Open Systems for Homes and Buildings: Comparing LonWorks and KNX

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About i&i limited

Alan Kell was the principal author of the 1993 study by DEGW *etl*[1] entitled “Bus Systems for Building Control” which was the first detailed study in this area to compare, among others, EIB and LONWORKS in the context of building control.

Peter Colebrook collaborated closely with Siemens in Regensburg in the late 1980’s, was one of the 12 founder signatories of the European Installation Bus Association (EIBA) and subsequently served as a Director of that Association. He was also one of the founders of the LONMARK Interoperability Association and similarly served as a Director of that Association.

Alan and Peter are directors of i&i limited. The Proplan division of i&i, established in 1980, has analysed the markets and technology for building controls and services in 37 different countries in North America, Western and Eastern Europe, Scandinavia, the Middle East, S.E. Asia and the Far East including Japan and China. A series of Multi-client studies entitled "Intelligent Controls in Buildings" have charted the progress of the advanced building controls industry and its players for seventeen years.

The objective has been to provide manufacturers and suppliers with accurate information on which to develop appropriate marketing and business strategies. This has been achieved with the assistance and co-operation of our clients who comprise the major suppliers to this business, including; ABB Building Technologies, Automated Logic, Novar Trend, Novar Gent, Carrier, Danfoss, Groupe Schneider, Honeywell Controls, Invensys, IBM, Johnson Controls, KMC, Olivetti, Omron, Philips, Saia, Satchwell Control Systems, Sauter, Siemens Building Technologies - Cerberus Division, Siemens Building Technologies - Landis & Staefa, TAC AB, Trane, Tyco, Weidmueller, Zumtobel.

These clients are the “movers and shakers” in the home and building systems industry.

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1 Effective Technology Limited, part of the DEGW Group.

Contents

Foreword

It is often said that every idea has its time. Indeed it is not unusual to find two or more patent applications filed for the same invention within days of each other: sometimes even on the same day. It should therefore not come as a surprise that, in the late 1980's, two companies 6,000 miles apart developed the same radical vision of the future of control networks: distributed intelligent devices cooperating by sharing data rather than the more traditional notion of a centralised device issuing commands.

This white paper examines the development of the ideas and the impact of design and marketing decisions during that development, the associations that support the respective technologies and their impact in one particular market: home and building electronic systems. Those two technologies are LONWORKS from the Echelon Corporation and European Installation Bus (EIB) – now the mainstay of Konnex (KNX) – originally developed by Siemens. The scope of the study is limited to the application area of the latter technology: LONWORKS is used in a much wider range of applications.

Whilst the underlying idea may be the same, there were substantial differences. Siemens was, and remains, a global giant of the electrical and electronic industries having some 365,000 employees at the time and now with some 417,000 employees[2] globally at the end of 2003. Echelon was a small start up that, by February 2004, had grown to 270 employees[3] of which 114 (42%) are wholly employed in technology and product development. This study compares the two organisations, the technologies that they developed and their impact on the European market for home and building systems.

IMPORTANT NOTE

This paper has been compiled primarily using information from two type of sources: firstly information that is or was publicly available and accessible, for example, on the Internet and secondly information that has been presented to standardisation committees, predominantly European standardisation committees, and which has either been published or which remains in draft form as committee documents. Additional information was sought regarding Konnex in telephone conversations and our thanks are due to those who responded.

There were little difficulties in obtaining information on LONWORKS, LONMARK and Echelon's technologies in general. There were, however, substantial difficulties in obtaining information on some aspects of Konnex, KNX or EIB. For example, a search for KNX or EIB profiles indicated that these were in Volume 6 of the KNX specification, that free access was restricted to Konnex members – minimum membership fee €2,500 – and that the Konnex specifications could be purchased for €1,000 refundable against subsequent membership.

In the context of recent press releases describing Konnex as "world first" and "open standard", we were disappointed.

[2] Siemens corporate web site. Of course, Siemens' business covers much, much more than control networks.
[3] Echelon annual Security Exchange Commission filing.

Executive Summary

It has been over ten years since Alan Kell first compared a number of bus systems for building control and, whilst a number of differing bus systems were considered, it was apparent then that two, European Installation Bus (EIB) and LONWORKS, were the leading contenders. Among the others considered, European Home Systems and BatiBUS have merged, with EIB, in the KNX protocol whilst some, CEbus and SmartHouse from the US, never really made any substantial progress and, in the case of the latter, managed to achieve insolvency three times.

In the succeeding years both EIB and LONWORKS have made substantial progress and a number of the issues noted in the earlier report have been addressed. LONWORKS has acquired a two-wire, free-topology medium that was under development at the time of that first report, EIB has acquired a powerline medium and the installation tools have come on in leaps and bounds.

Both protocols have also adapted, to varying extents, to the most significant change in homes and buildings; the growth of information networks in general, the development of additional Internet protocols and, most importantly, the use of the Internet itself and the new terminology that this involves: web servers, web services, HTML, XML, etc..

There are differences. LONWORKS has, as might be expected given its general nature, been adopted for a number of applications well outside the home and building space whilst, within that space, it is used for a wide variety of applications: lighting, heating, air conditioning, security, lift control, fire alarms and related devices and access control. The technology provides sufficient flexibility and capability that many complex buildings use LONWORKS as the only control system. It is also apparent, both from product catalogues and from membership of the LONMARK Interoperability Association (now LONMARK International), that the applications are substantially worldwide. Europe plays a significant role in this global demand and Germany is host to the largest and most active of all the LonUser groups – the LON Nutzer Organisation or LNO as it is known.

EIB's use is more limited with the majority of applications being in the lighting, heating and shading space. The bulk of the products originate from German manufacturers and are used within Germany and its close geographical neighbours. However, within that area, there is a high degree of penetration within the commercial building sector, less so in the residential sector, and this is due, in large part, to the successful inclusion of EIB technology in the education and training programmes for professional electrical installers.

Overall we believe that the EIB technology is well adjusted to the electrical installation industry in Germany and surrounding countries and to the smaller building arena. We hear some reservations as to the ease with which it can handle larger buildings although we note many successful large projects. However these appear to also require other technologies, such as BACnet, to be included for security and HVAC applications. EIB appears to rely heavily on BACnet, and BACnet tool vendors, to provide support for larger installations and to handle enterprise-wide integration.

EIB training appears to be very well integrated with the training of installers and planners in Germany – less well so elsewhere – and has led to a wide understanding of the technology.

We believe that products incorporating LONWORKS technology are suitable for both these larger buildings and for small buildings enabling the use of a single technology for all control applications in both commercial buildings and in homes. In the latter, good powerline technology coupled with self-installation methods fit well with the electrical installer. in business the technology is aided by the powerful LONWORKS Network Operating System (LNS) and by the Panoramix™ Platform which permits enterprise-wide data integration at a machine to machine level. Hence the accounts department can, for example, track worldwide energy expenditure on a minute-by-minute basis. The very powerful installation tools, and their associated cost base, may require revision for smaller installations if they are to be seen as cost-effective.

LONWORKS training has been delivered to a substantially smaller number of people concentrating on the more professional installers and integrators of larger systems. The similarity of EIB and LonWorks technologies should enable conversion training where required.

Overall Conclusion

Reviewing the body of evidence, it is clear that the initial investment by Echelon in their own chip design and their consequent ability to create a fully featured control protocol with functionality at each of the seven layers of the OSI model rather than cutting down on that functionality, as EIB were forced to do, was critically important. This created a sound technical architecture on which a complete network operating system could be hosted and which has subsequently adapted well to the growth of the Internet and the use of Internet protocols within business and, to an increasing extent, within homes.

