3 - Networking for Automated Buildings

The buildings of the next decade will contain an information technology infrastructure that will be capable of monitoring every facet of the building's operation from power consumption through to the integration of currently separate systems.

Commercial and residential buildings have seen over the last few years increases in the use of coordinated infrastructure that provides for the integration of fire control; access control; heating ventilation and air conditioning (HVAC); lighting; and, communications systems. The concept of using centralised monitoring for these systems is not new.

What will be new is the change in the approaches of building managers from a focus on the low cost of initial development to the intelligent management of systems that allow for increased revenue streams from more effective cost management processes. When planning for new developments designers are increasingly considering the costs associated with the entire life of a building rather than just the initial development costs and are allowing for future up-grades in the technology that will become available.

Over the next few years to 2008, there will be a move to a more open source of networking and control that will utilise the open standards currently in use through the Internet standard Transmission Control Protocol over Internet Protocol (TCP / IP) and through the Open Systems Interconnection (OSI).

Current Building and Construction Environment

The building and construction industry covers a wide range of possible structures including commercial and residential buildings, transport systems and infrastructure. The technologies that are discussed in this chapter relate to those that are shared between automotive, building and construction, engineering, electrical, electronics, information technology and telecommunications. In this sense, there is some limitation to the range of technologies that are likely to be emerging in this broad industry.

Technology Investment Philosophy in Building and Construction

Over the past 150 years of commercial and residential construction in Australia, there has been little evidence of anticipation of the possible introduction of new technology. The expectation by designers of an increased standard of living or alternative uses of the structure seem not to have been incorporated into the design. Consequently older buildings have external plumbing systems; exposed conduit for power and communications; and, intrusive HVAC ducting encroaching into the spaces available.

Investors do not usually allow the design and construction costs to include possible advances in technology or allow for increased expectations of future occupants. There is no defensible economic reasoning in increasing the costs of construction of a building in order to allow for future technologies. This is especially the case where competitive pressures exist.

Developers do allow for conduits to be placed in wall cavities where the additional cost is minimal. For commercial construction, alteration of cabling is able to be accomplished through dedicated communications risers and raceways. For the residential market, especially in pre-cast and tilt-up construction, the conduit is predetermined and provides little scope for re-wiring and no ability for re-positioning of outlets. For this reason some project developers are including full structured cabling so that if the client wishes to use this technology it is available.

Future Building Management

Modern building managers need to be convinced of the on-going advantages of incorporating new technologies. These technologies need to firstly allow building managers to control the cost of maintaining the building and allow for the reduction of on-going costs and secondly provide tenants with the ability to optimise power, HVAC and communications systems for their comfort and use. To a large extent, current technologies do provide for tenant optimisation and perhaps less so for the building manager.

A “whole-of-building” approach seeks to achieve low total costs over the life of the building by minimising energy and resource consumption. However the first-costs for a whole-of-building development can often be higher. Developers and builders generally have no stake in the long-term operating costs or performance of the building and are rewarded based on their ability to control first costs. The ultimate building occupants typically have little voice in design and construction decisions,

and are seldom able to quantify how the benefits of lower operational costs or improved building performance might justify a higher initial investment.[1]

Many of the technologies used for building management are non-integrated and vendor specific. When up-grades are required, some managers find that either the existing vendor's products are used or a complete refit using other vendor equipment is required. Ideally an open system is preferred where existing infrastructure is utilised and devices are added in a similar fashion to the "plug-and-play" functionality available through Microsoft operating systems.

At this stage, innovative building owners are moving towards more open standards for building automation and control. Existing vendors will continue to supply proprietary systems at decreasing costs in order to maintain the life span and profitability of their technologies. This strategy will begin to lose out to the more open systems that provide for common cabling infrastructure and interoperations between compatible devices.[2]

Current Networking Infrastructure – Commercial

There are a number of providers of equipment for automation in buildings. Some of these are Johnson Controls, Honeywell, Siemens, and others. Each of these vendors provide for optimisation in certain key areas of automation with other products and services as add-ons for those areas that might not be considered as core automation areas. Newer companies such as Automated Logic, Delta, Andover and Alerton are providing the leading edge communication and networking technologies for the Heating Ventilation and Air Conditioning (HVAC) industry. A single vendor with a total integrated solution for automated buildings is not evident.

