CHAPTER

Commercial Building Automation

13

13.1 Introduction

A Building Automation System (BAS) is a computerized, intelligent system that controls and measures lighting, climate, security, and other mechanical and electrical systems in a building. The purpose of a BAS is typically to reduce energy and maintenance costs, as well as to increase control, comfort, reliability, and ease of use for maintenance staff and tenants.

Some example use cases:

- Control of heating, cooling, and ventilation based on time of day, outside temperature, and occupancy (e.g. Morning Warm-up).
- Automatic control of air handlers to optimize mix of outside air in ventilation based on, for example, inside temperature, pressure, and time of day.
- Supervisory control and monitoring to allow maintenance staff to quickly detect problems and perform adjustments.
- Outsourcing of monitoring and operations to a remote operations center.

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- Data collection to provide statistics and facilitate efficiency improvements.
- Alarms for high carbon monoxide and carbon dioxide levels.
- Individual metering per apartment (to give incentive to save energy in multi-tenant buildings).
- Intrusion and fire detection.
- Building access control.

A BAS is normally distributed by nature to allow every sub-system to continue operation in case of failure in another system.

A BAS consists of the following components (Figure 13.1):

- Sensors (i.e. devices that measure, such as thermometers, motion sensors, and air pressure sensors).
- Actuators (i.e. controllable devices, such as power switches, thermostats, and valves).
- Programmable logic controllers (PLCs) that can handle multiple inputs and outputs in real time and perform regulating functions, for example.
- A server which monitors and automatically adjusts the parameters of the system, while allowing an operator to observe and perform supervisory control.
- One or more network buses (e.g. KNX, LonWorks, or BACnet).

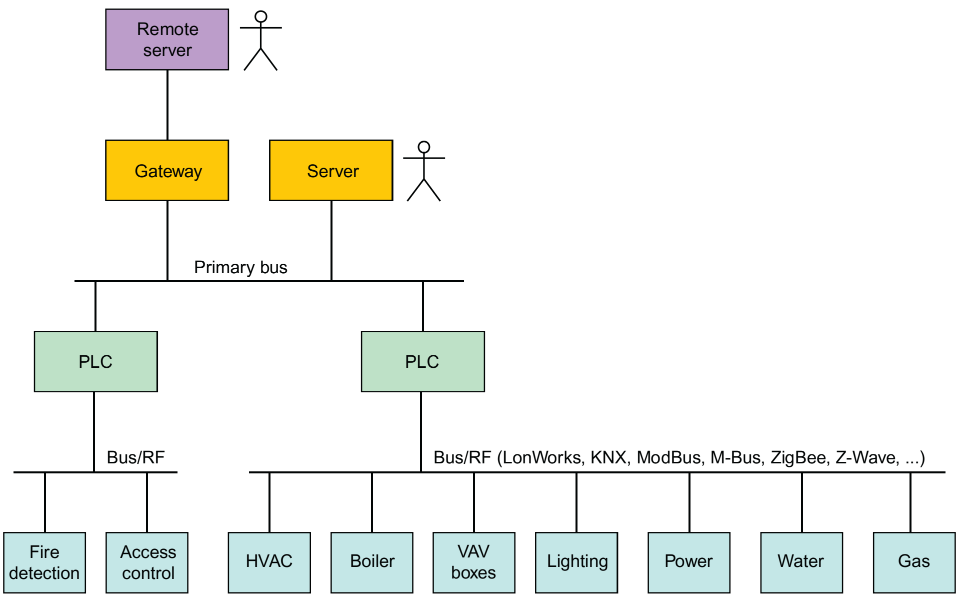

FIGURE 13.1

Central parts in a BAS.

We have divided the case study into two phases. In Phase One we give an example of what is commonly available today in regards to building automation. In Phase Two we explore new opportunities for building automation, such as the Smart Grid and the IoT.

13.2 Case study: phase one — commercial building automation today

13.2.1 Background

Company A wants to improve energy efficiency in their buildings and become GreenBuilding Partner (2013) certified, which requires lowering their energy consumption by at least 25%.