The Echelon range of transceivers is strong in all areas except wireless where there are several offerings but none of these is yet "LONMARKed", and particularly so in powerline and free-topology transceivers with the integration of the Neuron Chip into the transceiver thus reducing cost and complexity. We believe that the wireless issue is being addressed and that a single, open standard, wireless solution will be introduced. There is good third party support in terms of infrastructure components, routers and the like, and management tools. The range of companies manufacturing products based on the technology is wide, both in product types and in global reach, and, of the two technologies, only LonWorks-based products can meet the full spectrum of building needs and fully integrate into business systems.

LonWorks also seems to have managed the transition to "open" well with royalty free licensing on the major elements of the protocol well in place and, demonstrably, working.

LonWorks does however appear to have two areas of weakness both to do with installation. Firstly the number of trained installers, compared with those claimed by EIB in its native Germany, is low; in part due to the higher skill levels needed, particularly for larger installations where the range of devices to be installed and commissioned is much higher. Secondly, and the most common comment we heard from users, is the cost of using the installation tools based on LNS.

In contrast, the original decision to design EIB for a low-cost off-the-shelf microprocessor, and for a simple, next generation wiring device application seems to have restricted its growth a little in that the major market it was intended for, smaller businesses and homes which are the major consumers of electrical wiring devices, has been slower to mature than expected. The emerging opportunities for such smart wiring devices were initially largely in larger applications where a greater "richness" was required in the fundamental protocol. This has only recently been addressed with extensions for HVAC applications. However, even with these extensions, it appears that engineering large buildings still requires integration of several different protocols, including BACnet, to handle the range of occupier needs.

EIB was, to all intents and purposes, a low-speed free-topology solution with the original transceiver albeit that this was strongly featured and designed for the harsh environment of the electrical installation. The powerline solution, as mentioned elsewhere, appears to have failed to achieve popularity with users and, instead, many manufacturers are promoting wireless EIB for retrofit applications.

EIB has made good progress with training its traditional installers, the electricians, in Germany and surrounding countries with EIB being include in many of the electrician training syllabuses. This has been substantially less effective elsewhere where training methods are established on different basis and training is less formal.

Despite gaining the status of a European Standard (for parts of the protocol), we are less convinced about the openness of EIB and the whole Konnex specification. It still appears that membership of the Konnex Association is the only way to get the full details of the technology and that this, for a smaller manufacturer, is relatively expensive – particularly when recertification fees are factored into the equation.

KONNEX

Konnex, both as a technology and as an association, is the result of the merger of three European technologies for home and building control; EIB, BatiBUS and EHS. Of the three technologies, only the EIB technology remained relatively unchanged during the merger and only limited parts of the other two remain unchanged. Thus the overwhelming volume of Konnex product currently in the market is that built on the basis of EIB and which, because of the absence of relevant change, has retained its original certification. Products incorporating original EHS or BatiBUS technology require substantial changes before they can comply with the Konnex standards and there is little evidence that, so far, this has happened. Consequently this study considers that, unless the specific context requires otherwise, the terms Konnex and EIB are synonymous.

EUROPEAN INSTALLATION BUS

The European Installation Bus technology was originally developed in Regensburg by Siemens, specifically that part of Siemens dealing with low voltage wiring devices (switches, socket outlets, circuit breakers, dimmers and the like) used in homes, offices, etc.. The design intent was to create the next generation of those wiring devices with the requirement that these should be delivered to existing users (electricians) through the existing supply chain (electrical wholesalers). Consequently they adopted a modular form suitable for installation in flush-mounting wall boxes and a second form adapted for DIN-rail mounting in electrical enclosures. These modular forms were well adapted to the electrical installation industry and, with a novel Physical External Interface (PEI) on the wall-mounting Bus Coupling Unit (BCU) that could be adapted to various configurations of inputs and outputs, enabled a single design of BCU to work with a variety of wall-mounted products. A similar arrangement was achieved for the DIN-rail mounting units. The intention was to concentrate production on a limited range of complex products and to be able to customise these with relatively simple fascias with limited electronic content. This met the requirement for differing styles and colour schemes or wall-mounted units with minimum complexity or stockholding.

A key issue was clearly the cost of the electronics and Siemens opted to use an off-the-shelf mask-programmed Motorola 68HC05 microprocessor as the main processor with a special ASIC (Application Specific Integrated Circuit) to handle the low level access to the communication bus where simple routines need to be carried out at speed including sampling the bus at high frequency to detect incoming messages. This is essentially the bulk of the Link Layer of the ISO/OSI model. A clever transformer arrangement enabled the device to be powered from the bus and separated the signals from the nominal 24 volts dc on the bus and delivering a regulated and smoothed 5V supply for the electronics package.

The limited memory capacity of the chosen microprocessor required firstly that the programming of the communication protocol had to be extremely tight and that the protocol had to be relatively simple. Hence the Konnex protocol uses only five of the seven layers of the ISO/OSI seven-layer model with two of the layers, the session and presentation layers, being empty or null-layers. Secondly that limited capacity, and the need to have a universal device that could assume different functions, required that the appropriate software application were downloaded only when the BCU was associated with the appropriate hardware (switch, dimmer, etc.). In this case the application software had to be very compact since the original EIB BCU had only 230 bytes of EEPROM memory available for the product developer to create their application. Later versions of the BCU and the Bus Interface Module (BIM) use more powerful microprocessors with a larger memory of 858 bytes of EEPROM available to the user/developer.

The need to load the application into the BCU or BIM at install time necessitated a PC-based set of tools and that each manufacturer provided a suitable set of applications for each product. Since the same product, for example a light switch, could be programmed in several different manners, for example to control a light or to act as a dimmer, a number of such programmes would be required.

Konnex networks, at least the wired versions of these, are essentially synchronous in that all devices synchronise to the start of a transmission and retain that synchronism throughout the transmission. This permits the EIB system to use a carrier sense, multiple access technique (CSMA) but with an added bonus of collision resolution. If two devices start transmitting at exactly the same time, one or other will discover that the bus is not reacting to its transmission in that the bus has gone low (a “1”) when the device would have expected it to stay high (a “0”). In this case that device will immediately cease transmission allowing the other to continue uninterrupted. In this manner, and since one of the earliest frames transmitted on the bus is the device address which immediately follows the control field which itself includes a priority field, the device address has a degree of priority associated with it. Importantly, no packets are lost through collisions.

This synchronism, and the ability to electrically “or” data patterns, also permits several devices to send simple messages simultaneously. This is used for the Acknowledge (Immediate ACK), Negative Acknowledge (Immediate NACK) and BUSY messages that closely follow any originating transmission. These acknowledgement messages are generated at the data link layer and indicate only that the message has successfully transferred across one bus segment; they do not indicate that the message has reached the target device, which may be on another bus segment, or that that the message has been understood.

A consequence of this need for, and use of, synchronism is that the bus has to be short, in electrical terms, such that the time skew between devices on the same buss segment does not exceed 12µs and it is this which provides the fundamental limit on the maximum length of the bus between any two nodes. The overall maximum length of cable in any one segment is set by the capacitance of the cable and the ability of the nodes to sink current in the 1-state: that of a pull down of the bus voltage.

Since its original launch as a wired bus solution, Konnex has added alternative transmission media; notably powerline signalling and radio, with an infrared protocol expected shortly. These require alternative media access techniques.

The engineers also had to deal with interoperability between devices and chose to model the application layer using a weakly-typed model. In this model, there are a limited number of formats for information, defined as, for example, a 1bit Boolean, a 16bit signed or unsigned short or a 32bit IEEE float. As EIB note on their website, “Standard EIB Data Types - extreme customisation power when binding applications!” Extreme power can be useful but also has associated dangers and EIB appears to have limited protection against binding (connecting) data items which are associated with entirely different parameters but which use the same data types.