Opportunities exist for other companies such as Tridium and Frame Networks to act as translators between the vendors so that each vendor can supply its core technology and still allow for the integration with other competing non-compatible vendors. While this seems a suitable solution for an interactive system, each change initiated by a vendor will require additional work to be completed by these interface providers.[3]

There are two standards that provide approaches to unifying devices used within building automation and these are discussed below. To a certain extent these are competing standards with one developed by a standards committee and the other as a proprietary standard. Both are widely used.

BACnet (Building Automation and Control Network)

This standard has been developed by the American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) and supported and adopted by the American National Standards Institute (ANSI). This standard defines how automation and control systems inter-operate with devices such as HVAC, security, access control, fire safety systems, lighting and other systems. It is vendor independent and uses an object-oriented approach to represent communication and information within each controller.

This standard can communicate using Ethernet (IEEE 802.3a), ARCnet, (See Box 3.1) Master / Slave Token Passing (MS / TP – RS-485), Point-To-Point (PTP – RS-232),

and LonTalk (Echelon Corporation) and is therefore very versatile. While BACnet still uses its own protocol, it allows BACnet enabled devices to connect to the network and guarantees interoperability though interoperable data objects, standard network data packets and inter-vendor compliance. In January 2003, the International Organisation for Standardization (ISO) announced that it will publish BACnet as ISO 16484-5[4] and is widely adopted through European standards committees.

While BACnet always allowed for inter-vendor communication and Internet Protocol capacity, the first revision of the BACnet standard (ANSI/ASHRAE 135-2001) allows for specific communication via Internet Protocol and provides for greater flexibility. One of the major strengths of BACnet is the provision for a strong and flexible method for defining special events and alarms. BACnet is also able to notify workstations and other devices when these events occur.[5] Further work is expected to better clarify issues such as lighting control; liaison with energy providers; fire and access; and, network security issues.

LonWorks

LonWorks is a family of products developed by the Echelon Corporation in cooperation with Motorola with the proprietary communications network protocol LonTalk. Each device on this network requires an Echelon processor called a Neuron chip. LonWorks uses the Open Systems Interconnection (OSI) standard and Layers 5, 6 and 7. (See Box 3 2).[6]

While LonWorks does have a defined standard, vendors are able to use the data stream in different ways and some systems are not compatible. Due to the obvious incompatibility, vendors are yielding to the standards established by the LonMark Consortium and pay a fee in order to access these standards. Major vendors include Honeywell, Siemens, Invensys and others.

BACnet versus LonWorks

These two major networking protocols are not compatible and there is much discussion as to which networking protocol is the best. BACnet is a system-to-system solution and therefore is more expensive to implement however these costs can be reduced with BACnet compatible devices.[7] Critics of LonWorks cite the fact that every device needs to have a Neuron chip[8] and that it is unsuitable for system level interoperability.[9] Generally, BACnet is used for large systems where building-to-building communication is important such as a campus environment. Both LonWorks and BACnet are suitable for intra-building and device communication. A BACnet infrastructure is a more robust approach towards building automation and carries with it a higher initial cost. LonWorks is a device-by-device system and is less expensive to install. For smaller installations proprietary systems are usually preferred but may include LonWorks compatible equipment.[10]

It is anticipated that BACnet will see an increase in its market adoption with companies such as Westfield and major universities requiring BACnet as a standard.

BOX 3.1 – ARCNET

ARCnet is a data-link layer technology with no defined application layer. Designers write their own application layer to meet their particular needs and frequently do not advertise the fact that ARCnet is being used in their product. Originally introduced at about the same time as Ethernet, ARCnet incorporates a token-passing protocol where media access is determined by the station with the token. When a station receives the token, it can either initiate a transmission to another station or it must pass the token to its logical neighbour. All stations are considered peers and no one station can consume all the bandwidth since only one packet can be sent each token pass. This scheme avoids collisions and gives ARCnet its greatest advantage in real-time applications. This is of particular importance for control or robotic applications where timely responses or coordinated motion are needed. http://www.arcnet.com/abtarc.htm

Networking Infrastructure – Residential

Products available for networking residential premises are limited to time-controlled switches, pre-set lighting and structured cabling. Few residential systems provide for the building automation that utilises the full range of automated systems available for commercial applications.