After discussions with a building automation company (Company B), they have come to understand that this is a very good investment that will quickly justify itself in terms of reduced energy costs. They agree on a five-step plan that starts with collecting data from the buildings, followed by analysis, adjustments, and connecting the systems in the buildings to a local server, and finally connecting the buildings to a remote operations center.

They can now start with collecting data from existing systems. In some cases this requires new meters to be installed. Everything from water usage to heat and electricity consumption is logged continuously, as well as performance of the ventilation and room temperatures.

By comparing the key performance indicators with comparative figures, the need for corrective actions is assessed and used as a basis for an action plan that consists of adjusting the existing systems and installing new software. These adjustments quickly increase the efficiency of the systems and are continuously optimized during the project. Examples of adjustments are hot water temperature, improved control of indoor temperatures, as well as better control of fan and pump operation to avoid unnecessary operation.

One of the most central features of the improved system is the new web-based E-report. It provides information about current energy consumption and other key parameters from the buildings. This information is used to make both short-term decisions as well as long-term planning. Everyone has access to the web portal because it's not only important for the maintenance staff, but also needed to create awareness across everyone in the company.

The next phase of the project consists of connecting the systems in the buildings and analyzing the dynamics to be able to perform intelligent control. This both improves performance as well as reduces maintenance costs.

The final step to completion involves setting up a web-based Supervisory Control and Data Acquisition (SCADA) system for remote monitoring of the building systems. Through the web portal, the users can access information from the buildings in a coherent manner. Company A decided to outsource the operations and daily maintenance of the systems to Company B by utilizing their cloud-based offering. Company B's remote operations center is continuously monitoring the building systems. When building system operations deviate from their expected behavior, Company A's maintenance staff and their supervisors are notified by SMS and email. Typical events that can trigger a notification are, for example, mechanical failures or undesirable temperature deviations. Apart from notifications, Company B can also assist with equipment operation and adjustments remotely. For Company A, this arrangement is perfect because their in-house maintenance staff can respond to an alert 24 hours a day.

For Company A, the most important improvement has been the 35% energy reduction after the completion of the project. Another critical aspect has been the knowledge transfer from the experts at Company B that allows Company A to maintain the efficiency of the systems as well as the ability to continuously improve the operations of them.

13.2.2 Technology overview

Figure 13.2 depicts the setup for Company A.

Each building is equipped with a set of meters and sensors to measure temperature, water consumption, and power consumption, as well as one or more PLCs.

As seen in Figure 13.2, the PLCs perform real-time monitoring and control of the devices in the building. They also feature a user interface for configuration and calibration of (for example) the regulators, curves, and time relays. It is possible to remotely configure the PLCs from the Operations Center using the PLC Control system, which is connected to the PLC via a 3G-modem and an Internet Protocol (IP) modem that converts between RS-485 networks and Transmission Control Protocol/Internet Protocol (TCP/IP) networks. The PLCs communicate with the devices using several protocols, such as M-BUS, analog, digital, and Z-Wave, which is a low-power radio mesh-network technology. All logic necessary to operate the buildings is contained within the PLCs, allowing for minimal bandwidth requirements on the connection towards the