LONWORKS

The story goes that one of the origins of LONWORKS was a conversation between Mike Markkula, Chairman and outgoing President of Apple Computers, with the incoming president, John Sculley, formerly of Pepsi Cola. When Mike had described the pyramidal hierarchy of the computer market to John, John asked, “What lies beneath the personal computer?” Mike thought about this and decided it was something that was about control, something about $10 and with a market in trillions of units rather than millions.

Elsewhere in Northern California was the Rolm Corporation, makers of branch telephone exchanges with some radical ideas on control systems. In his 1985 book “A Passion for Excellence”, Tom Peters quotes an unnamed Rolm executive as saying “The insides of our CBXs [Computer Branch Exchanges] look just like us [as a company] – just a bunch of microprocessors on a board talking to each other. [Those of a particular competitor] look like them – inflexible and hierarchical architecture.” Here lay some of the seeds that Mike Markkula needed.

Following the profitable sale of Rolm to IBM, a number of key staff decided that they didn’t wish to remain with IBM and linked up with Mike Markkula to form what would eventually become the Echelon Corporation. Perhaps it was typical of the mood of the times, but the new corporation set out not merely to define a control network protocol for peer-to-peer operation, but to develop a new chip to run that protocol, a new language to programme the chip and a development system with which customers could develop products. The control network protocol became LonTalk®, a richly featured implementation of the ISO/OSI 7-layer communication model, the silicon chip became the Neuron® Chip and the programming language, a variation of the ANSI C language modified for event-driven programming, became Neuron C.

It is important to note at this point that LonTalk® is not restricted to implementation on the Neuron Chip alone, that alternatives implementations exist and that Echelon published a reference implementation in 1999 which may be freely downloaded from their website. Using the reference implementation, or otherwise working from the published standards, a number of alternative implementations have been produced including the ORION™[4] protocol stack for the ARM processor and the Linux/Java implementation for the Motorola ColdFIRE processor by domo:logic Home Automation GMBH. Both of these implementations use state machines for the lower layers of the LonTalk protocol and implement the higher layers in a microprocessor.

In developing LonTalk and the other products to support LonTalk, Echelon's engineers made a number of decisions that differed from those of Siemens' engineers. They chose an alternative method of controlling medium access, choosing to implement a technique much closer to that used in Ethernet, a simple carrier sense, multiple access technique but they added a unique twist. Traditional Ethernet saturates when the offered load exceeds about 40% of the nominal capacity. This is because, when two or more devices interfere, they both back off for different random periods and try again. As the load increases, the chance of a second or subsequent collision rises and the effective throughput falls. The engineers modified the technique by adding a mechanism to predict the forthcoming bus traffic and to increase the back off period so as to allow for this ensuring that the medium would never saturate and that capacity increased monotonically with offered load.

In choosing not to use a bit-wise arbitration technique such as Siemens had chosen, Echelon's engineers avoided the inherent speed limits that this created and were able to launch with a range of bus speeds including 78 kbps and 1.25 mbps. They had also created a single mechanism that was medium independent and would work on powerline and wireless media as well as on wired networks. However the simple ACK/NACK mechanism used in EIB cannot be used with these techniques and Echelon's engineers included an end-to-end acknowledged message service in the protocol.

The engineers also had to deal with the application layer of the protocol and they chose here and in Neuron C to produce a strongly-typed language defined by standard network variable types – known as SNVTs and pronounced "snivvets". These variable types not only define the representation used for the value but define what that value represents, for example, a temperature in degrees Celsius with a resolution of 0.1 of a degree. Interestingly for US-based engineers, the majority of these SNVTs are defined in terms of the International metric system or SI.

Using a strongly-typed language significantly prevents incorrect connections between data variables on different devices and promotes interoperability provided that there are clear, industry agreed, models how various devices are represented: this agreement and the production, distribution and certification of devices against these profiles is a key function of LONMARK International.

Wired Media

We compare the performance of wired media solutions in the following table noting that EIB devices are qualified only for the special EIB cable whereas LONWORKS devices are qualified on the preferred cable, Level IV twisted pair, but also on EIB cable, standard Belden cables, and on Cat5 cable used for data installations. Note that there is a substantially higher speed communication available with LONWORKS, 1.25mbps, but this is substantially a linear bus communication with very limited stubs. Since this is not a free-topology solution as required for wiring field-level devices in home and building automation, it is not included here. However we

[4] Orion is a trademark of Loytec Electronics GMBH

have included the details of the linear bus at 78kbps since there are a number of circumstances, such as in plant rooms, where this is a suitable method of connection.

Readers will note that the EIB solution offers a data rate one-eighth of that of LONWORKS but twice the maximum cable run. The cable runs of both systems can be extended using physical layer repeaters provided that the amount of data being transmitted is low. The use of routers or line couplers is preferred in both systems since this restricts data to bus segments in which it is needed and thus optimises the use of the communication media.

Characteristic	Konnex TP1-64[5]	Konnex TP1-256	Echelon LPT-11[6]	
Medium	Shielded twisted pair		Shielded or unshielded twisted pair	
Topology	Linear bus, star, tree or mixed	Linear bus, star, tree or mixed	Star, tree or mixed	Linear bus with 3m max stubs
Data Rate	9,600bps[7]		78,125bps	
Power supply	Bus or self-powered		Bus-powered (use FT3120 or FT3150 for self-powered devices)	
Device power consumption	3-12mA		Varies with application current drawn at 5v DC (LPT11 can supply up to 100mA for applications)	
Power Supply	30V DC SELV, polarity sensitive		48v DC SELV, polarity insensitive. Bus voltage 42.4v DC max	
Max No power supplies per segment	2		1 via LPI-10 interface	
Number of devices per physical segment	64 max[8]	256 max	128 max[9]	
Cable length per segment (Belden 85102)	Not specified		500m max	2200m max
Cable length per segment (JY(st) 2x2x0.8)	1,000m max		320m max	750m max
Cable length per segment (CAT5)	Not specified		400m max	725m max
Distance between devices	700m max (JY(st) 2x2x0.8 cable)		As maximum cable lengths above	

We believe that both systems offer appropriate cable lengths for home and building applications and more than enough capacity for connecting devices. We would be concerned as to the data capacity of an EIB bus were it to have 256 devices attached unless these communicated very infrequently due to the low data rate used by EIB.

Both Echelon and Konnex have introduced more highly integrated, lower cost hardware solutions for connectivity to their systems. In 2001 Siemens introduced, as an alternative to the original transformer connection to the bus, a combined analogue/digital chip solution: the TP-

[5] Data from prEN 50090-5-2 December 2002.
[6] Data from LPT-11 Transceiver User's Guide V1, 2003
[7] There is a 19.2kBaud option on the EIB transceivers but this has not been offered to CENELEC for standardisation.
[8] Segments may be interconnected using a bridge to support a larger number of devices
[9] Segments may be interconnected using a physical layer repeater or router to support a larger numbers of devices

UART or Twisted Pair – Universal Asynchronous Receiver Transmitter. This provides the connection to the bus, a 5-volt supply for the required microcontroller and an interface to that microcontroller. The digital portion of the TP-UART chip also manages the lower layers of the Konnex protocol, up to and including the logical link layer, thus reducing the processing load on the microcontroller.

Echelon has taken this level of integration at least one stage further by integrating the Neuron Chip and the transceiver electronics on the same chip to deliver what they term "smart transceivers". These require only the coupling transformer and a power supply to deliver a complete node.

