Connected microcontrollers essential to automation in buildings

Texas Instruments

Punya Prakash
Product Line Manager
SimpleLink™ microcontrollers

Casey O'Grady
Product Marketing Engineer
SimpleLink microcontrollers

Texas Instruments

Introduction

Commercial buildings account for more than 30 percent[1] of global energy consumption. A building's energy services include the monitor, control and maintenance of lighting, temperature control and water-heating systems, among others. Residential and commercial buildings make up 41 percent of total U.S. energy consumption[2], which grew by 51 percent between 1980 and 2011.

In the past, building construction technology advances have facilitated building management with relatively low energy consumption. But with the electrical grid's increasing susceptibility to power outages, building owners are investing in the automation of building systems to further reduce energy costs. These systems deliver self-sufficiency, improving overall operational efficiency. And while automation clearly enhances energy management, it is fundamentally a complex implementation that requires support for legacy wired communication setups, as well as advanced (and faster) wired and wireless communication systems.

TI's SimpleLink™ microcontroller (MCU) platform offers the broadest range of options for adding wired and wireless devices to any new or legacy building automation system (BAS), regardless of size. SimpleLink MCUs with low power consumption enable battery-operated devices to operate for years without replacement. In addition, SimpleLink products provide an on-chip, separate customer-dedicated environment, reducing external exposure to security threats. With a unified, common software development kit (SDK), designers can start development on one single MCU, and reuse software developed across other wired and wireless SimpleLink devices.

In this white paper, we will discuss BAS solutions and how TI's SimpleLink MCU platform helps facilitate intelligent automation of control systems while incorporating wired and wireless protocols.

Building Automation Systems

A BAS is a communication network infrastructure that manages various building services. The key to an effective BAS, as shown in Figure 1 on the following page, is having a ubiquitous system that can serve new and old building technology, as well as small and large commercial facilities. With well-established automated solutions, competent energy management is possible through building-to-building communication rather than just building-to-grid communication. Both wired and wireless

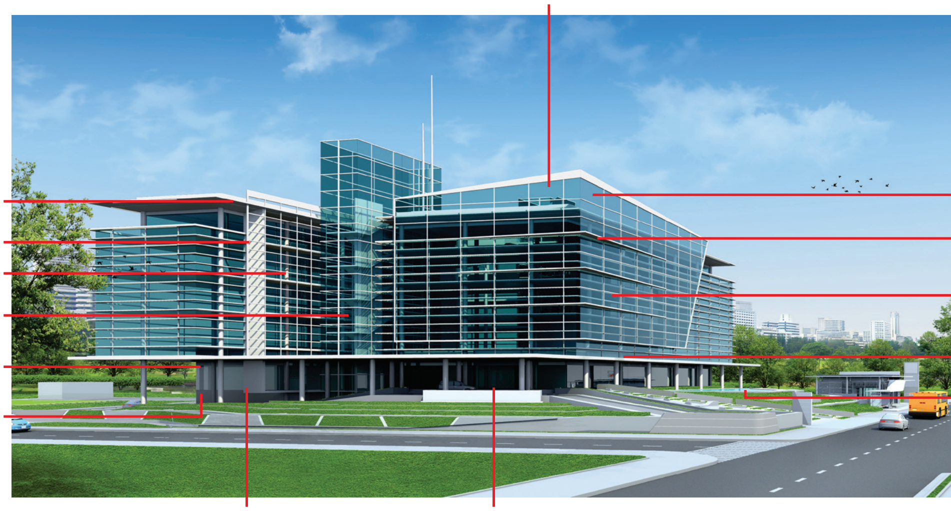


***Figure 1**. BAS example*

communication protocols must be incorporated into these systems as well.

Building management service (BMS) is a recurring expense. While automated systems can supervise regular building services, it's also possible to design them for failure detection and basic fault diagnosis. Early detection and well-recorded system data could contribute to enhanced operational performance. The data collected through connected systems can also improve occupants' lifestyles, providing a green, convenient and safe work and living environment.

A complex network of devices manages the comfort and safety of building occupants. These devices offer demand-based services that manage essential amenities such as air conditioning and lighting control. End users demand access to these devices through wireless and cloud-based applications.

Topology

A building automation device network typically includes both a primary and secondary bus, which are connected to various system nodes such as:

- BMS units.
- Building control systems.
- Zone controllers and end nodes.

BMS units

BMS units host the application and data servers. In addition to the servers, they are equipped with a user interface for data monitoring and control.

As shown in Figure 2 on the following page, the Building Control System (BCS) connects to the BMS through the primary bus. These back-end control systems comprise a centralized and interlinked network of devices that monitor and control the environment. Such control units are designed specifically for building automation and can support single or multiple networks and communication protocols.