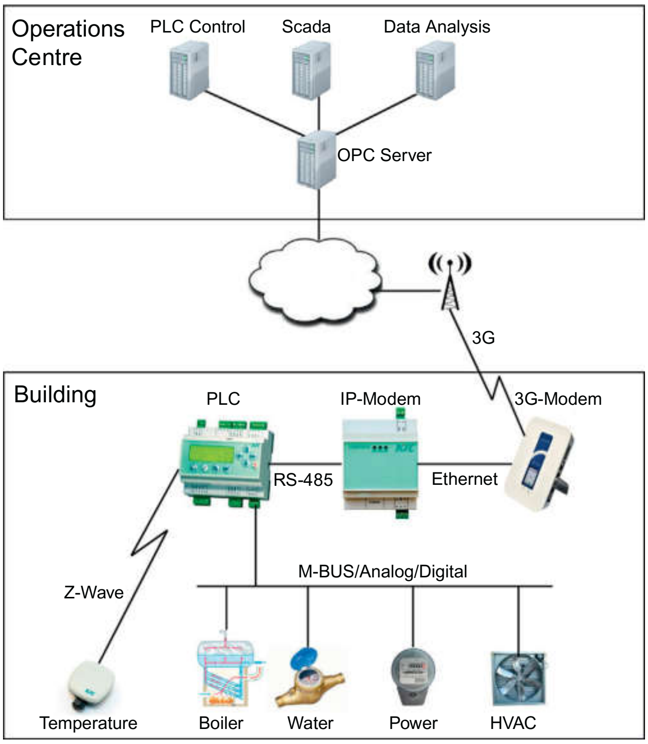

FIGURE 13.2

Illustration of the BAS.

Operations Center as well. It also means that the building systems can remain fully operational during periods of network outage.

The OLE for Process Control (OPC) server provides access to data, alarms, and statistics from the PLCs. When a value is requested from a user, a request is sent from the user's OPC Client to the OPC Server, containing an OPC Tag that identifies which PLC to contact and which value to ask for. The type of OPC communication used is called OPC Data Access. The OPC server then contacts the PLC in question and asks for the value using a protocol supported by the PLC (LonWorks or ModBus).

The SCADA system is used for operational monitoring of the buildings and provides information from all the relevant building systems. It uses the open and standardized OPC protocol, which enables integration with devices from many different vendors. The maintenance and operations staff can connect to the system using a web browser with a username and password to access dynamic flowcharts, drawing tools, timers, set points, actual values, historic readings, alarm management, event logs, as well as configuration for notifications over email, fax, or SMS.

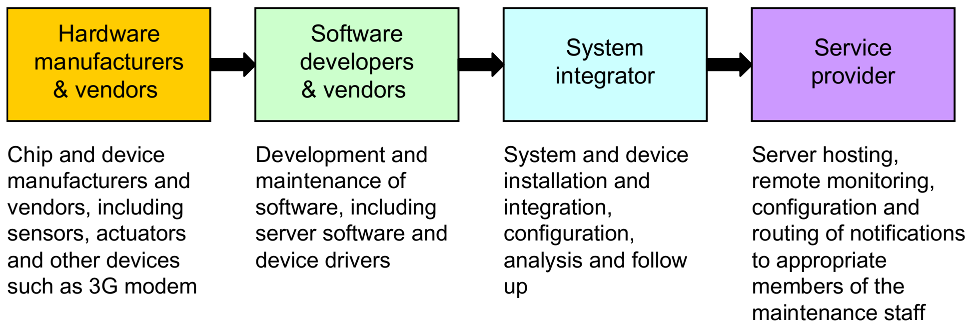

FIGURE 13.3

Applied value chain for Company A's system.

The Data Analysis server logs all historical readings from the buildings and makes it possible to follow up on different aspects of the energy and resource consumption, satisfying the varying needs of the tenants, economy department, and landlord. Through the OPC server it's possible to gather readings from all the building systems, regardless of vendor. Typical reports include trends, cost, budget, prognosis, environment, and consumption of electricity, heating, water, and cooling.

13.2.3 Value chain

Figure 13.3 shows an applied value chain.

13.3 Case study: phase two – commercial building automation in the future

13.3.1 Evolution of commercial building automation

Two major factors will drive the evolution of Building Automation: information and legislation (Figure 13.4).

Access to well-packaged information will provide the basis needed for decisions and behavioral changes. This can (for example) be electricity prices or where and when energy is used, and will allow for well-founded decisions that provide the best results.

Legislation, and taxes or tax credits to some degree, will provide the second driver. Legislative demands on green buildings and the Smart Grid will give rise to new opportunities, such as Demand/Response, Micro Generation, and Time-of-Day Metering.