Powerline Media

We compare the two Konnex powerline media and Echelon's powerline medium in the following table. PL110 is the original EIB powerline developed by Busch-Jaeger whilst PL132 is that developed within EHS and which is likely to be used principally for plug and play applications within household appliances. All comply with EN50065-1 and both Konnex's PL132 and Echelon's powerline transceiver implement the access protocol defined in that standard for devices operating in the 125-140kHz band. Independent tests have shown that both may operate simultaneously on the same power network without undue interference other than a reduction in throughput. An access protocol is not required in the 90-125kHz band. The Echelon powerline transceiver is also capable of operating in the 9-95kHz band defined in EN50065-1 for use by electricity utilities and commonly referred to as the "A band".

	Konnex PL110	Konnex PL132	Echelon PL3120 / PL3150
Primary Frequency band	90–125kHz	125-140kHz	125-140kHz
Secondary Frequency band	None	None	110-125kHz
Effective Data Rate	1,200bps	2,400bps	4,800bps
Error Correction			Yes
Throughput	5 packets/s		18 packets/s
	Class 116	Class 116	Class 116 or Class 134

The powerline technology developed by Echelon is inherently faster and, we believe, stronger than that of EIB and has the unique ability to operate in two different frequency bands to optimise performance in the face of interference on the powerline. Its large-scale rollout in electricity metering applications, using the A band, with 15 million meters so far installed in Italy, demonstrates that strength.

The recently launched PL 3120 and PL 3150 Smart Powerline Transceiver, which integrate two variants of the Neuron Chip with the powerline transceiver in a single package, significantly raise the cost/performance bar. This solution is well suited for the home automation market especially for the plugged-in appliances. This is the most cost-effective solution available in market for device-on-a-chip (transceiver, application processor and memory). This provides very reliable communications and it is compliant with communication regulations worldwide.

On the other hand, there appears to be little take up of the Busch-Jaeger developed PL110 with other manufacturers opting for wireless EIB solutions where the need is for "no new wires".

Wireless Media

EIB recently launched a wireless solution using the 868MHz band which is compatible with the wired media versions of EIB allowing wireless devices to be used as an integral part of an EIB installation. This offers a data rate of 38.4kbps, which is substantially greater than that of EIB wired media, and can be installed and managed by the ETS appearing as a separate logical line. As we indicated earlier, these do have some media specific aspects and, in particular the acknowledgement mechanism has been re-engineered to suit the wireless medium and to limit transmission durations to those required by the European standards for the 868MHz band.

Whilst Echelon launched LONWORKS launched with a wireless version, this never achieved real commercial viability. There are currently third party solutions on the market, principally around 433MHz for European use[10], but there is currently no LONMARK recognised radio channel. We believe that this is being addressed and that a robust, standards-based solution will be introduced. This is desirable but, since we note that the directors of LONMARK have indicated that acceptance by EIA/CEA is required prior to the adoption of any new physical layer, may take a little while.

CONCLUSION

On balance, we believe that the range of media supported by LONWORKS transceivers closely matches market needs in all areas except wireless. Although the Konnex wired media support a greater physical length of cable, and in one case, a greater number of devices, the low speed at which the media operates is a basic restriction which will normally require that the cable is segmented for bandwidth reasons. Similarly the powerline solution is slow and is often quoted as being unreliable (by EIB members!).

Security Aspects of Protocols

An area in the LONWORKS protocol that we have felt important is the integration of an authentication mechanism within the LONWORKS protocol stack; there apparently being no similar mechanism within EIB.

Researchers in the tele-haus project at the Technical University of Munich remark upon this general absence of security within EIB. In their paper[11], they comment, "In EIB installations it is quite easy for a potential invader to listen to telegrams and to send them himself to open for example a door. An even higher security leakage is in radio frequency and powerline transmissions. To avoid these problems, cryptographic secure data have to be used for communication."

They then develop an elegant method to protect EIB telegrams using the Advanced Encryption Standard (AES) but again comment, "Unfortunately standard BCUs are not powerful enough to compute the necessary de- and encryption algorithms, so a new hardware has to be defined."

The issue of system security, and particularly "authentication" versus "encryption" has been discussed frequently and, interestingly, whilst the researchers at Munich deliberately implemented an encryption system, they accidentally also implemented a basic authentication system using a "shared secret". The difference between authentication and encryption, and the need for these techniques, is neatly summarized by Jeremy Roberts in an article in LONMARK's "Interoperable News" when he comments, "Encryption is useful for document content, and credit-card numbers: things that are useful out of the context of the media in which it travels." Later in the same article he adds, "Authentication is useful for defining originator, or requestor: things that have no meaning out of the context of the media in which it travels."

Considering the case addressed by the Munich researchers, is it important that a signal from the security controller of a building to a door controller be encrypted so that it cannot be read? If the signal is to a door controller, anyone can guess that it is to either open/unlock or close/lock the doors. Therefore, encryption is not helpful in this case.

Is it important that a signal from the security controller of a building to a door controller be authenticated so that it is verified to come from the correct origin? If the signal is to a door controller, we want to be sure that it came from the security controller of the building, and not from someone tampering with the network.

For control networks, authentication can prove to be more important than encryption and a strong authentication mechanism is integral to the LonTalk protocol. Encryption might,

[10] Control Network Solutions Limited, Kongsberg Analogic A/S and Yokogawa Electric Corporation.
[11] Secured Data Transmission for Control and Supervision of an EIB Installation using mixed Network Topologies.

however, be required if biometric data were being transferred because this does have value out of the context of the media. The file transfer protocol described in LONWORKS Engineering Bulletin 005-0025-01D provides a suitable method of transferring such data and the Neuron Chip provides sufficient processing power to handle encryption.

CONCLUSION

The integrated security measures within the LonTalk protocol are sufficient for the majority of applications in homes and buildings although they do not protect the content of messages where that content has value out of the context.

EIB appears largely lacking in basic security.

Standardisation Activities

Standardisation, in the de jure[12] (by law) sense, has been an important thrust of the Konnex Association and those associations that preceded it. Taken with the trumpeting press releases, there appears to be an element of coercion here: this is the standard; you must use it.

Perhaps, given its American roots, Echelon was initially less concerned with the formal process noting that many standards, such as VHS for example, achieved their position through market success, so called de facto standardisation, and took a very open approach to their technology publishing the formal specification for LonTalk on their own website. However the pressure, from others pursuing the formal standardisation route, caused something of a rethink and a reluctant approach to standards bodies both in the USA and in Europe. This reluctance appears to have originated not from any desire for secrecy but the recognition that formal standardisation added cost and complexity out of proportion to any gain to the users.

This section reviews both the approach to technology standardisation in Europe, and the degree of progress made so far. It does not review the benefits, if any, that this provides to users of the technologies afforded by those standardisation efforts.

KONNEX STANDARDISATION ACTIVITIES

On 4 December 2003 Konnex announced, under the headline "The KNX Standard; the world's first open, royalty-free and technology platform independent, standard for home & building control" that "The CENELEC Technical Committee has signed to-day the final documents to declare the KNX standard as a Norm for Home and Building Control (registered under the following EN numbers 50090-3-1, 50090-4-1,50090-4-2, 50090-5-2 & 50090-7-1)."

In fact the three organisations that formed Konnex have been involved in standardisation for many years starting with work in the French National Committee that was subsequently transferred to CENELEC TC205[13] as a standard consisting of three incompatible protocols. When it came to a critical series of votes, a significant minority of countries defeated the draft standard which meant it was unlikely to ever succeed in the then current form.

The various associations then took their work to CEN TC247[14] where, together with LONWORKS, it was incorporated as the field level into the three-layer model which TC247 then used: field level, automation level and management level. All four protocols (BatiBUS, EIB, EHS and LONWORKS) were published in single massive pre-standard, ENV13154: 1998. This temporary standard expired in 2003 after the initial three-year term was extended for the maximum allowed two-year second term. A second temporary standard, ENV13321-2, covering EIBnet, was obtained in 2000.

