²C, SPI
- Portable software across wireless & ETH

SimpleLink MSP432E4 Features

Key Features
- ETH MAC+PHY, 256K SRAM, more
- LCD controller with graphics library & examples
- 10 1²C, 8 UART, 4 QSPI, USB, 1-wire
- SimpleLink SDK with wireless plug-ins

Figure 4. *The advantages of the SimpleLink MSP432E4 MCU go far beyond just the PHY savings it offers. Its architecture addresses the design challenges typical of intelligent gateways required by different industrial markets.*

As you scale your IoT network and connect more sensor nodes to the gateway, using various wired and wireless technologies and protocols, having the ability to scale and add more interfaces as well as getting access to complimentary hardware resources become important design considerations. **Figure 5** illustrates the high degree of integration, highlighting the MCU configuration catering to the growing and demanding needs of an intelligent industrial gateway.

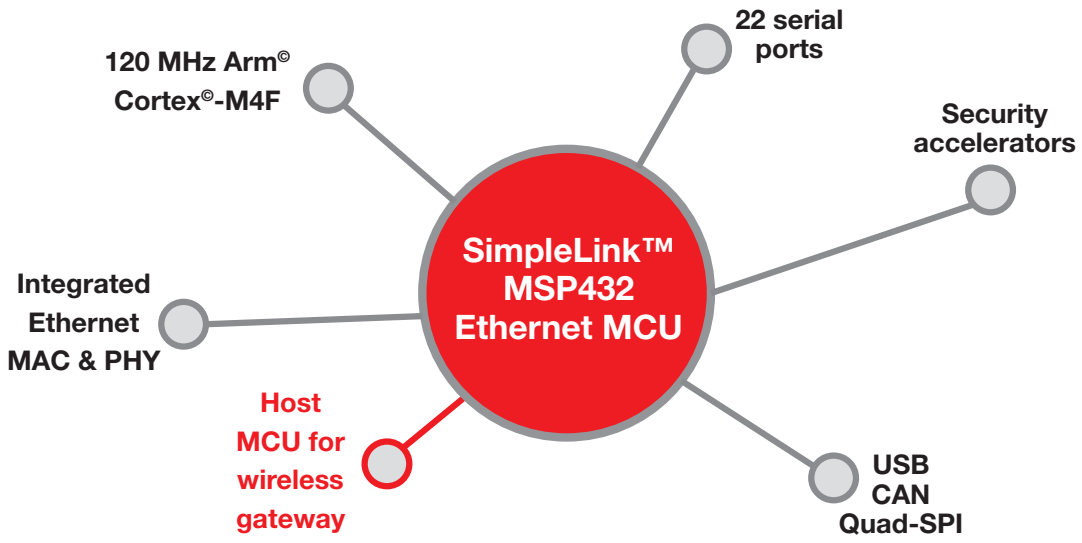

Figure 5. *The high degree of integration of SimpleLink MSP432E4 MCUs offers a wealth of hardware resources with which to develop a highly connected wireless and intelligent gateway that has robust Ethernet connectivity.*

Beyond the hardware

For modern IoT applications, hardware is only half of the battle. The need for a gateway to simultaneously connect to more sensor nodes using various wired and wireless protocols, implement more stringent security protocols and run cloud services is driving exponential software growth. A comprehensive software development kit (SDK) of software components, networking and security stacks can help accelerate the development cycle and time to market.

Figure 6 shows the SimpleLink MSP432E4 MCU SDK, which equips you with a comprehensive and extendable software framework to develop and customize your intelligent gateway solution.

Foundational components such as the TI-real-time operating system (TI-RTOS) kernel, TI drivers and industry-standard Portable Operating System Interface (POSIX) layers enable quick development of robust baseline applications.

