Intelligent Building Concept

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EXECUTIVE SUMMARY

The Intelligent Building concept of the early 1980's advocated use of sophisticated networks and systems to enhance user interface with the building management or facilitate voice, data or centralized word processing systems. The cost to benefit evaluations, at that time, could rarely justify the cost premiums involved.

The generalized use of personal computers in the work place, the globalization of markets and communications needs, over the past 20 years, have led to the development of more performing and lower cost communication strategies to serve the specific needs of the different management, data, voice and imaging systems. Development of each system was carried independently with little or no concern for interaction between systems.

Modern office buildings must meet the environmental and social concerns of today's more sophisticated worker while providing him with state of the art internal or global communication capabilities.

The Intelligent Building (IB) of the new millennium aims to regroup these enhanced independent building management and communication system capabilities through well planned and coherent building concept. The IB concept's objective is to maximize interactivity between the different systems while maintaining full flexibility to accommodate upgrades and implementation of new user requirements in the future.

For a successful implementation the IB concept must be retained in the initial planning stages of a new building or its major renovations.   A well structure and modular communication backbone must also be included in the base building plan.

Quality of the environment in the work place, an efficient integrated Energy Management and Control System and full internal or external Communication capabilities are no longer optional in today's modern office building.

The Intelligent Building concept is no longer a prestige item. It has become a viable and justifiable alternative in the building's cost to benefit life cycle evaluation .

1- General

An Intelligent Building is one conceived and designed with an integrated flexible and modular communication cabling infrastructure capable of accommodating the needs of information intensive users for advanced information technology and services.

Ever increasing occupation densities as well as the exponential development and quasi universal use of personal computers coupled to market globalization and communication capabilities, over the past 20 years, have rendered the Intelligent Building (IB) concept a priority consideration in the planning of new or upgraded Office buildings.

Evolution towards new social priorities, for the more educated office worker of today, has also led to substantial increases in environmental issue demands and standards. Social studies revealed a direct relationship between user satisfaction in the workplace and productivity. Individual control capability of ambient conditions, at each work station, was identified as a major element leading to user satisfaction.

Technological developments and cost attenuations through technological development and product availability have now rendered the Intelligent Building a viable and a justifiable option from a strict cost to benefit aspect.

2- History

The IB concept surfaced in the early 80's and generally advocated extensive use of elaborate centralized electronic systems to facilitate control of building support and communication systems for voice and data. The initial concept promoted communication networks to allow centralized word processing services and limited interaction between individual occupants and the Building Automation Systems through touch tone phones to override local HVAC set points and lighting schedules.

Builders and owners were pressured to develop intelligent buildings, in spite of the high premium costs, at that time, for prestige reasons and for enhanced rental potential.

The Building Automation System and the Communication System industry as well as other specialized interest groups soon developed specific products and applications to meet and facilitate the implementation of the Intelligent Building concept. These developments coupled to the burgeoning Personal Computer market development have since reduced cost premiums drastically and greatly improved the ensuing benefits for Intelligent Buildings.

The IB concept is now well accepted and applied in Europe, Asia and North America.

3- Overview

Definitions for the Intelligent Building concept still vary but the most accepted description is the one produced by the Barcelona-based Institut defons Cerdà:

"A building which incorporates information systems that support the flow of information throughout the building, offering advanced services of business automation and telecommunications, allowing furthermore automatic control, monitoring management and maintenance of the different subsystems or services of the building in an optimum and integrated way, local and/or remote, and designed with sufficient flexibility to make possible in a simple and economical way the implementation of future systems."

To the uninitiated, the perception of a building's degree of intelligence is too often correlated with the sophistication level of its Energy Management and Control System (EMCS) and its Communications system. However, to be effective, it must also encompass its mechanical and electrical systems order to minimize costs and maximize efficiency. There would be little point in developing ideal EMCS and Communication systems for the occupants if HVAC, Lighting and other systems cannot meet and satisfy the needs of the occupants.

In a new IB installation we should expect the following features:
- High- speed fibre optic communication network trunk for data, video and BAS;
- Flexible HVAC system with modular distribution and 100% outdoor air capability to take advantage of free cooling as well as to allow flushing of the building to dilute volatile off-gassing contaminants;
- Advanced integrated Energy Management & Control System (EMCS) utilizing direct digital control technology for HVAC, Lighting, Fire Alarm and other building support systems;
- Dedicated circuit power distribution network complete with Uninterruptable Power Supply units;
- Generous standby power generation;
- High efficiency filtration, energy recuperation and/or thermal storage features to improve indoor air quality and energy consumption performance;
- Networked multi-user access incorporating structured password protection;
- Maximum transparency and communication capabilities between sub-systems;
- Electrical design features tailored to Intelligent Building;
- Individually controlled HVAC terminal units allowing occupant control flexibility through Intelligent Terminals Controllers at each workstation.