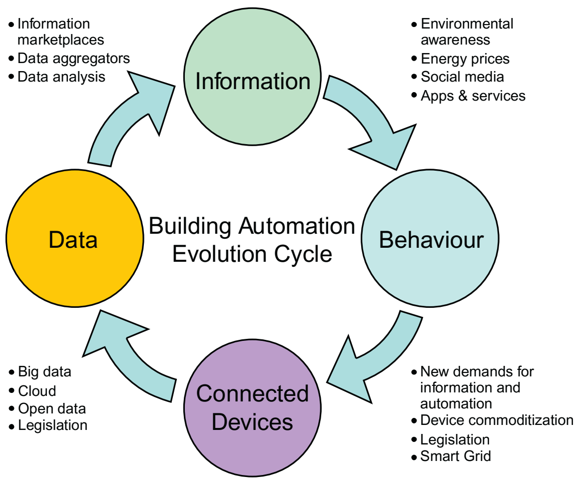

FIGURE 13.4

Building automation evolution cycle.

Market growth will result in economies of scale, standardization and commoditization, driving down prices, and increasing availability of devices and services. It will be possible to buy advanced devices off-the-shelf, perform installation, and connect them directly to service providers on the Internet.

13.3.2 Background

A few years have passed and Company A has decided to outsource the maintenance of its buildings to a local contractor who provides services to several other customers in the neighborhood. This will save money since that will enable them to utilize a shared caretaker pool.

At the same time they plan to upgrade their buildings to become fully automated with, for example, occupancy sensors, automated lighting, and integrated access control. To make this cost efficiently, they intend to make use of the existing IP infrastructure in the buildings, which also saves on operating expenditures as the network administrators can also manage the BAS infrastructure. According to studies, a converged IP and BAS network can reduce maintenance costs by around 30% while also lowering the initial investment for installation and integration by around 20% (according to studies performed by Cisco®). A shared infrastructure also leads to increased energy efficiency.

New political incentives in regards to energy efficiency have increased the development pace in the building automation area. Many neighboring buildings in Company A's area are now fitted with building automation, which allows for sharing of information and resources. The increased customer base has also enabled new niches in the value chain, which has been split up to a large degree. Where before the rule was to have one single integrator and service provider, we now see a multitude of new actors, such as specialized service providers for remote monitoring, security, optimization, data collection, and data analytics. This allows Company A to choose freely what combination of service providers to use, while also providing a smooth transition when moving to a new provider. This is made possible by a new niche in the value chain: the Cloud Service Broker (Figure 13.5).

The process of integrating with the maintenance contractor's systems is simplified by the service broker because it provides immediate access to Company A's BAS. The caretakers can use their own specialized software as the service broker provides a bridge that can convert between several common protocols used for building automation.

When it comes to selection of devices, Company A opts for using standardized protocols to avoid vendor lock-in. They also decide to keep certain parts of the old system, as these would be too costly to replace. To still benefit from a fully integrated system, they also invest in a constrained application protocol (CoAP) gateway that translates between legacy devices and the new system.

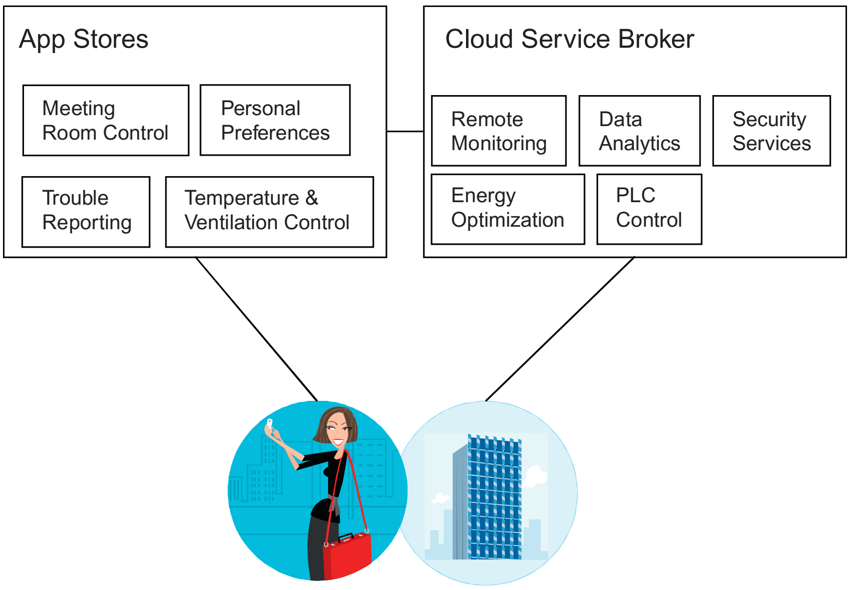

FIGURE 13.5

Cloud Service Broker.