The primary and secondary bus might connect to devices such as:

- Low-level controllers.
- Simple input/output devices.
- End-user applications such as room thermostats or alarm-monitoring systems.

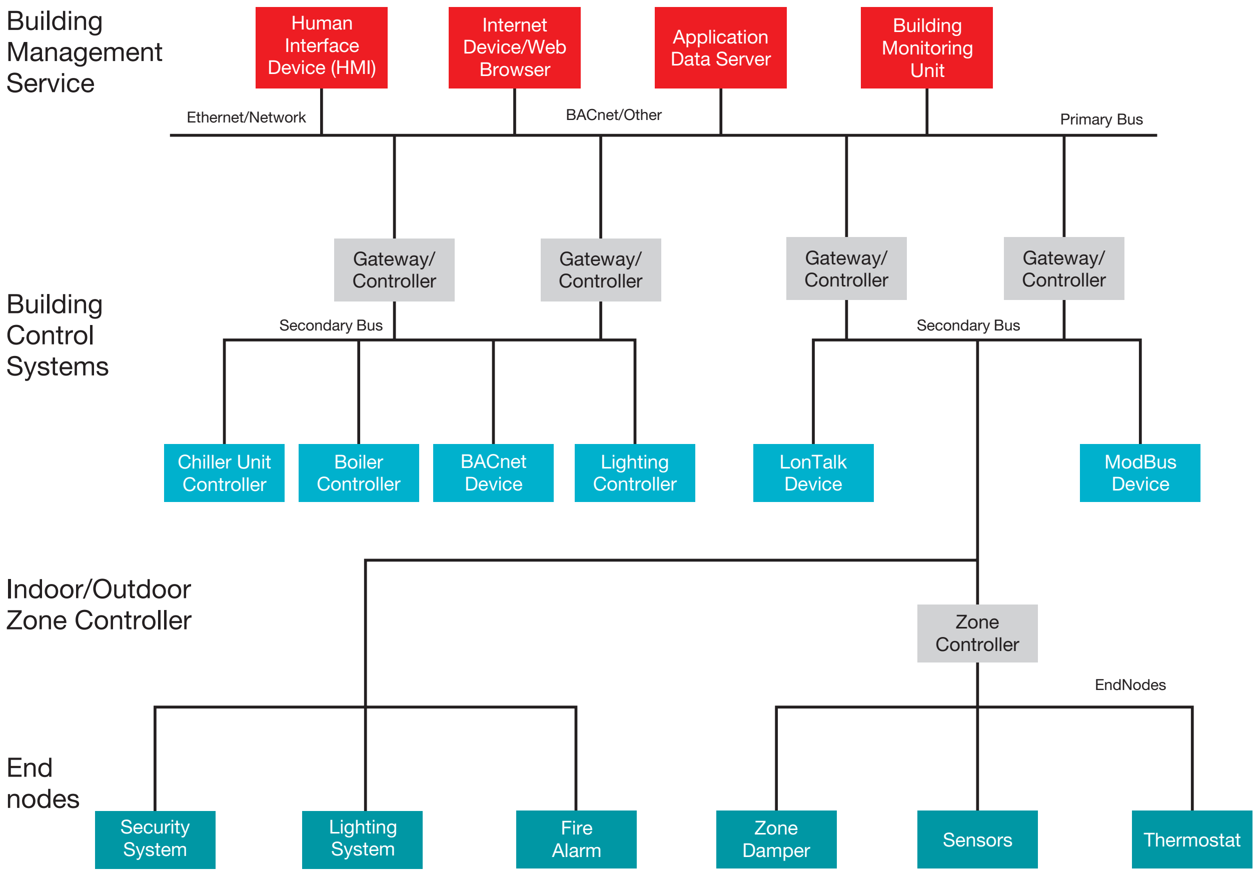


Figure 2. *Typical BAS topology*

The primary and secondary bus may connect through RS-485, Ethernet, Controller Area Network (CAN) or a wireless connectivity network.

The potential applications in an BAS end-node network include a security surveillance unit, a fire alarm system or an alarm system relaying arm/disarm information to BMS units. An indoor or outdoor zone controller can monitor and control systems calling for cooled or heated air as needed. Wireless connections back to the BCS are becoming a popular retrofit for existing systems, or a requirement for new systems.

Building control systems

The deployment of digital control systems in buildings started the trend of truly automated systems. However, since no communication standards existed, individual manufacturers invested in the development of systems with proprietary communication protocols. Consequently, traditional BAS solutions, although automated, were not interoperable among various manufacturers.

Given the various custom solutions, building systems were tightly coupled with a specific manufacturer. The need to establish a standard communication standard led to the realization of open communication protocols that are now accepted globally.

