Automatic control system

All buildings almost irrespective of their size require some form of control system that may range from a simple thermostat through to a complex computer based control system running artificial intelligence with cloud-based services.

Within the UK building services industry there are perhaps five key suppliers of control systems:

- Johnson Control
- Honeywell Controls
- Trend
- Schneider
- Siemens

These companies have merged with numerous other organisations such as:

- Satchwell
- Tour & Anderson
- Andover
- Landis & Gyr
- Staefa
- Barbara Coleman
- ABB

and there are a number of smaller and perhaps less well known companies such as:

- Privia
- Distech
- Automated logic corporation
- Cylon
- North building technologies
- Sauter
- Easy I/O.

Over and above all this there are other control suppliers for plant and equipment particularly DX heating/cooling systems both for office air conditioning and office ventilation plant. These include:

- Mitsubishi
- Panasonic
- Samsung

To complicate the matter even more particular plant suppliers also provide control systems for such equipment as:

- Boilers
- Chillers
- pressurisation units
- electrical load shedding
- lighting

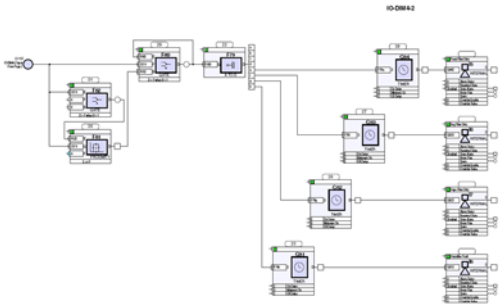
Evidently with many different suppliers each has developed their own control software, communication protocols and user interfaces.

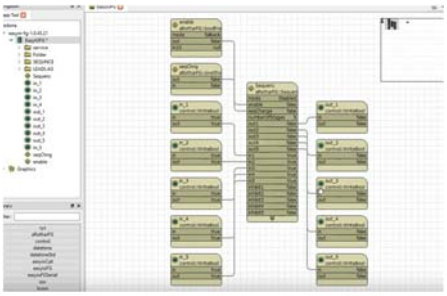
Control strategy software

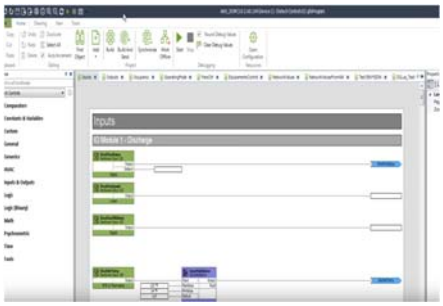
The software within the controllers provided by all and any of the previously listed companies was initially specific to their organisation and required licensed access and extensive training.

However within the past 15 years the controller specific software has tended to become very similar and makes use of block programming with simple tie lines between input and outputs with the blocks having specific actions that in themselves include complex software.

The examples below are from 3 different suppliers and it can be seen that the block diagram is used by all and each block is identified to its purpose and the inputs and outputs are connected together by a wire line.







There are several general standard communication protocols these include

- Modbus - which is extensively used within the electrical industry, motor automation, factory production lines
- KNX - this is a lightweight communication system more often seen in Europe than the UK.
- M-bus - this is a communication network developed for meters and is extremely simple but slow transmit of information.
- DALI - a protocol used within the lighting industry.
- Other companies use their own communication system generally based on RS-485 protocol.

Fortunately ASHRAE recognised the challenge of multiple communication protocols and in 1987 started development of a common protocol named **B**uilding **A**utomation **C**ontrol network now more commonly known as BACnet.

It should be noted though that BACnet is a communication protocol it is not software used to write strategy within controllers. The strategy within the controllers is still supplier specific but as can be seen above is generally block based and fairly easy to read and understand. Experience shows that most BMS software writers and most BMS commissioning engineers can easily move between companies and that the development of the operating strategy software does not cause them to much problem.

BMS user interface

For each project there is generally a requirement that a dynamic graphic is provided through which the user is able to view, manage and adjust the operation of the mechanical plant and equipment.

In simple terms the graphics are just a representation of the plant with click boxes, drop-down dialogue boxes and keystrokes through which the user can access information.

However, behind-the-scenes the overarching BMS graphics, history logging and alarm handling package can be quite complex. Each BMS supplier has developed their own graphics package which is specific to their product and often software writers and commissioning engineers spend more time trying to understand the graphics package than the control strategy that maintains the building conditions.

Next generation controllers

There has been a sea change within the BMS industry in the past 5 years in that one dominant control system supplier has developed a controller that incorporates services required by the **I**nternet **O**f **T**hings, is able to act as a web server, provides highly sophisticated graphics, much of the operating software is open source and freely available, ability to provide standard tag names along with analytics and all at a competitive price.

This company is known as Tridium, based in America and are currently owned by Honeywell although there are numerous distributors outside of the Honeywell envelope. Within the UK the Tridium solution can either be bought direct from the Tridium Corporation, through Honeywell ,any of the major BMS providers and indeed from numerous control specialist.