By exporting historical data and configuration parameters from the old OPC Server it's possible for Company A to choose new service providers that can replace the old systems for PLC control, SCADA, and data analytics with a minimum of manual effort.

As an added service, the new platform also provides data brokering. This gives access to a multitude of data sources, such as the following:

- Historical and current KPIs to similar buildings.
- Integration with local government facilities.
- Weather forecast information.
- Utility prices, both current and future.

Apart from providing access to new service providers, the cloud broker also hosts a client API that enables third-party app developers to create smartphone applications. A number of users have purchased apps that allow them to do the following, for example:

- Control HVAC settings in meeting rooms.
- Report problems and service requests.
- Integrate with Outlook to adjust meeting rooms in advance.
- Create personal profiles to automatically adjust room settings.
- View instant and historical personal energy consumption and compare to others using social media.

13.3.3 Technology overview

Thanks to the rapid development of technologies for IP Smart Objects, it's now possible to use IP for both constrained devices, such as battery-powered sensors and actuators.

The new system is to a large degree based on IP technology (Figure 13.6). There are several IP-based protocols to select from, but in this case CoAP and Sensor Markup Language (SenML) were selected. CoAP provides both automatic discovery as well as a semantic description of the services the device provides. This drastically reduces installation costs, as much less configuration is needed. CoAP is similar to Hypertext Transfer Protocol (HTTP), but is binary to reduce the size of the messages. It also defines a Representational State Transfer (REST)-like Application Programming Interface (API) optimized for M2M applications. As with HTTP, a format for the content is also needed, in this case SenML, which is used as a format for sensor measurements and device parameters.

As mentioned before, there are still a few legacy devices, and these need a gateway to enable communication with the IP-based systems.