HPM Industries have had available a system known as Oscar that uses a single controller for time-switch control of various devices through relay units, movement sensors and lighting configurations. Preferences are selected through the use of a single control panel or remotely via telephone communications. This system is limited to a maximum of 150 devices.[11]

More complex systems are becoming available to the residential market that will allow control of devices via the Internet thus providing for greater access to devices in the home including Closed Circuit Television (CCTV). HPM Technologies has the iCONTROL that utilises Echelon Neuron devices and resembles a commercial application more than a time-switch control. Full internet capabilities with a computer-driven Graphic User Interface (GUI) are also available. Gerard Industries has the Clipsal HomeMinder system that provides for a similar interoperability to the iCONTROL system through the use of the C-Bus. These systems can allow for remote answering of the front-door intercom via mobile telephones, remote locking and unlocking of doors, monitoring of security status and access to security cameras.

The Korean appliance manufacturer, LG Electronics utilises Echelon LonWorks for its networking platform[12] and therefore provides interoperability within the iCONTROL system from HPM. The Clipsal C-Bus is able to integrate with LonWorks, BACnet and TCP/IP but requires the addition of an interface.[13] Clipsal has also introduced the Neo C-Bus switch to be used in conjunction with the iCONTROL system and incorporates the option for an infra-red signal through a remote controller to activate the switch.[14]

There are a range of other systems such as Hills Home Systems (Australia), Omni by Home Automation (USA), Smart House by the company Smart House (New Zealand) or Jeeves by Smart Company (USA) that provide similar functionality and will compete with the HPM and Gerard/Clipsal systems. One of the more

popular "do-it-yourself" automation products is X-10 and provides wireless connections between devices.

As this is an emerging area, developers may choose to utilise domestic suppliers which will provide the incumbents with greater access to these markets. Therefore it is possible that HPM and Gerard's Clipsal systems will gain the greater market share.

BOX 3.2 – OPEN SYSTEMS INTERCONNECTION

The OSI reference model was developed by the International Organisation for Standardization (ISO) in 1984. This is the primary model for computer networking and plays a significant role in interoperability. The model describes how information passes from one computer software application through to another computer's application.

The model lists seven layers that provide for specific network functions. Each of these layers provides for a specific task to be completed independent of other layers.[15]

***Layer 7 Application** – This is the layer that provides application software with communications. The actual software application is not contained in the OSI model. It is at this level that the File Transfer Protocol (FTP) and Simple Mail Transfer Protocol (SMTP) operate.*

***Layer 6 Presentation** – This layer provides for the coding and conversion of data and ensures that the exchange is understandable. This layer provides for the exchange of data from one application to another through common data formats such as ASCII for text and Graphics Interchange Format (GIF). This layer also provides for data encryption and compression.*

***Layer 5 Session** – This layer establishes, manages and disconnects the communication session between computers. This layer ensures that data is sent and retrieved from other computers. The Zone Information Protocol (ZIP) and Session Control Protocol (SCP) operate within this layer.*

Structured Cabling Systems - Residential

This use of structured cabling is likely to increase within new residential construction and retro-fitting. Some of the drivers of this are increased use of broadband access to the Internet, increased use of computers by all age groups, distributed entertainment systems access throughout the house, networked computers and greater access to telephones. Structured cabling is able to provide for each room to have these various services provided at minimal cost during construction.

One concern of suppliers of structured cabling is the low emphasis placed upon communications networking within the home by architects and builders that will allow for cables to be upgraded. Commercial buildings have communications rooms, risers, conduits, ducting and raceways built-in for maintenance and re-fit work. In order to save initial costs, residential buildings do not usually have these conduits in place nor are there dedicated communications rooms. The positioning of powerboards, control panels and other centralised systems is distributed throughout the house.

Purchasers of new homes are able to be influenced by developers who provide rational and economic arguments regarding the installation of structured cabling.

It is possible to imagine that those developers and builders who do not have a working understanding of the uses of structured cabling may chose to down-play the utility of such systems. The owner may choose to have the cabling installed for life-style reasons or for future resale opportunities but education of the consumer is felt to be the main driver for structured cabling.