All the main suppliers detailed at the beginning of this report offer a BMS based both on their own systems and utilises the Tridium Niagara framework as the basis of their flagship controller.

The ubiquitous name for the Tridium controller is a JACE however, this is rebadged and renamed by suppliers such as TONN 8, EC-BOS -8, EIO-J-8000.

The significance of the '8' is that Tridium refer to their most sophisticated controller as the JACE 8000.

The BMS also tend to use the Tridium solution currently known as N4.

The Tridium controller communicates via BACnet/IP, BACnet/MSTP and more importantly contains numerous gateways that allows third-party protocols to be converted to BACnet. These gateways provide a solution where integration between disparate control systems is required and generally there are hardly any interfaces that are not available through the Tridium controller. As the software is open source anybody can develop gateways if required however, it is unlikely that any system would be installed for which a driver is not already available.

The controllers are Web servers and those with a higher specification are provided with MQTT communication protocol which is the de-facto solution for the IOT world.

It should be recognised that a JACE 8000 would not be used for remote terminal unit such as fan coils and is often not used for small control systems mainly because of its cost. However, so long as the terminal device controller communicates BACnet then the JACE is the go to central plant Integrator. Smaller controllers are available from the Tridium range as well as controllers from many other companies and so long as BACnet is the communication protocol integration will not be an issue.

Draft specification for an open protocol BMS solution.

The Automatic Control system, or Building Management System (BMS), for the central plant will provide control and monitoring for the complete services installation. The system will be a Direct Digital Control (DDC) type with fully distributed intelligence. The system shall be configured to allow full access via a web browser and be expandable to other systems by use of native BACnet to ASHRAE's BACnet/IP protocol standard CEN ISO 16484-5 or Modbus and the like, LON shall not be provided.

The terminal device controllers shall be freely programmable and communicate BACnet/IP or BACnet/MSTP to the master controllers.

The master controllers shall be a web enabled web server with at least one controller being a JACE 8000 with 10,000 licensed points and complete with MQTT protocol for future connection to the Internet of things.

Each master controller shall be complete with embedded graphics that shall be accessed via an android type display screen mounted on the face of the control panel. Embedded graphics shall be provided for all connected plant and equipment. The display screen shall utilise a web browser for access to the graphics, under no circumstances shall graphics be held within the display screen.

The master controllers and associated expansion modules shall be connected either via an integrated bus connection or external BACnet/MSTP, BACnet/IP network cabling. This network cabling shall not however exit the control panel.

The expansion modules are not required to be Tridium specific and consideration should be given to providing modules with integral HOA switches.

The BMS specialist shall provide a layer 2 managed switch within each control panel to which controllers, dumb I/O and display screens shall be attached.

The form 1 control panels shall be constructed in 2 sections, one a door interlocked section shall contain the controls transformers and cable protection devices, whilst the other non-door interlocked shall contain ELV control services. The only LV Service within the ELV control section shall be the twin socket unit that shall be mounted on the sidewall between LV and the ELV section.

It is encouraged that conventional HOA switches and run/trip lamps are not provided on the fascia control panels. The BMS specialist shall develop embedded graphics within the controllers that display plant HOA switches and plant status when requested by the touchscreen.

All control equipment shall be 24 Volt and plug top transformers shall not be provided.

Where controllers monitor critical plant, such as generators, switchgear, frame rooms a panel mounted UPS shall be provided by the BMS specialist for monitoring and communication in the event of power failure.

The BMS specialist shall provide all downstream networks from the master controllers to peripheral equipment utilising either BACnet/MSTP or BACnet/IP as appropriate.

Where BMS monitoring is required of third-party equipment such as electrical meters, the BMS specialist shall provide the Modbus network, no more than 32 devices per network and terminate this at the JACE, other interfaces such as a SIP should not be provided.

Where the BMS is required to monitor energy metering by M-bus, the BMS specialist shall provide the M-bus network and terminate this at the JACE.

The BMS head end supervisor should be based upon the Tridium solution with the latest technology (N4). The head end shall be fully configured with dynamic graphics and alarm handling as appropriate. The head end supervisor shall either be a PC or a rack mounted device complete with local UPS (if required for critical monitoring). The PC should contain operating systems required for the BMS supervisor but with all other standard Windows applications removed. Access to the BMS supervisor should generally be via the web browser route with native access being available for software configuration.

The BMS specialist shall separately provide a cost for Niagara analytics with the latest technology (2.1).

The BMS specialist shall configure all device tagging names following the principal of the Tridium haystack convention.

The site wide BMS network shall include layer 2 managed switches that are connected by horizontal cat 6 runs to the master controllers. The switches shall be interconnected in a ring solution with spanning tree protocols and cat 6 cabling.

The BMS specialist shall develop the cyber security which follow the principles of the Niagara 4 hardening guide such as the use of strong passwords, password timeout, all unused ports to be closed, antivirus software to be implemented and upgraded on a regular basis.