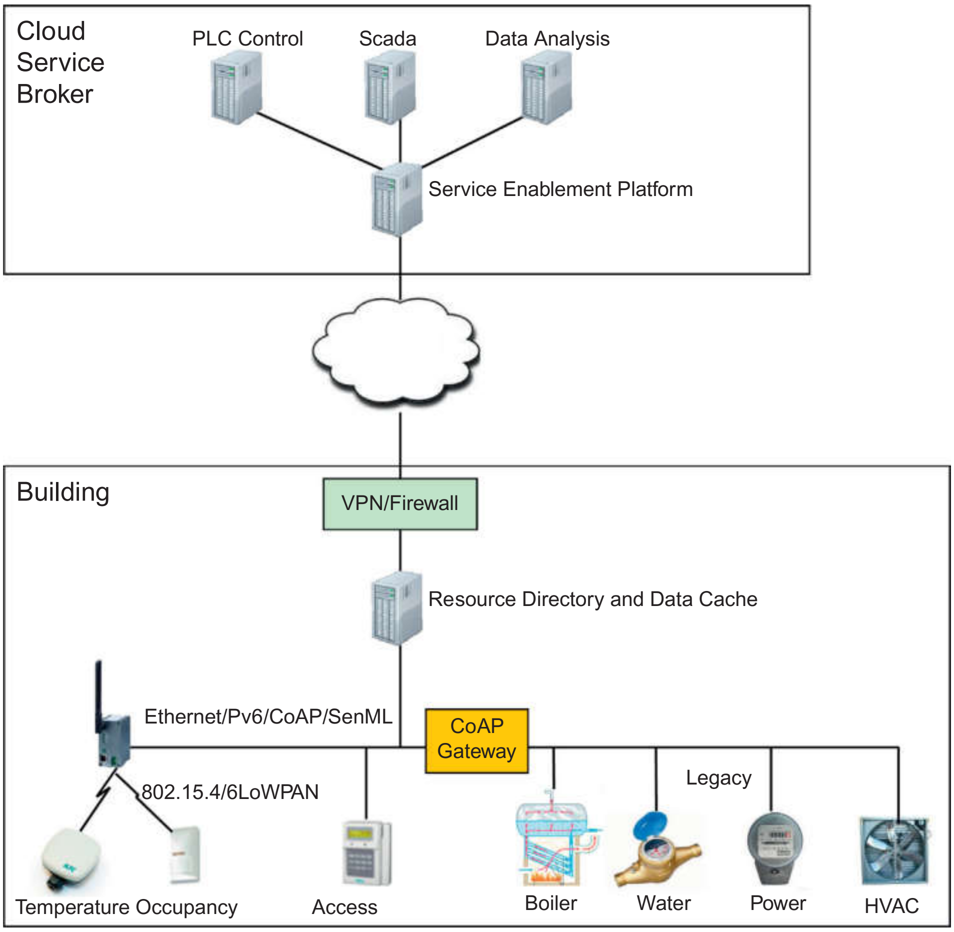

FIGURE 13.6

Architectural overview of the upgraded system.

A local Resource Directory and data cache is also installed to keep track of all the devices in the company network. This allows local lookups of devices and data, and serves as a safeguard in case of failure.

To protect the system from intruders, a normal network firewall is used. For the connection towards the service broker and the service providers, a permanent Virtual Private Network (VPN) connection is established.

Historical data is exported from the OPC server to the Cloud service broker's data storage to make it available to new service providers. Apart from data storage, the Cloud service broker also provides management functionality for control and data access, as well as access to specific service provider's management portals. It also offers a global Resource

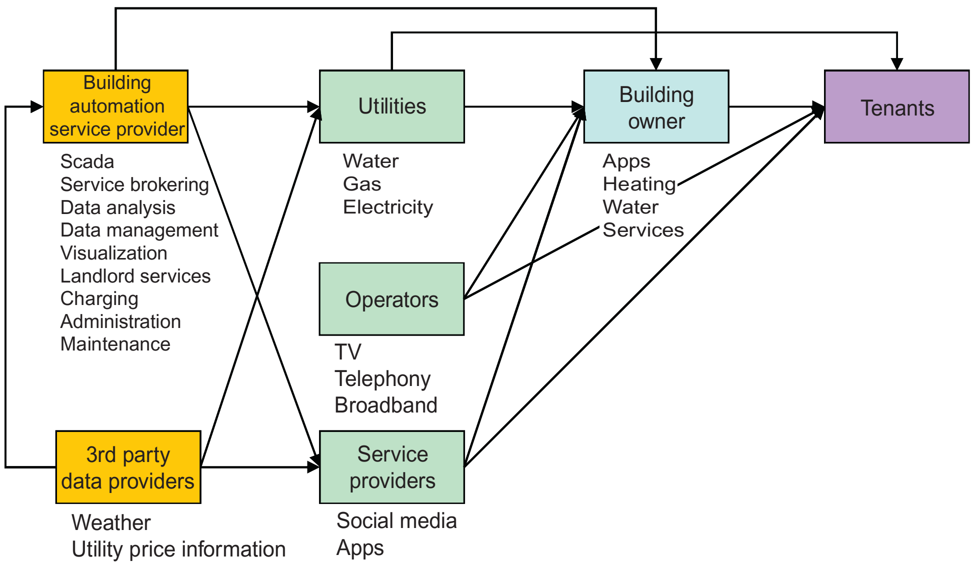

FIGURE 13.7

Evolved value chain for building automation.

Directory with semantic resource and data description, along with a contextual model that covers schematics, geospatial information, and indoor location.

13.3.4 Evolved value chain for commercial building automation

As the demand for M2M services grows, new niches in the value chain will emerge, such as information brokers, service brokers, and service enablement providers (Figure 13.7). These will enable new use case areas by allowing vertical domains to be integrated (e.g. security, energy, waste management, police, and public transport). It will also provide the openness needed for third-party service providers to create apps and social media integration, to allow for (for example) comparisons with neighboring buildings, competitions, and end user involvement. Privacy and security will, however, be essential to build up the trust needed for this ecosystem to develop.

In addition to new use case areas, major improvements can be expected within the areas of efficiency, convenience, comfort, reliability, and safety.