In retrofit buildings we would expect variations of the above features based on an owning and operating economical analysis taking into account the existing services and the benefits ensuing through their replacement and/or upgrade. Major retrofits, particularly those involving designs dating back 20 years or more, are generally dictated by a combination of the following:

- New code requirements,
- Updated indoor air quality standards,
- Revised energy efficiency guidelines,
- Increased internal electrical requirements associated to the generalized use of PCs.
- Revised building use.

The average life cycle of most M&E installations is 20 years versus an average building life cycle of 50 years. These retrofits, therefore, often dictate a complete revamping of the existing M&E installations well before the building's life cycle has expired. This frequently offers an opportunity to upgrade the building's support systems to IB standards.

4- Future trends

The former Intelligent Building Institute (IBI) foundation advocated, a few years ago, a need to recognize, in future building designs, the transition from national economies to a combination of local and global economies and therefore the need to facilitate each employee's access to global communication networks. They predicted that information technology access will provide the biggest single impetus for change in the office environment. This prediction has now become a reality.

IBI also predicted that environmental issues and particularly Indoor Air Quality (IAQ) were becoming a primary concern in the design of the new office buildings. Improved air filtration and increased air change were pinpointed as major concerns in addition to flexible ambient room condition control.

Other studies performed recently reveal that the use of Personal Environment Controllers formerly called Intelligent Terminal Controllers) or has measurably increased occupant satisfaction in the workplace on a number of pilot project installations. PECs are a combination of mechanical, electrical and control devices developed for the work station environment control and conceived to provide the occupant with the means to define and interact on temperature set points, air flow volume and diffusion patterns as well as lighting levels affecting productivity and user satisfaction. These studies have associated improved production to the use of Intelligent Terminals Controllers.

5- Intelligent Building Model

The IB model structure has been subdivided into seven systems which may be interfaced to varying degrees. These systems are...

1 Heating Ventilating and Air Conditioning (HVAC) system;
2 Lighting System;
3 Electrical Power Distribution system;
4 Vertical Transport System;
5 Security System;
6 Life Safety System;
7 Communications System;

The general objective of the Intelligent Building System is to regroup control of these subsystems and facilitate interchange between them to the maximum justifiable extent while maintaining maximal initial and future competitive bidding possibilities of each component as well as allowing dependent and timely upgrading of each system as new technologies evolve in its particular field.

The IB concept also attempts to combine, wherever possible, the cabling networks for these subsystems in order to minimize costs and facilitate intercommunication or allow future upgrading.

Efforts are being deployed between ASHRAE, IEEE, AEE and the computer industry to develop universal communication protocol standards. It is not expected, however, that universal standards will become a reality for another decade. The cabling structure must therefore be conceived to accommodate the foreseeable requirements with minimal disturbance and cost when and if universal standards materialize. The favoured backbone communication cabling technology at this time favors fibre optic technology, because of its high speed communication potential.

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4 Vertical Transport System;
5 Security System;
6 Life Safety System;
7 Communications System;

The objective for Intelligent Buildings is to regroup control of these subsystems under a compatible communication protocol while maintaining, to the extent possible, independent design and tendering packages for each system.

The communication compatibility will allow use of a common cabling backbone infrastructure incorporating all immediate and foreseeable communication requirements. This backbone infrastructure will link the building's different communication networks to telco (telecommunication) rooms strategically located throughout the building. Distribution from the telco rooms, on each floor, to each work station could then use segregated floor distribution cabling as required to meet specific area needs of each user.

The independent design and tendering for each communication specific package under predefined compatible communication protocols, instead of an single all encompassing overall tender package will enhance tender competitiveness and will allow independent and timely upgrading of each system as new technologies evolve in the concerned specialty.

The general IB concept aims to combine the cabling backbone networks for the systems in order to render the building ready to accommodate any initial or future system implementation as building user requirements evolve. This will substantially minimize cost, increase flexibility and enhance the building's value over its expected life

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6- IB Systems

  6.1 <u>HVAC</u>

      .1 General

In Intelligent Buildings Systems the governing principle to be used in the selection of the HVAC system options must be to satisfy ventilation standards and occupant comfort control while optimizing, flexibility, energy efficiency and maintenance costs.

