Building management and control systems (BMCS) – Part 2

What is a Building Management and Control System (BMCS)?

A building management and control system (BMCS) controls and monitors the internal environmental conditions of commercial buildings. They are also referred to as building management systems (BMS), building automation systems (BAS), and building automation and control systems (BACS).

A BMCS consists of a number of digital controllers which communicate via a network infrastructure and report to a computer referred to as a head end, supervisor or operator workstation. The function of the operator workstation is to send operational parameters to the controllers, such as set points and time schedules. Conversely, the controllers can send operational information to the operator workstation such as temperatures, alarms and system performance information.

The controllers are digital and operate with embedded software which has been developed specifically for HVAC control known as direct digital control (DDC). The software has incumbent control algorithms or logic, which can perform a multitude of tasks when configured in a sequence. Configuration of the DDC software is known as control logic, control sequences, or simply code.

Digital control of buildings has been available since the late seventies, but took hold of the industry during the eighties. Prior to this, pneumatic or electric controls were used which often operated on a standalone basis.

During the infancy of BMCS, the operator workstation was instrumental to the overall operational performance of the system. For instance, trend logging and time schedules would be performed from the workstation software which put an onus onto the reliability of performance of the computer hardware. This style of architecture relied upon the communications network and created large quantities of traffic between the controllers and the workstation. More recently, this functionality has been placed into the controllers to create a truly distributed system which does not rely on a single component. The terms BMCS, BMS, BAS, and BACS refer to the complete control system and not just the operator workstation and associated software.

The relationship between BMCS and essential services

The functionality of a BMCS stops short of the control of essential systems such as standby power generators, and building safety systems such as fire control or smoke management systems. Due to their critical nature, the control of essential services requires strict compliance with Australian Standards and building codes. Where a BMCS might share information across its network to provide control variables, essential systems use local information and hard wired interlocks for reliability and resilience. A BMCS may, however, monitor the status of the essential services plant to provide reports and alarms to the operator workstation.

In some designs, an item of plant may have a dual purpose. For instance, a relief air fan could also be providing smoke management. In this scenario, the BMCS would provide the relief air control strategy, and the smoke management control system would provide the smoke management control strategy. The smoke management control system will take priority over the BMCS whenever the system is in smoke management mode. This priority of control will be implemented by control signals directly connected to the associated fans, damper etc without the reliance upon the BMCS controllers or network. Items of plant considered as life safety equipment will be set up as islands of automation; they can stand alone and operate independently from other systems.

Levels of BMCS

A BMCS architecture typically has three levels:

- Field level,
- System level, and
- Management level.

The field level refers to application specific controllers, such as terminal devices including fan coil units, and variable air volume boxes and control peripherals, such as sensors and valve or damper actuators.

The system level, also known as the automation level, is associated with controllers serving the main plant such as the air handling units, chillers and boiler control.