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[12] "*De jure* is a Latin phrase meaning "by right" or "legally" that English has taken over first in legal jargon and then adopted into the general language. It usually contrasts with *de facto,* which means "in fact but not in law." A *de jure government* is one legally in place; a *de facto government* is one effectively in power and operating, but without legal authority." Taken from The Columbia Guide to Standard American English

[13] Then TC105 – now TC205 Home and Building Electronic Systems.

[14] Controls for Mechanical Building Services

Following their successes in TC247, the Konnex Association again turned its attention to CENELEC TC205 and sought, and gained, the status of a "Cooperating Partner" to CENELEC which gave particular access to CENELEC committees and the right to submit, draft standards to the CENELEC management. A number of such standards have been submitted, allocated to TC205 for study and voting and finally passed: specifically 50090-3-2[15], 50090-4-1,50090-4-2, 50090-5-2 & 50090-7-1). However these cover only limited parts of the Konnex system: Aspects of Application – user process, application layer for HBES Class 1, Transport layer, network layer and general parts of the data link layer for HBES Class 1, network based on HBES Class 1 – Twisted pair and, finally, Management procedures. One further part is in the voting process and is likely to be successful. This is prEN50090-5-1: Powerline.

The critical issues are, firstly, those parts which Konnex plans to deliver to CENELEC which have not been submitted: EN 50090-3-x corresponding to the KNX Interworking Model, EN 50090-5-5 corresponding to the KNX Radio Frequency Medium and EN 50090-8-x corresponding to the KNX Application Descriptions or, as they have also been described, the device profiles.

Secondly there are those parts (or volumes) of the Konnex internal standards that Konnex, apparently, does not intend to offer for standardisation: Volume 4 on the certification of hardware, Volume 8 on the test specifications for the KNX protocol features and Volume 9 on the KNX standardised basic and system components.

The press release referred to earlier went on to state: "The KNX technology is the world's first approved standard in the area of communications for home and building control that:

1. Is completely free of additional royalty charges for Konnex members.
2. Is completely independent of any specific hardware / software technology platform.
3. Has application profiles incorporated as an integral part of the standard.
4. Has a compulsory product certification procedure to guarantee multi-vendor interworking allowing certified products to be marked with the KNX trademark logo.
5. Has an integrated software tool for installation planning, engineering and commissioning."

Clearly, on the basis of the approved standards and those drafts that have so far been submitted to CENELEC, some of these claims cannot be substantiated. There are no application profiles submitted, there is no compulsory certification in the standards passed or the drafts submitted and there is no description of the integrated software tool.

LonWorks / LonMark Standardisation Activities

We referred to the work in CEN TC247 that resulted in the four-part European pre-standard ENV13154: 1998. The LonWorks section of this was based on the original Echelon specification for the LonTalk protocol and for the Echelon specifications for the transceivers, power supplies and the like. However those pre-standards expired in late 2003 and, in preparation for that expiry, European users of LonWorks technology began to prepare for new editions of the standards in agreement with TC247 and in recognition that the current agreements between the various European standards bodies (CEN, CENELEC and ETSI) and the European Commission prevent duplication of work in two or more standards bodies. The fact that Konnex technology was under consideration in CENELEC TC205 meant that it could not also be considered for standardisation in CEN TC247.

Fortunately substantial standardisation work had been proceeding on LonWorks outside Europe, particularly in the United States where the LonWorks content had been submitted to committee R7.1 of the Consumer Electronics Association: the same organisation as had standardised CEbus and EIB[16] in the USA. The resulting US standards formed a good basis for a submission to Working Group 4 of TC247 which is now considering four draft standards covering the LonTalk protocol (described as a control network protocol), powerline

[15] Not 50090-3-1 as Siemens' press release.
[16] EIA/CEA-776.5

transceivers, free-topology twisted-pair transceivers and tunnelling the control network protocol over IP.

Importantly, with the changes in structure within the LONMARK Interoperability Association and the changes to LONMARK International, it has been agreed to release the LONMARK Profiles, the basis for interoperability, for standardisation. In many ways this is almost unnecessary because all finalised LONMARK Profiles are publicly available on the LONMARK website at www.LONMARK.org/products/fprofile.htm together with the LONMARK Interoperability Guidelines.

CONCLUSION

Whilst standardisation of both Konnex and LONWORKS is proceeding, as it should, in separate European Standards committees, the degrees of progress are not dissimilar. A part of the Konnex system has been published as European standards but there are substantial gaps where there are no committee drafts as yet and where there is no public access to the information.

The LONWORKS system is documented in drafts before TC247 and, profiles apart, is substantially complete.

Supporting Organisations

It is clear from studies of a number of technologies that a strong supporting organisation is required to develop and promote these technologies as, for example, the various associations promoting different industrial field busses. In the present case these supporting organisations are the European Installation Bus Association, now the major element of Konnex, and the LONMARK Interoperability Association, now LONMARK International.

EUROPEAN INSTALLATION BUS ASSOCIATION (KONNEX)

Siemens, as the original and main promoter of the EIB technology realised very early on that the needed to achieve a degree of standardisation within the electrical industry because the presence of multiple competing technologies within that market would cause confusion and delay the growth of the market. They also realised that they needed to build a marketing and promotion vehicle for the technology. Consequently they worked to create the European Installation Bus Association (EIBA) which was officially founded in early 1990 when twelve companies, mainly German companies but with French and British companies as well, signed the founding documents agreeing to establish a Brussels-based, not for profit association. Gunter Seip, of Siemens, was elected President; a post he held until February 2003 when he stepped down to take the presidency of the merged organisation Konnex before handing this on to another member of Siemens, Dr Peter Penczynski.

In the early years it rapidly became clear that, although marketing was the original objective of EIBA, there was substantial technical work to be done, particularly in three areas; completing the documentation in a form that allowed others to implement the technology, working out the details of interoperability – how to ensure that devices from different manufacturers would work together in a reliable manner and creating a product certification scheme and associated trademark. Finally one key task was to seek formal status as a de juré national or International standard.

The failure, on the part of EIBA, BCI and EHSA, to obtain standardisation in the mid-90's was one of several factors which led to an agreement to merge technologies and to form a single organisation to promote those technologies: this single association subsequently became Konnex. The current status of standardisation activities is discussed elsewhere in this white paper.

Konnex currently has 95 member companies[17] of which 47 are headquartered in Germany and 58 members (61% of the total membership) are based in German-speaking countries. Only four

[17] In the press release of 4 December 2003, the Konnex Association claims 98 members but the latest information on the website, last updated 1 December 2003, lists only 95. We cannot identify the additional three members.

members are non-European (meaning outside the borders of the (post May 2004) European Union of 25 countries or the European Free Trade Area) and one of these, the Continental Automated Buildings Association (CABA), is neither a manufacturer nor a user.

This strong European focus is also shown in the 15-person Konnex board and which is elected for a period of four years by the Konnex General Assembly on which every member has a seat. This board is currently drawn from former members of all three former associations and features eight members who list their legacy association as EIBA, three as BCI and seven as EHS: this adds up to 18 because three members list two legacy associations. The board is predominantly drawn from France (7 Members) and Germany (6 members) with a single representative from each of Sweden and Switzerland.

One of the key responsibilities of the Konnex Board is that of setting the annual budget for approval by the General Assembly and which is funded by annual membership fees, joining fees and certification fees.

Membership fees vary with company size ranging from €2,500 ($3,125) for manufacturers and service suppliers with less than 10 employees up to €12,500 ($15,625) for companies with more than 100 employees. An additional membership class, 'I', exists for interested parties, who cannot manufacture Konnex products, at a cost of €2,000 (£2,500).[18] In all cases an additional joining fee is charged in the first year of membership amounting to the membership fee, i.e., the fee in the first year is double the fee in subsequent years.

