Building automation for enhanced energy and operational efficiency

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Introduction

Commercial buildings contribute to 40 percent of energy consumption in the U.S. alone. Building services include monitor, control and maintenance of lighting, temperature control and water heating systems, among others. A 58 percent increase in electricity generation from 1985 to 2006 was mainly due to buildings' energy demand.[1] In the recent past, building construction technology advances have facilitated building management with relatively low energy consumption. With increasing susceptibility of the electricity grid to power outages, building owners are investing in automation of the network of building systems that subsequently reduces energy costs. These systems deliver self-sufficiency, improving the overall operational efficiency.

Building Automation Systems are deployed across all levels ranging from small building segments to larger building establishments. The Texas Instruments (TI) Sitara™ processors offer the flexibility to design automated applications enhancing the system energy performance. The AM335x Cortex®-A8 processors support speeds that span from 300 MHz to 1 GHz and are supported with the same scalable software package as the AM437x (Cortex-A9) and AM57x (Cortex-A15). In addition to the scalable frequency, pin-to-pin compatible devices enable our customers to innovate and develop a comprehensive range of solutions.

In this white paper, we will discuss building automation solutions, focusing on aspects of the Building Control System. TI's Sitara processors facilitate intelligent automation of the control systems. The scalable Sitara processor portfolio offers an opportunity to build a platform solution that also spans beyond Building Control Systems.

Building Automation Systems

Building Automation System (BAS) is a communication network infrastructure that manages various building services. Key to an effective BAS is having a ubiquitous system that can be deployed to serve new and old building technology as well as small and large commercial facilities. With such well-established automated solutions, competent energy management can be achieved through building-to-building communication rather than just building-to-grid communication.

Building Management Service (BMS) is a recurring expense. While automated systems could supervise regular building services, they could also be designed for failure detection and basic fault diagnosis. Early detection and well-recorded system

***Figure 1**. Building Automation System*

data could effectively contribute to enhanced operational performance. The data collected through connected systems can also be used to improve occupant lifestyle providing a green, convenient, and safe work and living environment.

In addition, the comfort and safety of building occupants are managed through a complex network of devices. These devices offer demand-based service that manage essential amenities such as air conditioning and lighting control.

Topology

Typically, the complex building automation network of devices includes a primary and secondary bus that is connected to various nodes in the system:

- Building Management Service
- Building Control Systems
- Zone controllers
- End nodes

Building Management Service (BMS) units host the application and data server. In addition to the servers, they are equipped with a user interface for data monitoring and control.

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

The primary and secondary bus could be connected to the devices such as

- Low-level controllers
- Simple input/output devices or
- End-user applications such as a room thermostat or local alarm monitoring system

The primary and secondary bus could be RS-485, Ethernet, CAN or a wireless network.