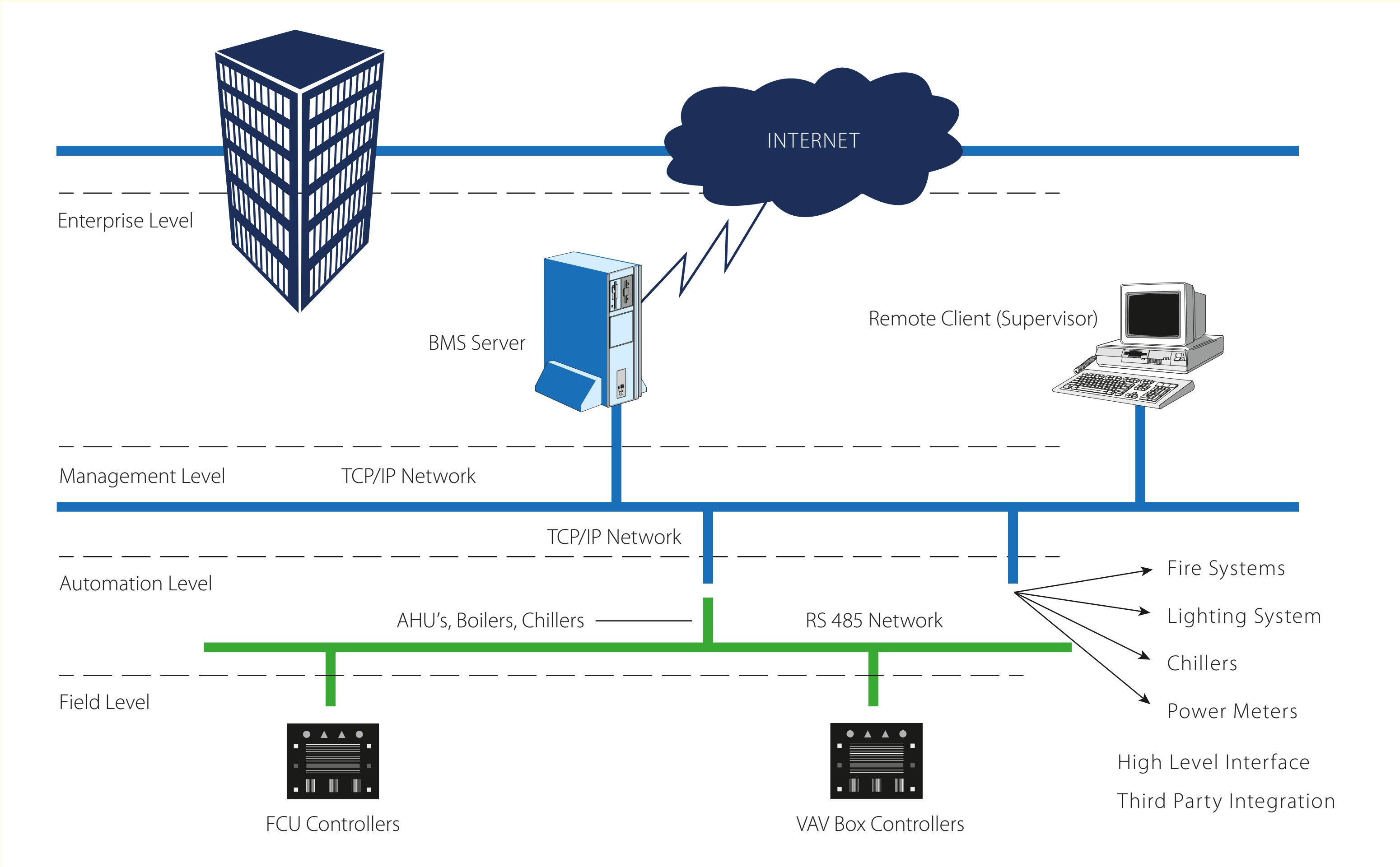
The management level comprises the BMCS server and the operator workstation, also known as the head end or building dashboard. The management level of control allows the management and monitoring of the control system from a single point.

In addition to these three typical levels, in some installations there is a fourth level, the enterprise level. This sits above the other levels usually within a corporate network to provide data analysis such as asset management.

Very simple systems may not require the management or enterprise levels (i.e. a two level architecture) and this control topology is more correctly referred to as direct digital control.

What is a DDC controller?

Direct digital controllers (DDC) reside upon the BMCS network and share information with the system. Their primary function is controlling mechanical equipment such as fans, pumps valves, and dampers. These controllers typically have two types of functionality:



BMCS architecture

- Fixed function, or
- Freely programmable.

The fixed function controller, otherwise known as application specific controllers, are traditionally associated with field terminal devices such as fan coil units and variable air volume boxes. The controllers have DDC software which has been factory pre-configured to carry out specific tasks. They have a small footprint or spatial requirement with limited fixed input and output channels to cater for the local field sensors and control peripherals.

In many installations there are numerous terminal devices which control identically. These controllers provide an economical solution as they do not require any programming. The fixed functionality, however, does present problems if the system design has specified requirements beyond the standard controller's application capability. In this instance, a freely programmable controller is required.

A freely programmable controller offers the flexibility to write a control strategy by either text (plain English) programming or graphical flow charts. In recent years, manufacturers have developed graphical programming applications known as graphical function blocks; these can be easier to follow than the text programming applications.

The hardware associated with the DDC controllers will vary between manufacturers. There are controllers with onboard inputs and outputs (IO) and controllers that have external IO being modular in design. Both have their pros and cons.