Similar to the complexity of Ethernet hardware design, Ethernet and TCP/IP networking software libraries can be intimidating and time-consuming. The SimpleLink MSP432E4 MCU integrates a comprehensive connectivity layer, including unified Transmission Control Protocol (TCP)/IP networking services as well as mbed transport layer security (TLS) as part of the SDK middleware. This fully integrated stack provides a robust internet-ready baseline so that you can spend more time developing top-level applications.

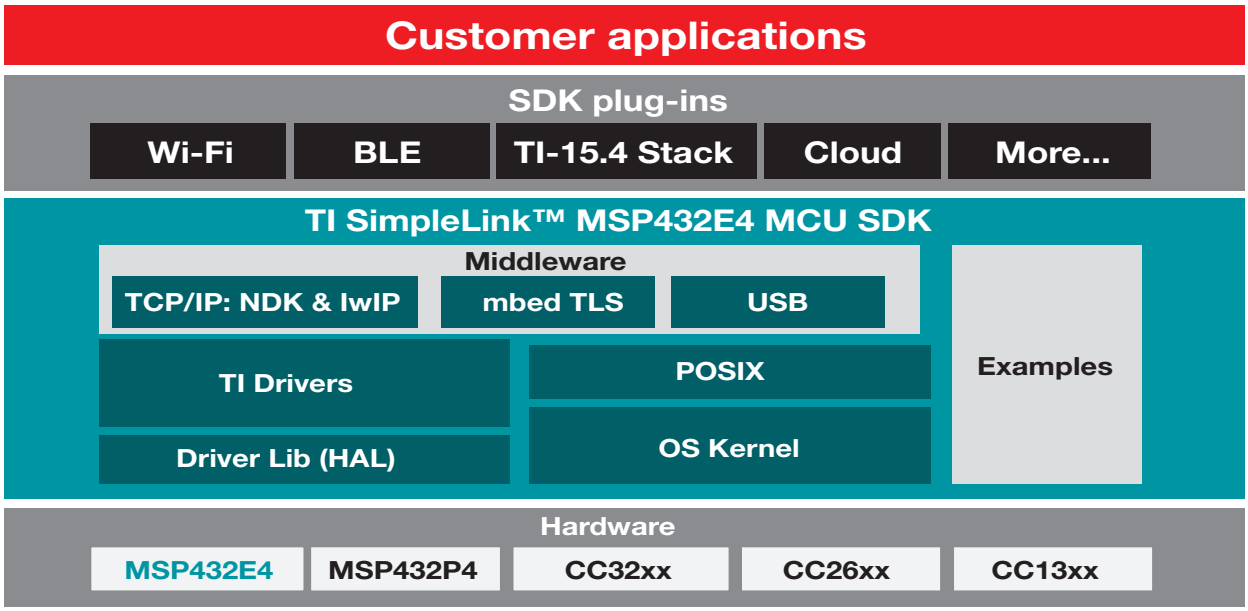

Figure 6. *The SimpleLink MSP432E4 SDK offers a comprehensive connectivity and internet networking services framework, extendable with various wireless and cloud plug-ins.*

The SimpleLink SDK framework is extendable via SDK plug-ins including Wi-Fi, Bluetooth® low energy or Sub-1 GHz 802.15.4 to seamlessly add various wireless options to gateway applications. Because the SimpleLink SDK is portable across the entire SimpleLink MCU platform, including several wireless MCUs, you can maximize code reuse across the gateway and various wireless sensor nodes with a single framework. This consistency minimizes the learning curve and maximizes interoperability across the entire network. You can ramp quickly across projects and ultimately release products faster.

Related websites

- SimpleLink Academy training modules for the MSP432E4: ti.com/simplelinkacademy.
- SimpleLink MSP432 E2E™ Community forum: e2e.ti.com/support/microcontrollers/msp430.
- Power-over-Ethernet TI reference design: ti.com/tool/tidm-1018.
- Product Folder: ti.com/product/MSP432e401y.
- SimpleLink MSP-EXP43E401Y Ethernet LaunchPad development kit: ti.com/tool/MSP-EXP432E401Y.

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