Certification fees are payable both to the party carrying out the test, which must be approved by Konnex, and to Konnex itself. The fees to Konnex include €600 ($720) for registering hardware, €180 ($215) for registering new software or a new combination of hardware and software and a €75 ($90) per product per year annual surveillance fee.

Konnex National Organisations

An obvious strength of EIBA, which Konnex appears to have built upon, is the formation of national organisations to promote the technology in individual countries. In particular, Konnex, or EIB, has national groups in Austria, Belgium, France, Germany, Italy, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland and the UK and these appear to have strong links to the main organisation and to act as strong advocates for the Konnex technology.

LonMark International

Unlike EIBA, which was an early part of Siemens' thinking, the LonMark Interoperability Association – now LonMark International – arose somewhat later in the process. It was formed in May of 1994 by early adopters who used to meet every six months in the early "LonUsers" meetings and who saw the need to promote the then emerging products and, in order to enable the market, develop mechanisms to ensure interoperability at the device level rather than at the data variable level that LonWorks technology then provided.

Currently the association recruits members at four differing levels; each with different privileges. These are Sponsors (who get an automatic seat on the controlling board), Partners and Associates (both of whom elect representatives to the board but Associates may not have certified products) and Individuals.

LonMark International currently has over 300 members worldwide but the membership is constructed differently from that of Konnex and the two cannot be directly compared. Firstly LonMark has a large number of LonMark Associates who, whilst they may be product manufacturers, services providers or other interested parties, cannot use the LonMark logo on any products they may produce. A substantial number of those that do produce products either do so without wishing to use the logo or find that they cannot use the logo because the necessary LonMark profiles are not yet in place. Many of these, to the annoyance of full members of LonMark, describe their products as "LonMark compliant" or "LonMark compatible".

[18] For this white paper, we have used an exchange rate of $1 = €0.8 equivalent to €1 = $1.25.

Secondly, members of LONMARK are drawn from a wider range of industries than those covered by Konnex and to include all such members would not be a useful comparison. We have therefore eliminated from a comparison those companies where we cannot find clear evidence that they are active in our present field of interest: home and building electronic systems. As a result we can positively identify 93 companies active in the market with either sponsor or partner membership of LONMARK.

As might be expected the geographical distribution of these differs markedly from that of Konnex with 26% of the members having headquarters' addresses in Asia and Australasia, 32% in North America and 42% in Europe. Neither LONMARK nor Konnex list members with addresses in South America nor the Indian sub-continent. 13% of the LONMARK members give addresses in Germany and 19% give addresses in German-speaking parts of the world.

This balance will change under the reorganisation currently in progress and which marks the independence of the LONMARK interoperability Association under the new name of LONMARK International. LONMARK International adopts a new, not for profit, organisation and a new membership strategy under which many members will join through their local affiliate or national grouping such as the LNO (Lon Nutzer Organisation) in Germany. This is described in a recent announcement from LONMARK.

"As with the original association, membership is extended to any person, firm, or corporation engaged in the development, distribution, or marketing of open, multi-vendor control systems utilizing ANSI/EIA709 and related standards. Current members of the LONMARK Interoperability Association will retain their membership status in the new organization. Unlike the previous organization however, most members will belong to LONMARK International through a regional affiliate. A LONMARK Affiliate is a non-profit organization that is a member of the federation of associations that make up LONMARK International. Organizations interested in becoming a LONMARK Affiliate will sign a LONMARK Affiliate Agreement defining the terms of the relationship. LONMARK Affiliates will become an extension of LMI by providing local membership services to members. Membership dues will be paid to the local LONMARK Affiliate for membership in LMI and the affiliate."

This move effectively unites the 16 LonUsers Groups in Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Poland, Russia, Slovenia, Spain, Sweden, Switzerland and UK into a coherent pressure group for LONWORKS technology.

The current board of directors of LONMARK does show a distinct bias to North America with seven directors from Asia, four from Europe and the remaining 12 from North America. This will change under the new arrangements when Partners and Associate members will elect three directors each from the three regions of the world defined, by LONMARK International, as Europe, Asia and North America. Sponsors, of course, retain their right to a seat on the board.

As with Konnex, LONMARK International has significant running costs and is predominantly funded from annual membership fees. Sponsors pay $20,000 (€16,000), partners pay $5,000 (€4,000) whilst associates and individuals pay $1,000 (€800) and $100 (€80) per year. Unlike Konnex, there is no joining fee.

Certification to the LONMARK Guidelines is necessary for devices to carry the LONMARK logo. Initial certification costs $500 (€400) whilst certification of an upgrade, such as a software or hardware revision, costs $250 (€200).[19] There are no third-party fees to pay and the certification only covers use of the LonTalk protocol and compliance with the LONMARK Guidelines. There are no annual surveillance or recertification fees payable. Manufacturers are free to certify compliance with, for example, electrical safety and EMC as they see fit or as required in the various countries in which the product is to be sold – for example by CE-marking in Europe.

CONCLUSION

The two organisations, whilst superficially existing for the same purpose – promotion of a particular technology and products and services based upon that technology, differ substantially

[19] Effective 1 April 2004 replacing the previous, more complex fee structure.

in practise. LONMARK International is a slimmer organisation with fewer staff and a more representative management board structure including representatives of users and installers. The Konnex Association has a larger staff, is more involved with development (especially of tools) and has a board drawn wholly from manufacturers.

Available Product Ranges

KONNEX

EIBA maintained a reference list of certified products by language and Konnex has since maintained this. The latest listing page dated 24 February 2004. This page contains separate pdf files for German-speaking countries (206 pages, 42 manufacturers), English-speaking countries (3 pages, 1 manufacturer), French-speaking countries (27 pages, 3 manufacturers), Italian-speaking countries (13 pages, 2 manufacturers) Asian countries (2 pages, 2 manufacturers), Israeli-speaking countries (2 pages, 1 manufacturer) and Scandinavian countries (30 pages, 5 manufacturers).

Analysis of these files indicates that over 75% of manufacturers are based in German-speaking countries of Germany, Austria and Switzerland and account for some 72% of the different products available.

These lists of certified products are produced, among other purposes, for the use of installers and list not only each product but also the various application programmes that may be downloaded to the BCU. Consequently certain products may be listed several times – perhaps as many as eight times – and may also be listed again in a different set of colour-ways. This is particularly so in the case of "on the wall" products where colour and style are an important part of the proposition. It is therefore difficult to establish the real number of distinct products in the market.

It easy, however, to establish the range of products that, as might be expected, is essentially composed of those devices that might be expected from electrical wiring device manufacturers and which would lie within the experience of electrical installers. Hence there is a substantial range of input and output modules, wall switches, dimmers, thermostats and regulators, presence sensors together with essential items of technology such as power supplies, data-rails, line-couplers and bus interfaces.

Curiously we could not find any reference to fan coil unit controllers although we have identified two such products, the Syncro 700 from Siemens Building Technology and the "ecobus" from Woertz AG. Both these appear to rely on the recently developed logical tag extended mode introduced to facilitate HVAC applications.

LONWORKS

LONMARK International recently announced that the number of products certified to LONMARK Guidelines had exceeded 600. At the time of writing this appears to have risen to 647 with the additional of additional products from Trane, Philips Lighting and others. Our analysis suggests that some 80% of these are intended for application in home and building applications.

The open nature of LONWORKS does not require certification to LONMARK guidelines or profiles and, in a number of cases, suitable profiles do not exist or cannot be applied because, for example, the products require a software download at installation time in a similar manner to EIB products.