The Copper Development Corporation is promoting the "Smart Wired House" in association with the National Electrical and Communications Association (NECA), the major device vendors and structured cabling producers. This initiative employs a strategy of training electricians in the aspects of generic structured cabling and educates the general population of building owners of the advantage of structured cabling.

Most installers of data cabling are familiar with Category 5 and 5e cabling. Some commercial installations are including Category 6 with Category 7 cabling becoming available. With the move to each new cabling type, greater data speeds are available to the user.[16] Applications that require large bandwidth such as video-on-demand and on-line internet computer games are expected to become available and well adopted.[17]

These applications will most likely utilise Ethernet (IEEE Standard 802.3a) and will place greater expectations on cabling contractors.[18] Fast Ethernet runs at 10 Mbps (10BASE-T) and Super High-Speed Ethernet runs at 100 Mbps (100BASE-T). The next standard is known as Gigabit Ethernet (1000BASE-T) and runs at one billion bits per second. It is at this rate that the user will find these heavy bandwidth applications working well. Telstra has recently decided to increase the network backbone between Sydney to Melbourne with a 10 Gigabit connection in anticipation of greater broadband traffic.[19]

The Gigabit Ethernet standard was standarised by the IEEE as 802.3z in 1998 for use on optical fibre and copper cabling and in 1999 for Category 5. This increase is necessary to ensure that networks are able to run the high-bandwidth applications and to avoid a slowing of the network as a result of heavy traffic. However it is estimated that only around ten percent of installations at that time would be able to run at the data speeds available on Category 5 cabling.[20]

Air-Blown Fibre Optics

This is a technique for installing fibre optic cable within conduits and uses air to "pull" the fibre. This technique developed by British Telecom in 1982 is also able to be used in the local loop as it is within existing buildings. This technique is used for rapidly growing networks in areas not catered by large infrastructure.[21] It is possible to imagine that the trenching that exists for copper cable will eventually give way to fibre optics.

IMPLICATIONS FOR THE SHARED TECHNOLOGY INDUSTRIES

Automotive

No implications predicted for these technologies in this industry.

Building and Construction

The move towards more automation and cabling requirements will see the need for increased knowledge and understanding of the networked systems by members of this industry. This includes anticipation of new technologies in the design process, future changes in occupancy requirements, appropriate construction planning, and installation of various devices. The automated building will become a networked system that behaves in a similar way to a Local Area Network (LAN) computer system.

Engineering

Limited impact of these technologies in automated buildings. Please see Chapter 4 – Networking for Engineering for a more complete review of applications in the area of networking.

Electrical

The move towards a more integrated building especially within residential buildings will require electricians to become more knowledgeable of the various types of cabling requirements. Network cabling testing will require greater levels of attention and performance by members of this industry. Future networks will require testing of cabling to increasingly faster data rates and poor connections or inappropriate fixing of cables will be noticed by clients demanding these fast data speeds.

Electronics

Devices installed in automated buildings will contain greater levels of electronic sophistication. The newer network systems will allow for devices to operate in a peer-to-peer relationships without necessarily communicating through a central location. This will present challenges for electronics personnel who will need to problem solve interoperability issues among supposedly compatible devices.

Information Technology

The information technology industry will see more opportunities within these automated buildings for network management, data management and software applications. The building will be the network and will need individuals with skills in network administration and management to operate buildings as they would operate a computer network.

Telecommunications

The increasing complexity of the next generation of telecommunications networks will see greater integration with carrier networks and building infrastructure. Moves to bring optical fibre closer to the desktop computer, integration of voice communications through the Internet, and the mobility of individuals throughout a network building will require greater knowledge and skills from members of the telecommunications industry in order to bring these technologies into operation.

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[1] Office of Building Technology, State and Community Programs. (2000). *High-performance buildings: a technology roadmap.* Washington, DC: United States Department of Energy. Available: http://www.eere.energy.gov/buildings/commercial_roadmap Accessed: 25 February 2003.

[2] Henry, J. (2002). *BAS or BS?* St. Peters, NSW: Electromation. Available: http://www.automatedbuildings.com/news/jul02/articles/jh/jh.htm Accessed: 25 February 2003.