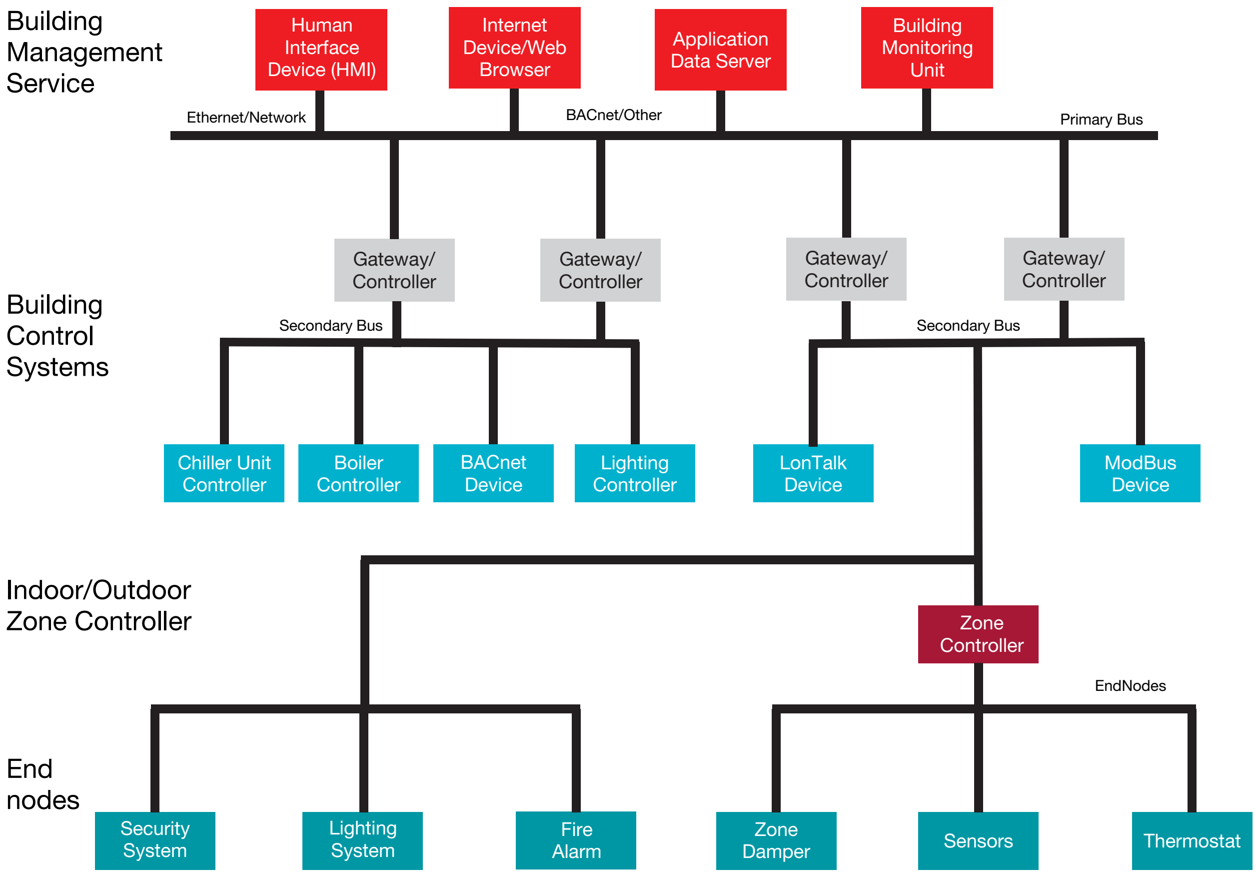

***Figure 2**. Typical BAS topology*

The applications in an **end-node** network of a BAS could be a security surveillance unit or a fire alarm system. It could also be an alarm system relaying arm/disarm information to the BMS units. An indoor or outdoor **zone controller** could be used to monitor and control the systems calling for cooled or heated air as needed.

Building Control System

Initial deployment of digital control systems in buildings started the trend of true automated systems. However, since no standards were established for communication, individual manufacturers invested in development of systems with proprietary communication protocols. Consequently traditional BAS solutions, although automated, were not inter-operable across various manufacturers.

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

Control Solutions

Control systems are used to monitor distributed devices in the BAS. This solution manages the priority structure of the network and provides feedback to other controllers. This core functionality of the controller can be combined with additional features providing differentiation and adding value to the system solution.

A BCS with adaptive control offers continuous fine-tuning of network elements. This also delivers real-time data on the status of the various nodes. With access to this information, maintenance and diagnostics can be realized for failure prevention and detection. The deployment environment having a flexible and scalable architecture enables customization of applications. These applications could also be provided pre-programmed, improving install time and decreasing engineering development time.

TI's Sitara processors support the implementation of BAS protocols. In addition to this, the rich peripheral set equips the system with flexibility to expand communication beyond wired to wireless connectivity solutions. Integration of wireless technology in BCS aids lower installation cost as well as improved performance and user experience. For instance, *Bluetooth*® technology could be used for commissioning and troubleshooting remote installations.

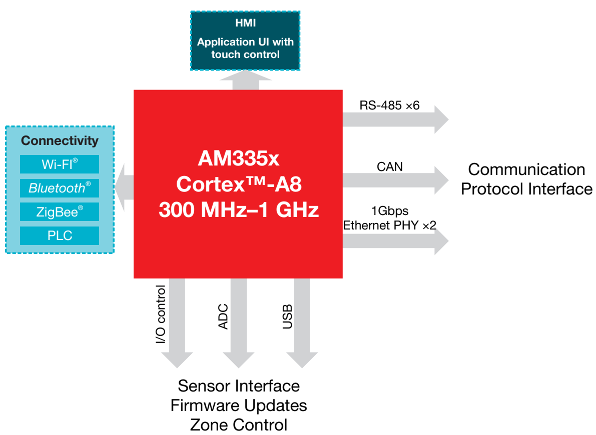

***Figure 3**. BCS based on a TI Sitara AM335x processor*

The flexible AM335x ARM® Cortex-A8 processors aid integration of various protocols on a single system. A remote user interface can be established by hosting a web server on the embedded Sitara processor. System features such as demand management, alarm and scheduling can be managed through this remote user interface application. Along with supporting standard BCS protocols, packet transfer through Ethernet using standard User Datagram Protocol (UDP) could be added serving as a protocol bridging system.

One of the most **prominent communication protocols** used in BAS systems is Modbus. **Modbus** is a truly open standard and is one of the most widely used protocols in the industrial manufacturing environment. Its messaging structure establishes master-slave, client-server communications between devices. A relatively smaller percentage of installations are Modbus certified.

BACnet is an open building automation control and communication standard that is 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, ISO-16484-5. **LonMark** standard is based on the proprietary communications protocol LonTalk. The LonTalk protocol establishes a set of rules to manage communications between devices, while LonWorks defines the content and structure of the information that is exchanged between them. Like BACnet, LonWorks has been accepted and adopted by the international standards organizations (ANSI/CEA 709.1 and IEEE 1473-L).

The Sitara AM335x processor evaluation modules (EVMs) and software offerings, including Linux® and TI-RTOS Processor software development kit (SDK), prove to be a great foundation for developing BAS. Layout and schematic reference design guide, diagnostics tool, core peripheral benchmark and software drivers significantly improve the development cycle accelerate time to market.