There is however a voluntary listing of LONWORKS-based products on the Echelon website which, at the time of writing, amounts to 1147 different products. Again we believe that some 80% of these have direct applications in homes and buildings.

We referred earlier to the extent of the choice of certain on-the-wall products using EIB. We also note that, using LONWORKS-based equivalents of the EIB BCUs from SVEA, many of these EIB on-the-wall products are also usable with LONWORKS-based systems.

CONCLUSION

The range of EIB products covers only some of the functions needed in a commercial building although, within those functions, the choice of colours and styles is vast. The range of LonWorks-based products is wide enough to meet most commercial building requirements although the choice of styles may be slightly more restricted in some cases.

Profiles and Interworking Standards

It became apparent, particularly in the field of home and building control, that specifying a single data element for a device did not fully describe a device and that a collection of data elements and associated configuration parameters was required, especially for complex devices such as found in HVAC applications.

EIB PROFILES

For EIB, we have been able to establish that Volume 6 of the Konnex Specification contains the Konnex profiles. Unfortunately we have not been able to obtain access to this and cannot therefore comment on this important area.

LonMark PROFILES

The LONMARK website currently lists 65 different profiles of which three are concerned with the control of refrigerated display cases and six with the control of lifts and elevators. The first group probably fall outside the strict "home and building", scope being concerned with the use of buildings specifically for food retailing, whilst lifts and elevators are traditionally, at least in Europe, regarded as "life safety" applications and would have limited connection to building control systems.

Of the remaining 56 profiles, four deal with access control and intrusion, nine with fire systems, 15 with HVAC applications, two with standby power supplies, two with generic analogue inputs and outputs, 10 with lighting applications and nine with generic sensors.

These profiles are heavily structured, well detailed and well documented and, most importantly, include requirements for "self-documentation" within the devices themselves. This makes the device network itself self-documenting so that attached tools can recover the necessary configuration data. These profiles port well to XML that is the "secret ingredient" for the next generation of enterprise-wide integration.

CONCLUSION

We believe that the interoperability model developed by LONMARK is stronger than that which we have been able to see with EIB.

Installation Tools

A critical issue with any of these "bus system" technologies is that of the tools provided for the installation, commissioning and maintenance of the systems for, certainly in larger systems, the effectiveness and ease of use of these makes or breaks the installation from performance and cost perspectives. In this section we look at the range of installation tools available for Konnex and LONWORKS systems with a view to larger and more complex installations.

KONNEX

Konnex supports three installation modes, Automatic, Easy and System modes. The first of these addresses the technologies inherited from EHS whilst the second relies upon the setting of DIP-switches, the sequenced pressing of push-buttons or similar techniques rather as used in the earlier BatiBUS technology. As such these modes are not normally used in the range of larger installation that we are considering here, it is the third mode, System Mode, which we discuss.

The Konnex installation tool is the ETS, or Engineering Tool Software, which is moving into its third generation with the release, at the Frankfurt "Light & Building" show in April 2004, of

ETS version 3. This is a substantial rebuild of the earlier versions of the ETS to provide a consistent user interface and to integrate the two major modules of the earlier versions; that for design and that for commissioning. The user interface is highly customisable and can be configured to resemble the "classic" ETS 2 interface to ease the transition process for those familiar with ETS 2.

The ETS additionally includes the functionality of other, third party, tools providing low-level access to, and interpretation of, messages on the bus ("telegrams") for diagnostic purposes. A connection manager allows a choice of methods of connection to the bus; serial, USB or IP, and more than one may be used at a time allowing diagnostic tools to use an alternative connection if required.

ETS 3 introduces a new format for the installation database but can convert databases from versions 1.2 and 1.3 of ETS 2 and can import project and product data from all versions of ETS 2. ETS 3 also introduces clean interfaces for "plug-ins"; device-specific software programmes which may be used to programme and manage more complex devices. A starter version of ETS 3 is available which provides a simpler user interface and, importantly, a simpler vocabulary.

Konnex states, as a major benefit of the new release, that the KNX / EIB system concept is unique in offering this single, manufacturer- and vendor-independent toolbox for installation designers and electrical fitters alike.

LONWORKS

Unlike Konnex, where substantially all installations are performed using the ETS, there are a variety of installation tools available for LONWORKS networks with over 20 different solutions available in the market. The majority of these installation tools are built on the basis of Lon Network Services (LNS), a network operating system from Echelon.

LNS provides a standard platform for supporting interoperable applications on LONWORKS networks. LNS permits multiple applications and users to manage and interact simultaneously with a network. Multiple users can access a shared LNS server via the LONWORKS network, a local area network or the Internet.

Echelon themselves offer three variants of their own installation tool: LonMaker Professional, LonMaker Standard together with a trial version, LonMaker Trial. These incorporate Microsoft's Visio as a powerful graphical tool and vary in the version of Visio they include, Professional or Standard. The graphical features in LonMaker Professional are greatly enhanced. These versions also vary in their ability to install devices, since they are provided with differing levels of LonMaker Credits.

The LonMaker tool provides comprehensive support for LONMARK devices, *i*.LON Internet Servers and other LONWORKS devices. The tool takes full advantage of LONMARK features such as standard functional profiles, configuration properties, resources files, network variable aliases, dynamic network variables changeable types. LONMARK functional profiles are exposed as graphical functional blocks within a LonMaker drawing, making it easy to visualise and document the logic of a control system.

The LonMaker tool conforms to the LNS plug-in standard, which allows LONWORKS device manufacturers to provide customised applications for their products. These applications make it easy for system technicians and engineers to define, commission, maintain and test the associated devices.

As mentioned earlier in this section there are a significant number of other installation tools based on Echelon's LNS and it is not practicable to review them all here. However, all LNS-based tools have one key feature: there is a charge, in the form of an LNS credit, for each device installed.

AUTOMATIC OR SELF-INSTALLATION

There is an alternative to installation using installation tools: automatic or self-installation. This is important for residential applications and particularly so in the case of "white goods": washing machines, dishwashers, refrigerators and freezers. These are normally bought at retail and simply delivered with the householder left to arrange installation. Automatic installation, or a much simplified installation procedure, is also useful to the electrical installer in residential and similar applications.

The importance of automatic or self-installation for white goods, mentioned above, cannot be overemphasised given recent developments in Europe, Ceced, the European Committee of Manufacturers of Domestic Equipment, announced its CHAIN initiative, CHAIN standing for Ceced Home Appliances Interoperating Network. This defines the protocol for connecting larger appliances in a single multibrand system designed for control and automation of key services in a home: e.g., remote control of appliance operation, energy or load management, remote diagnostics and automatic maintenance support to appliances, downloading and updating of data, programs, and services from the Web.

Whilst this, on the face of it, suggests that Ceced was competing directly with Konnex and Echelon in trying to establish and end-to-end solution, this is not the case and Ceced is working closely with both organisations. A latter press release makes this clear when, in discussing the timetable for CHAIN, it indicates that mapping onto both EHS/Konnex and LONWORKS is planned and, indeed, that mapping is well underway at the time of this white paper.

Both Konnex and Echelon offer automatic installation (as Konnex terms it) or self-installation (service-pin binding), as Echelon puts it, and both are relatively similar in their capability. Triggered by an external event, such a pressing the service pin on a LONWORKS device, devices can recognise other devices on the network and configure themselves to suit. This requires that the functions are relatively basic and are fully structured in the way of a profile or similar. This is because the small amount of processing power available cannot resolve ambiguities in the way that a human using a network management tool can. Incidentally, it was an early proposal to facilitate automatic or self-installation that led to the development of objects and profiles within LONMARK itself.