An owning and operating cost analysis coupled to an energy simulation of each viable option is mandatory to determine the optimal HVAC solution. In intelligent buildings additional considerations must also address flexibility and modularity as well as state of the art Direct Digital Control (DDC) Building Automation Systems to minimize future costs associated to tenant fit ups as well as incorporate centralized control to implement energy optimization routines, scheduling, monitoring and interface with other IB systems.

      .2 All Office Buildings

In new buildings or renovated buildings with sufficient ceiling space central VAV systems coupled to perimeter radiation heating remain the system of choice by designers because of their ability to diversify cooling loads, allow use of free cooling, building flushing and centralized maintenance. Unfortunately VAV systems present frequent drawbacks in terms of unreliable minimum outdoor air volume control and poor air diffusion patterns at the room or workstation level

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          .1 Air Diffusion

The traditional VAV system design has been using VAV terminal boxes with fixed diffusers to meet the individual room or work station load variations. Fixed diffusers are generally selected for the maximum air volume demand. At peak demand their air diffusion pattern generally performs as intended when not hindered by partitions or furniture. Under ideal conditions the cold supply air stream should theoretically blend with adjacent air and reach the occupant at tempered conditions . Too often partitions or furniture layouts (undefined at design time) create havoc with the intended air diffusion pattern. Furthermore when the air flow volume is reduced by more than 20 to 25% the intended air flow diffusion pattern no longer performs as intended and cold primary air is either "dumped "directly on the occupant without going through the intended tempering process or, alternatively, it is short circuited directly to a return air grill due to reduced velocity. In either case the

room occupant is negatively affected via excessive temperature variations, drafts or lack of air change because of the short circuiting. Since VAV systems, in our Canadian climate, operate at an average of 60 to 65% of peak capacity this problem becomes the rule rather than the exception.

A new technology involving the use of air jets coupled to "Personal Environment Controllers" (PEC) is fast gaining credibility as the solution to VAV diffuser problems. The PEC concept was developed in the general context of Intelligent Building to provide occupants with full control over their particular office work station environment. PEC units allow the occupant to control temperature, air flow volume and direction as well as lighting through their local PC (where IB exists) or through hand held portable remote control units. In an PEC concept standard fixed position diffusers are replaced by one or more air jets strategically located to project cold air streams downward and away from the occupants. The occupant has control over the air volume and its direction.

Recent studies have also demonstrated that the use of Personal Environment Control (PEC) units at each Work Station in lieu of the traditional VAV terminals, with fixed diffusers, provides improved occupant satisfaction while maintaining the basic energy savings justifying the use of VAV systems in office buildings. Other relevant studies have associated occupant satisfaction to productivity increases in the order of 1 to 3%. When factored into the cost to benefit analysis this reported productivity increase can often help justify the use of the air jet option.

This option deserves serious consideration in any Intelligent Building concept since it allows individual workers to adapt to their particular ambient environment, metabolism and preferences rather than be submitted to subjective average requirements dictated by international standards. This option can also compensate for air flow deficiencies associated workstation furniture and partition obstructions.

.2 Minimum Air
The American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) have documented, through numerous studies, that fixed minimum air damper positioning or supply and return fan flow tracking are inaccurate and unreliable techniques to control minimum outdoor air in VAV systems.

VAV systems are used to supply cold tempered air which is modulated via terminal units to track a building's cooling load. In other words, as the cooling load decreases so does the VAV system's air flow thus resulting in lower energy consumption through reduced fan horsepower

and lower demands on the cooling or heating coils. In our Canadian climate, during occupancy hours, experience has shown that VAV air flow averages between 50 and 60% of peak design flow. ASHRAE studies have also confirmed that under these reduced air flow conditions fixed minimum air damper settings or supply and return fan flow tracking techniques cannot be relied on to insure that minimum outdoor air requirements are met.

Alternate control techniques such as resetting supply air temperature in VAV systems to artificially increase air volume defeats the basic principle of energy saving associated to the VAV system concept and often lead to reduced ambient temperature comfort particularly in interior zones. ASHRAE is now advocating the use of dedicated minimum outdoor air fans to insure that minimum air flow requirements are respected at all times.

.3 Additional Considerations for Renovation Projects

Additional selection considerations in retrofit or upgrade applications where limited ceiling or raised floor space availability precludes the possibility of integrating free cooling, dictate that HVAC terminal units integrating local heating and/or cooling coils be used to minimize distribution duct sizing. These terminal units use water to distribute heating or cooling energy to each terminal instead of air. Water requires approximately 50 times less volume than air to transfer an equivalent amount of energy.