System Energy Automation

BAS primary role is to bind the various systems and devices in a given facility. By connecting individual building elements, it provides a centralized core that can be 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, a scalable bridging platform that can access and control end nodes based on divergent protocols can be deployed. While significantly improving the operational efficiency, these systems could also be used to ascertain reliability. In addition to lower operational and energy costs, use of data logging and cloud computing could introduce learning-based applications, cultivating higher lifestyle standards. As manufacturers invest in the next generation of BAS, lower installation costs may be achieved through pre-programmed application-specific installations.

In addition to the BCS applications, Sitara processors can be used to develop end-node applications such as fire panel, intrusion panels and thermostats. Taking advantage of the display and touch controller, as well as the in-built graphics accelerator, superior user experience can be achieved. For more information on smart thermostats, refer to TI's white paper [Smart thermostats are a cool addition to the connected home]().

Scalability

In addition to AM335x processors, TI's Sitara family offers processors with even higher performance. The AM437x Cortex-A9 processors provide a performance boost as well as a parallel camera interface. The AM57x processors provide single- or dual-core ARM Cortex-A15 processors, C6000 DSPs, and video acceleration capabilities. All of these devices are supported on the Processor SDK to maximize software reuse and to provide a consistent developer experience.

Conclusion

BAS developers continue to explore a scalable, cost-competitive solution that supports standardized open communication protocols. Flexible BMS tailored for easy deployment and user-

Core Feature	AM3351	AM3352		AM3354		AM3356		AM3357	AM3358	AM3359
Package	13×13 mm, 0.65 mm (ZCE)	13×13 mm, 0.65 mm (ZCE)	15×15 mm, 0.8 mm (ZCZ)	13×13 mm, 0.65 mm (ZCE)	15×15 mm, 0.8 mm (ZCZ)	13×13 mm, 0.65 mm (ZCE)	15×15 mm, 0.8 mm (ZCZ)	15×15 mm, 0.8 mm (ZCZ)		
CPU Speed (MHz)	300, 600	300, 600	300, 600, 800, 1000	600	600, 800, 1000	600	300, 600, 800	300, 600, 800	600, 800, 1000	800
Operating Temperature Range	Commercial: 0°C to 90°C Extended: –40°C to 105°C	Commercial: 0°C to 90°C Industrial: –40°C to 90°C Extended: –40°C to 105°C				Extended: –40°C to 105°C	Commercial: 0°C to 90°C Industrial: –40°C to 90°C Extended: –40°C to 105°C			
Core Internal Memory	64KB SRAM shared w/ Data 32KB Cache, Programmable 32KB Cache									
On-chip L2 (KB)	256									
External Memory Interface	DDR2/DDR3/DDR3L/mDDR (LPDDR) 2 ×16 bit NAND ECFC									
Graphics				PowerVR™ SGX 3D graphics					PowerVR™ SGX 3D graphics	
Operating System Support	Linux®, Android™, RTOS, Windows Embedded®, no-OS									
PRU-ICSS (200 MHz)						2× 32-bit RISC processor w/ 8KB L1P & L1D + standard industrial protocols		2× 32-bit RISC processor w/ 8 KB L1P & L1D + all industrial protocols	2× 32-bit RISC processor w/ 8KB L1P & L1D + standard industrial protocols	2× 32-bit RISC processor w/ 8 KB L1P & L1D + all industrial protocols
EMAC 10/100/1000	1 port	1 port	2-port switch	1 port	2-port switch	1 port	2-port switch			
USB 2.0 OTG + PHY	1	1	2	1	2	1	2			
Serial Ports	6× UART, 2× SPI, 3× I^2C, 2× McASP, 2× CAN, 8× timers									
System	EDMA, WDT, RTC, 3× eQEP, 3× eCAP, JTAG, ADC (8 ch)									
Parallel	3× MMC/SD/SDIO, GPIO									

* Standard protocols for AM335x SoCs include protocols such as EtherNet/IP, PROFINET® RT/IRT, PROFIBUS®, SERCOS® III and more.
All protocols for AM335x SoCs include standard protocols plus EtherCAT® and POWERLINK.

***Figure 4**. TI's Sitara™ AM335x processor is a scalable platform with six pin-to-pin compatible devices*

friendly configuration significantly contribute towards affordable operational costs. TI's Sitara AM335x processors offer a flexible architecture which is a combination of a rich peripheral set and scalable processor speed. This processor offers pin-to-pin compatibility and a wide temperature range, making it ideal for cross-platform common-core solutions.

With raising energy costs, grid-hardened green buildings that also offer superior occupant safety and lifestyle convenience is a compelling proposition to future building solutions.

For more information about TI's Sitara AM335x ARM Cortex-A8 processors, please visit www.ti.com/dsp-arm-bldgautowp-mc-lp.

Resource

[1] http://apps1.eere.energy.gov/buildings/publications/pdfs/corporate/bt_stateindustry.pdf

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