Control solutions, zone controllers and end nodes

Control systems monitor distributed devices in the BAS, managing the priority structure of the network and providing feedback to other controllers. The core functionality of the controller, when combined with additional features, offers differentiation and adds value to the system solution.

A BCS with adaptive control offers continuous fine-tuning of network elements and delivers real-time data on the status of various nodes, thus enabling the realization of maintenance and diagnostics for failure prevention and detection. A deployment environment with a flexible and scalable architecture allows for customized applications. Or making pre-programmed applications available could improve installation time and decrease engineering development time.

Getting the data from the various system nodes to the BCS requires some sort of communication protocol. Some legacy systems, especially, depend on wired protocols for communications between the controller and end nodes. Many new applications use faster wired protocols, which can transfer data from more sensors promptly. However, this requires a significant infrastructure upgrade, including but not limited to rewiring existing buildings. Using wireless protocols for communication eliminates the need for huge infrastructure changes. With increasing Internet of Things (IoT) devices and smart sensor technology, such end nodes are attainable. And while this adding wireless technology to zone controllers and end nodes solves the infrastructure challenges, it does introduce software and system integration complexity, given the mix of wireless technologies enabled in these end nodes.

Wired building automation protocols might be based on serial interfaces such as RS-485 or Ethernet for faster communication. These are the most prominent wired communication protocols used in a BAS system:

- **BACnet** is an open building automation control and communication standard established and monitored through the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). After years of development, it is now accepted as an international standard, International Organization for Standardization (ISO) 16484-5.
- **LonMark** is a standard based on the proprietary LonTalk communications protocol, which establishes a set of rules to manage communications between devices. LonWorks defines the content and structure of the information exchanged between them. Like BACnet, LonWorks has been accepted and adopted by international standards organizations—American National Standards Institute/Consumer Electronics Association (ANSI/CEA) 709.1 and Institute of Electrical and Electronic Engineers (IEEE) 1473-L.
- **Modbus** is a truly open standard and one of the most widely used protocols in industrial manufacturing environments. Its messaging structure establishes master/slave and client/server communications between devices. A relatively smaller percentage of installations are Modbus-certified.

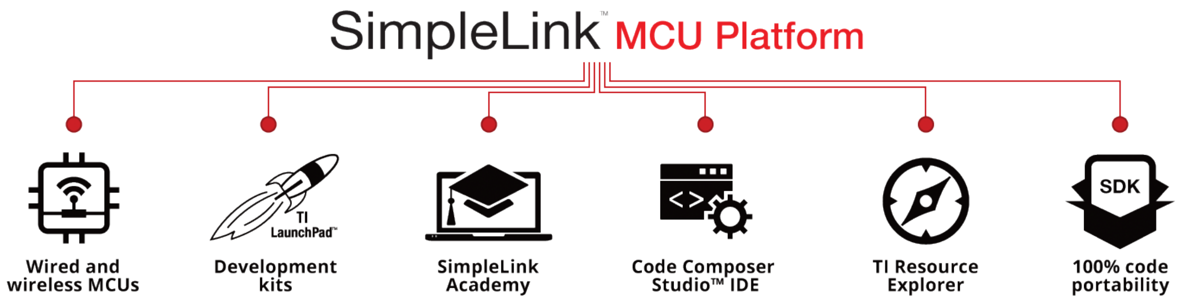
As we mentioned, there is a growing trend for wireless support in end-node applications, which today include multiple wireless protocols:

- ***Bluetooth*® low energy** is an open-source, standardized protocol designed to span personal, industrial and IoT networks. It is perfect for devices operating on small coin-cell batteries or for energy-harvesting applications. Bluetooth low energy has an abundance of use cases in building automation, ranging from small sensors to smart door locks. Bluetooth low energy technology has inherent smartphone interoperability, making it an easy choice to control end nodes using a phone or tablet.