Controllers with onboard IO are considered more resilient than the modular approach due to the processor being directly connected to the IO channels. However, they can have a restrictive footprint when retro fitting into existing control panels. The modular systems offer flexibility of installation and can be pre wired off site.

BMCS and network communications

All DDC controllers have the ability to communicate on a network. The types of networks used within a BMCS have been developed in line with standard information and communications technology (ICT) networks. The different types of networks used are associated with the three level architecture topology as described on page 15.

The field level controllers communicate on a simple network infrastructure physically connected together in a daisy chain.

The system level controllers typically have two levels of communications. One for the field level network and one for the system level network. The system level network, generally Ethernet, provides a higher speed and wider bandwidth to cater for large amounts of data transfer. This type of controller also acts as a network router to direct traffic across the field level network and the system level network.

A communication network consists of the following two main elements:

- A transport mechanism.
- A communications protocol.

Both are equally as important for communications compatibility between devices. The transport mechanism refers to the type of physical media being used (e.g. wire, optical fibre, radio link), and the protocol is the language of the data which is a set of common rules for the communication signals.

Transport mechanisms or media used in a BMCS can include:

- Master Slave/Token Passing (MS/TP) - Serial communications using an EIA-485 signal in a daisy chain configuration.
- LonWorks - Based on the proprietary Neuron chip.
- Ethernet - Data transmission up to 1 Gbit/s on a typical ITC medium.

Network communications can be extended beyond the boundary of the BMCS by connection to the internet for remote monitoring and control functionality.

Web-based systems and remote monitoring

Remote monitoring has traditionally been via a dial up telephone line. Currently, with the advancement of telecommunications, remote monitoring is generally via the internet, due to the speed and reliability available. There are broadly two types of BMCS communications architecture:

- Web based, and
- Non web based.

A web based system behaves like an internet site, which serves pages of information, which can be accessed by a standard web browser.

A non web based system uses proprietary software to view the system which can be accessed using either a separate web server application in conjunction with the BMCS operator workstation software, or a remote desktop application.

Some web based systems require additional software to be installed on the client computer, which often conflicts with company procedures when accessing from a corporate environment.

Systems which do not need any additional software for access use a "thin client" arrangement, which depends heavily on some other computer or server to fulfil its computational role. This can create security issues in certain circumstances.

Information gathering

Significant functionality of the BMCS derives from its ability to capture operational performance information of the connected equipment either instantaneously, historically, or at pre defined time intervals. As well as monitoring critical variables and generating alarms system, operating and performance information can be collected into trend logs of system performance which can provide invaluable information for building operators, system maintainers, engineers, and designers.

Trend logs

The term trend analysis refers to the concept of collecting information at regular time intervals and attempting to identify a pattern, or trend, by analysing the information. Trend log is the term used for the data files compiling the trend variables for analysis. A trend log is created by sampling and recording a system point at a predefined interval. This interval can be either time based or change of value (COV) based. A trend log can be associated with any point on the system either digital (on/off also known as binary) or analogue (variable).

Trend logs can create large amounts of unnecessary data if not managed correctly. For instance, a trend log set up as a COV, will record the point value whenever there is a value change outside of the predefined limits. A temperature sensor log may be set up with a COV of 0.1°C. Every time the temperature sensor reads a 0.1°C change, the value will be recorded. This small incremental change of value in temperature would not be appropriate in most cases.

Trend logs typically reside within the system level DDC controllers, which have a limited capacity for storage. When the memory allocated to trend data is full, the information will either be uploaded to the BMCS server or the oldest data will be over written. This depends on how the system has been set up. Alternatively, some field level controllers have trend logging capabilities. Again, data storage capabilities and protocols need to be addressed.

The trend log data can be used to generate a graph on the operator workstation, or text files which can be imported to external processes such as spreadsheet applications. A graph can be set up to display multiple points of information for comparing different values over the same time intervals.

When a multiple point graph is required, it is important to make sure that all the point's trend sample intervals are identical and the time clocks within the controllers are synchronised. ■

The content in this month's Skills Workshop originates from the AIRAH Application Manual DA28 – Building Management and Control Systems (BMCS).