[3] Continental Automated Buildings Association. (2002). *Technology Roadmap for Intelligent Buildings*. Ottawa, ON: Author. Available: http://www.caba.org/trm Accessed: 24 February 2003.

[4] BACnet Manufacturers Association. (2003). *BACnet approved as an international standard.* Available: http://www.bacnetassociation.org/MiscNews/BMA%20NEWS%20RELEASE-International%20Standard.doc Accessed: 24 February 2003.

[5] Bushby, S. T., & Newman, H.M. (2002). Bacnet today: significant new features and future enhancements. *ASHRAE Journal*, October, 2002. pp. 10-17. Available: http://www.bacnet.org/Bibliography/index.html Accessed: 24 February, 2003.

[6] Continental Automated Buildings Association. (2002). *Technology Roadmap for Intelligent Buildings*. Ottawa, ON: Author. Available: http://www.caba.org/trm Accessed: 24 February 2003.

[7] Echelon Corporation. (2000). *Echelon White Paper: Implementing open, interoperable building control systems*. Palo Alto. CA: Author. Available: http://www.echelon.com/solutions/building/papers/BacNetComp.pdf Accessed: 24 February 2003.

[8] VCI Controls. (2002). *What is BACnet?* Ottawa,ON: Author. Available: http://www.vcicontrols.ca/prod03.htm Accessed: 24 February 2003.

[9] Henry, J. (2002). *If the Open versus Closed argument indicates open (as it will in most cases) then the choice is effectively between Lon and BACnet*. St. Peters, NSW: Electromation. Available: http://www.automatedbuildings.com/news/aug02/articles/jh/jh.htm Accessed: 24 February 2003.

[10] Continental Automated Buildings Association. (2002). *Technology Roadmap for Intelligent Buildings*. Ottawa, ON: Author. Available: http://www.caba.org/trm Accessed: 24 February 2003.

[11] HPM Industries. (2002). Oscar intelligent home automation system: Contractors' & engineers' data. Reference No.: 450/0299. Alexandria, NSW: Author.

[12] Echelon Corporation. (2000). *LG Electronics Promotes Echelon's LonWorks Networks for the Home*. Palo Alto. CA: Author. Available:

http://www.echelon.com/about/press/2000/lgePromotesLonWorks.htm Accessed: 2 March, 2003.

[13] Clipsal Integrated systems. (2000). *C-Bus Energy Management Systems: The intelligent choice for your next building project*. Reference no.: 16036. Bowden, South Australia: Author. Available: http://www.clipsal.com/cis/products/C-Bus_brochure.pdf Accessed 2 March, 2003.

[14] Design Awards 2002 – 2003 (2002). *Clipsal Neo C-Bus switch*. Bowden, South Australia: Clipsal Integrated Systems. Available: http://www.designawards.com.au/ADA/02-03/INDUSTRIAL%DESIGN/040/040.HTM Accessed 3 March, 2003.

[15] Cisco. (2003). *Internetworking Basics*. Available: http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/introint.htm Accessed: 13 February, 2003.

[16] Telecommunications Industry Association. (2002). *Category 5 Cabling: A standards and system overview*. Arlington, VA: Author.

[17] Economist. (2003). The complete home entertainer? *The Economist*, 27 February, 2003.

[18] Baddar, A. (2000). *High-speed transmission over structured wiring systems: BICC General White Paper*. CITY, STATE: BICC. Available: http://www.biccgeneral.com/North_America/NA_DataTechPapers.htm Accessed 28 February, 2003.

[19] Sydney Morning Herald. *Telstra beefs up net backbone*. 25 February, 2003. Available: http://www.smh.com.au/articles/2003/02/25/1046064011818.html Accessed: 26 February, 2003.

[20] Intel Corporation. (2000). *Gigabit Ethernet Solutions*. Author. Available: http://www.intel.com/network/connectivity/solutions/ethernet_guide Accessed: 10 March 2003.

[21] PricewaterhouseCoopers. (2002). *Technology forecast: 2002-2004 Emerging patterns of Internet computing*. (Vol 2). Menlo Park, CA: Author.