- **Sub-1 GHz** is a long-range wireless protocol with lower radio-frequency (RF) attenuation through walls, making it a proven solution to achieve excellent indoor coverage. Sub-1 GHz is an ideal protocol for end nodes like elevator monitoring systems that must communicate through concrete walls and other barriers. Also, Sub-1 GHz has great traction in thermostats and motion detectors to provide wireless connectivity on small coin-cell batteries.
- **Wi-Fi®** enables a battery or line-powered end node to be quickly connected to the Internet. This allows building automation systems such as thermostats, various sensors, video cameras and even appliances to be easily and securely connected to the cloud. Users can leverage Wi-Fi communication to create highly innovative end nodes that can be remotely controlled or monitored using the Internet.
- **Zigbee** is a standards-based technology for remote monitoring, control and sensor network applications. The standard was created to address the need for a cost-effective, standards-based wireless networking solution that supports low data rates, low-power consumption, security and reliability. With its support of self-healing mesh networking, Zigbee is a decentralized network topology very similar to the Internet. It allows nodes to find new routes throughout the network if one route fails, making it a robust wireless solution.
- **Thread** is an open IPv6-based protocol allowing for easy connection with existing IP-based networks. This low-power wireless mesh network for home and building automation provides a robust framework for device-to-device, device-to-mobile and device-to-cloud communication. A Thread network is scalable to more than 250 devices, and with smartphone-enabled commissioning, it is easy to add nodes to the network. Millions of devices on the market today can support Thread with a simple software upgrade due to Thread's IEEE 802.15.4 MAC layer.
- **Gateways or multi-standard/dual-band devices** use some combination of the other protocols, such as Wi-Fi plus Bluetooth low energy, Sub-1 GHz plus Bluetooth low energy, Zigbee/Thread plus Bluetooth low energy and others. Combining multiple protocols into one application helps designers create flexible and robust BASs that are fully connected. By leveraging multiple wireless connectivity technologies, designers can combine the benefits of each protocol to achieve a mixture of long-range, cloud connectivity or smartphone connections.

Another important aspect of building automation applications is system security to prevent hackers from gaining control of sensitive devices like smart locks, yet security protocols require a large amount of processing power and memory that many devices cannot spare. TI's SimpleLink MCUs include on-chip hardware accelerators and engines to offload the controller and provide the robust security that today's devices need.

TI's SimpleLink MCU platform is a good choice for BCS applications. SimpleLink devices support many wireless standards and technologies found in building automation systems. In addition to the breadth of wireless selection, TI's SimpleLink MCUs are low power, thus aiding the creation of smart end nodes with long battery lifetimes—as long as 10 years. The SimpleLink platform also provides flexibility to add wireless connectivity as a stand-alone MCU or in a network processor configuration communicating with a host MCU. Designers can maintain their custom application code and



seamlessly add connectivity with the addition of a network processor.

Furthermore, TI offers both integrated circuit (IC) and module options for wireless MCUs. A module enables faster development with full integration, pre-certification and reduced RF design complexity. TI's wireless modules provide supply continuity and steadfast performance.

System energy automation

The primary role of a BAS is to bind the various systems and devices in a given facility. By connecting individual building elements, a BAS provides a centralized core managed from a main supervisor. This communication network infrastructure ensures reliable data transfer and logging.

By supporting various wired and wireless protocols in a BCS, it's possible to deploy a scalable bridging system that can access and control end nodes based on divergent protocols. These systems could also ascertain reliability while significantly improving operational efficiency. In addition to saving on operational and energy costs, data logging and cloud computing could enable the introduction of learning-based applications, cultivating more convinient lifestyle standards. Lower installation costs may also be possible as manufacturers invest in the next generation of BAS through pre-programmed application-specific installations.

With TI's SimpleLink devices, designers can develop end-node applications such as fire panels, intrusion panels, wireless locks, smart doorbells, smoke detectors and thermostats. The SimpleLink platform makes it easy to incorporate a variety of wired and wireless protocols with scalable, highly integrated, low-power ARM®-based MCUs. The new SimpleLink SDKs allow designers to learn one development environment and then use it to develop countless applications across any supported SimpleLink devices. Learn more about the SimpleLink platform and its developer ecosystem at www.ti.com/simplelink.

Conclusion

BAS developers continue to explore a scalable, cost-competitive solution that supports standardized open communication protocols. Wired and wireless protocols are now integrated into every facet of building control systems. TI's SimpleLink MCUs are highly integrated, low-power solutions that enable developers to quickly add connectivity protocols to end nodes in BCS systems. With enhanced security through dedicated on-chip execution environments, SimpleLink MCUs can offload the MCU and provide state-of-the-art security protocols. A common software platform means that code is reusable from application to application, making it quick and easy to add functionality to new or existing applications.

With rising energy costs, the future of building solutions lies in green buildings that also offer superior occupant safety and lifestyle convenience.

Resources

[1] IEA, “Energy Efficiency Market Report 2015.” (2015): 67. International Energy Agency. IEA. Web. Mar 6, 2017. <http://www.iea.org>.

[2] Alliance Commission on National Energy Efficiency Policy. *Residential & Commercial Buildings*. (7011 So. 19th St., P.O. Box 11700, Tacoma 98411-0700): APA-Engineered Wood Association, 2013. https://www.ase.org. Alliance to Save Energy, Jan. 2013. Web. Mar 6, 2017. <http://www.ase.org>.

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