Both ETS3 and LonMaker (and related LNS-based tools) can manage Konnex and LONWORKS self-installed devices respectively although, in the case of LONWORKS devices, these must include a **SCPTnwrkCnfg** configuration property (defined in LONMARK standards) to indicate that the device has been modified by a network management tool.

There is however, on critical difference between Konnex and LONWORKS in this area. Self-installing LONWORKS devices use the same protocol and the same network variable techniques as all other LONWORKS devices. Automatically installing Konnex devices use a modified version, in that the addressing was aligned with that of EIB, of the original EHS protocol and which is not interoperable with EIB-derived products and for which a translator device is required.

It is important to note that Echelon also offer what they term automatic installation which is a far more powerful technique for small networks of up to 128 devices on one or two channels. Using a Neuron-based node, the device manager, a network can be defined using LonMaker and loaded into the Device Manager. Subsequently the Device Manager will take over the management of the network, automatically detecting the presence of new devices on the network, identifying, logging and reporting faults and replacing failed devices. This is especially suitable for applications where a PC is not usually on site or where a PC cannot be easily brought to site.

CONCLUSION

We have not had the opportunity to examine Konnex's ETS3 in detail but, on the evidence we have at present, we believe that this represents a significant improvement on the earlier versions and to be very similar in capability to Echelon's LonMaker Standard version. It is, so far as we can see, a single-user tool and does not support multiple concurrent users in the manner that

LNS-based tools do. Neither is there any choice of tool apart from the ability to reconfigure the user interface.

ETS3 appears to lack some of the graphical features found in LonMaker Professional although these do have to be paid for: ETS3 is expected to sell for a regular price of €895 against the $1315 (€1052) for LonMaker Professional plus the on-going costs of LNS and LonMaker credits. However those doing large building integration clearly find that the capabilities of LNS and LonMaker are essential, having been driven by industry feedback, and that tools lacking these capabilities do not deliver.

Echelon's self-install technique appears to be as good as that within Konnex but has the distinct benefit that its use of the protocol is identical with the use for network-managed devices. This is not the case with Konnex's technique. Echelon's automatic installation, fault monitoring and automatic replacement technique is very valuable and is unmatched in Konnex.

Development Tools

Development tools consist of the hardware and software needed to develop and test bus devices. Both Siemens and Echelon produce specialised development tools and there is evidence of third party tools in the market. The ability of these to produce interoperable solutions appears, in one case, to depend heavily on the understanding of the developer and, in the other case, to be almost automatic.

EIB

Siemens supply the EIB Integrated Development Environment that consists of a developer board for Bus Interface Module BIM M112, the EIB-IDE tool itself together with the user library and extensive help files. The EIB-IDE does not include either the C-compiler or assembler that have to be obtained separately. Siemens offer a developers training course with the slightly ominous prerequisite "Participation of the instabus EIB Compact Course and knowledge of an assembler language."

Clearly there is no integrated development environment for EIB and programming has to be done at a very detailed level using assembler language and with intimate knowledge of, for example, the memory maps within the devices.

LONWORKS

Echelon's first development system, the LonBuilder, became available well before the first Neuron chips and provided a integrated developer's workbench with all necessary resources and a good selection of hardware.

NodeBuilder, Echelon's current development tool, consists of the NodeBuilder software, the LNS integration tool, the LNS DDE server (OEM version), the LTM-10A platform, a Gizmo board and a LONWORKS Module Application Interface. The LTM-10A platform is a complete LONWORKS device with downloadable flash memory and RAM that can be used for application and prototype I/O hardware testing.

A critically important development in the NodeBuilder range is the inclusion of "wizards" which facilitate the development of interoperable products by creating boiler plate Neuron C code as well as generating all the documentation required for LONMARK certification and generating any necessary plug-ins for use in LNS-based management tools.

Other device development systems are available for LONWORKS devices including that from Visual Control LLC which takes a graphic approach to device programming.

CONCLUSION

Whilst the LONWORKS environment is potentially richer, and consequently the task of device development may be more complex, than for EIB, the NodeBuilder from Echelon provides a powerful but simple development tool designed and configured to produce interoperable devices as standard. Device development times are radically shorter with NodeBuilder.

The Internet

We referred earlier to one of the major changes since the original introduction of both EIB and LONWORKS: the explosive growth in the use of IP protocols and the Internet. Here we examine how both protocols have adapted to, and taken advantage of, the Internet and, more importantly, the growth in the use of Internet Protocols in managing the enterprise.

There are several aspects to the use of Internet protocols and, as in most other cases, "it depends what you want to achieve". One case is simply to use Internet protocols to connect separated groups of devices together all of which use the same communication protocol – EIB or LonTalk in this case. This simply requires that native protocol frames be "tunnelled" over IP by being completely wrapped within Internet protocols and, at the destination, these frames are unwrapped and acted upon as if they had originated locally. Provided the devices at both ends use exactly the same protocol, and that the addressing scheme provides for this, the two groups of devices may operate as one.

A second case is where the Internet (and its protocols) are being used to represent a collection of devices to a human being by, for example, being represented in one or more pages of HTML code accessible in a web browser. This requires that a device – a gateway – takes information from the devices on a control network and renders this into HTML using a web server.

The third case is where machine-to-machine connections are to be made but the machines run dissimilar protocols. This requires that the information from each device be rendered into a common format or, at least, a format that is essentially self-describing. In Internet terms, this requires the use of XML (eXtensible Mark-up Language) and SOAP (Simple Object Access Protocol).

The two protocols under consideration have made varying degrees of progress in using internet protocols effectively.

EIB

EIB originally published EIBnet, a specification for the transport of EIB telegrams over Ethernet. This was rapidly extended to provide for the use of UDP[20]/IP and TCP[21]/IP to provide a more generic solution this is compatible with the Internet. UDP is used to transport EIB frames whilst TCP is used to transport configuration and status messages. This formed the basis for a tunnelling solution which was subsequently extended as ANubis (advanced Network for Unified Building Integration Services) to provide services for the three cases above.

LONWORKS

The tunnelling of LONWORKS messages over IP is standardised in EIA-852 published in 2001. Echelon and third-party vendors have supported this with a wide range of IP routers enabling LONWORKS packets to be routed over intranets as well as the Internet. These also enable packets to be routed to and from attached computers that may run web servers to present information from the LONWORKS network in HTML or other formats.

The introduction of the *i*.LON range of network interfaces by Echelon increased the range of Internet Protocols usable in connection with control networks and, importantly, introduced web serving capacity directly to the network. HTML pages can be downloaded to the *i*.LON and can reference any data items on the attached network including network variables, data logs, etc..

[20] User Datagram Protocol – an unacknowledged, unordered, data transport method.
[21] Transmission Control Protocol – a data transport method that provides both acknowledgement and re-ordering of information.

Echelon built upon this effective connectivity between control networks and the Internet introducing the Panoramix™ Enterprise Platform which, using their LNS technology, enables machine-to-machine communication without human intervention. This allows, for example, the integration of the back office processes of an energy provider or energy services company with meters and controls spread across a country, a continent or seven continents. Panoramix forms the basis of Echelon's Networked Energy Services offering which provides:
- Automatic Meter Reading (AMR)
- Time-of-use, real-time pricing
- Virtual and hard remote connect and disconnect
- Theft, tamper detection and revenue protection
- Low voltage grid energy management
- Outage detection and restoration reporting
- Individual customer service quality level monitoring
- Remote change in customer maximum power threshold

CONCLUSION

Perhaps it was Echelon's location in California which led them to early identification of the importance of the Internet and the role that it now plays. Whilst they and EIB have been pursuing similar paths, so far it is only Echelon who really appear to have mastered the business opportunities of the Internet with Panoramix and Networked Energy Services.