Examples of terminal unit applications using water to transfer heating and cooling energy to terminal units include:

•Closed loop water source heat pumps (WSHP),
•Fan coil units,
•Fan powered variable air volume (VAV)
•Powered terminal units terminal with integrated reheat
or re-cool coils.

These terminal units, however, still require parallel central air units to supply outdoor air to individual rooms. The parallel air system and its distribution ductwork, however, are much smaller since they are sized to satisfy minimum outdoor air requirements only. These parallel air make-up systems also become the vehicle to provide humidification to the individual spaces.

The terminal heating/cooling systems listed above allow individual room start/stop scheduling and increased flexibility to adapt to eventual basic load changes. They are also more likely to satisfy ventilation standards since outdoor air flow is no longer subject to variations. Additional energy savings can often be realized since supply and return air are no longer subject to air

friction losses associated to long distribution duct lengths inherent to centralized HVAC systems.

On the negative side, however, terminal units tend to increase maintenance cost for air filter changes and motorized equipment maintenance.

Two or four pipe induction unit terminals offer another means to use water to distribute energy to individual rooms. Induction units, however, still require a high pressure central air system and do not lend themselves to individual room start/stop programming.

Induction units cannot practically be used on interior zones because of the complexity associated to their primary air distribution.

In IB installations the Building Automation System must interact with other systems to take advantage of specific sensors or programs affecting multiple systems such as motion detectors which may be used to the enhance security system , define the occupancy/non-occupancy mode for both HVAC and Lighting systems.

6 . 2

Lighting

The Lighting control system, in IB installations, must be integrated to the EMCS in order to facilitate interaction with the other systems. When used with multilevel lighting control and/or perimeter zone daylight systems certain zones may also be tied to the load shedding program in the Power distribution system. In IB installations occupancy mode, during extended hours, may be controlled from local PC terminals or from strategically located override switches.

.1

Interior Lighting

The extent of lighting control distribution, the use of motion detectors or infrared sensors and the use of lighting level sensors, in perimeter areas, to allow use of natural lighting whenever possible must be evaluated on a project by project basis for each particular application or feature.

In an IB project, however, the cost analysis must take into consideration the benefits ensuing to other systems. A pertinent example would have motion detectors turn the particular room*s lights on or off through the lighting system but it could also interface with the HVAC system to change the room temperature from occupancy to non-occupancy mode. The same motion

detector should also be interfaced with the security system. Interfacing between systems carries minimal or negligeable costs.

IB installations lighting control should be extended to each room or work station in order to take full advantage of the energy savings associated to non-occupancy mode or the limited and localized occupancy activation during extended hours for the HVAC and Lighting systems.

The lighting system and control strategy development in IB applications should seriously consider the use of "intelligent lighting control" systems which are compatible with the features associated to integrated Energy Management Control Systems.

.2 Exterior Lighting
Exterior lighting control should be under regular or solar time of day programming,
In addition to exterior light level sensor or security system sensor activation.

.3
Task Lighting
Task lighting allows higher lighting levels in specific areas where its is needed and therefore allows reduced lighting levels from the ceiling lighting grid and it offers distinct advantages in terms of glare for video display terminals. Task lighting also offers the possibility of providing a friendlier environment with the possibility of no cost relocation when the work station layouts are modified. However, unless task lighting power outlets are under EMCS control, it increases the risk of leaving lights activated after occupancy hours since they may not be under a programmed control system.

6.3   Power distribution
The power distribution system generally deals with major electrical components and electrical energy monitoring. Key elements under monitoring and/or control include the emergency power generator, Uninterrupted Power Systems (UPS), the Emergency Lighting System, Individual tenant power metering units and other major electrical loads.

.1 Emergency power
This system interfaces with other systems to annunciate normal power interruptions and initiate reactivation of emergency loads when emergency power becomes available. It performs similar functions upon restoration of normal power including preprogrammed orderly reactivation of heavy electrical loads.

.2

Load shedding
The Power Distribution system in an IB installation may also incorporate, when feasible, a load stabilization or load cycling program to minimize electrical demand charges and the associated cost penalties levied by the hydro utilities.

.3 UPS
Uninterruptable power source units are constantly monitored for critical elements such as normal/emergency power mode, trouble or alarm conditions etc....

6.4 Vertical transport
In IB installations this system interacts with other systems such as the life support Fire Alarm or the Security systems to define the number of elevators required, the mode of operation and in some instances the accessible floor levels.

Specific programmed sequences may also be incorporated to prioritize floors under fire alarm condition in order to facilitate the evacuation of the handicapped.

To minimize energy consumption the number of activated elevators may also be reduced on the basis of time of day schedules, week or weekend days and statutory holidays.

6.5 Security

The type of security system may vary depending on the application. Simple systems involving automatic functions such access monitoring, card access control, guard tour monitoring or motion detectors can readily be accommodated by packaged EMCS manufacturer programs. More elaborate security systems involving intensive human intervention from guard stations and closed circuit TV and recording should be sourced from specialized security system manufacturers but should be designed to interface with the EMCS to take full advantage of the individual work station motion detectors.

The card access security program may be interfaced with the Lighting and HVAC subsystems to define activation of the necessary lighting paths and the specific room occupancy mode.

Similarly the Life Safety Fire Alarm program could interface with security to release specific locked doors under alarm conditions.

6.6 Life Safety

This system deals with the Fire Alarm system, the Emergency Lighting. the Egress lighting system and the Smoke Evacuation system.

Interfacing of the Life Safety system with other systems in an IB installations is critical to eliminate nuisance alarms and to initiate appropriate sequences such as stop HVAC systems and start the smoke evacuation system.

Interfacing may also allow temporary transfer of spare emergency power not required at the time to other non-critical areas until such time as it is required. As an example during an extended normal power failure when the building has been fully evacuated emergency power assigned to elevators or fire booster pumps if not required could be transferred to perimeter heating pumps, UPS units, freezers or other pre-assigned loads.

6.7   Communications

General

The Communications system in the Intelligent Building differs from its predecessors in that communication is now possible among systems that previously were independent "islands", separately designed and administered. For example, the EMCS has traditionally been built with wiring that was completely separate from wiring for all other services in the building. In addition, there was no means of connecting the EMCS to non-EMCS equipment in the building, such as user workstations.   In the intelligent building, integrated communications is possible. The systems that may communicate include traditional LAN-based (local area network) clients and servers, telephones and telephone switches, video conference devices, and the full range of EMCS devices for HVAC, Security, Lighting, and Fire Alarms.

The most basic questions in the design of the intelligent building are:

-
Which systems need to communicate?

-
What type of transmission, capacity, and distance are required by each type of communications traffic?

-
Should all systems use the same cabling?

-
Should all systems use the same communications protocol?

The first question is addressed in other parts of this document, relating to the opportunity afforded an intelligent building to have users exercise more direct control via Personal Environment Controllers over their environment than was previously possible. The most obvious requirement arising from this arrangement is that user workstations (usually PCs) must be able to communicate with the EMCS for Lighting and HVAC purposes. In addition, the various components of EMCS must communicate, e.g., to allow fire alarms to affect HVAC, elevators, and exit doors.

The remaining questions will be addressed in the sections that follow.

.1 Types of Traffic and Transmission Capacity Requirements

The communications traffic in the intelligent building must be characterized before design is undertaken, because each type of traffic places different constraints on the communications network design.

For example, telephone traffic typically requires either 3.1 kHz of analog bandwidth or (if the transmission system is digital) 64 kbit/s of synchronous transmission. Digital video, however, may require from 128 kbit/s to *1.5* Mbit/s of transmission capacity, depending on how the video is coded. Until recently, the LAN traffic between clients and servers has been satisfied by the 10 Mbit/s capacity of Ethernet LANs, but increasing amounts of image traffic have resulted in a growing number of installations of Fast Ethernet (100 Mbit/s) and Gigabit Ethernet (1000 Mbit/s). EMCS traffic has usually been less demanding than any of the other types, since its bit rate has been modest and its communications sporadic rather than continuous.

In addition to differences in the transmission capacity required, the various types of traffic have differed in their geographical needs. For example, telephones have usually been distributed throughout the building, and wired to a central switch or wiring frame, usually in the basement. LAN connections have led from user locations to concentrators or hubs near the users on each floor of the building, with high-capacity connections through the risers between floors. EMCS equipment has traditionally been concentrated in penthouses and mechanical rooms that are widely separated, although VAV boxes have resulted in a need for connections to many devices throughout the building.

.2 Local and Remote Access

The distance considerations in the previous section were described only in the context of a single building. However, in addition to increased local access to various systems in one intelligent building, there is an increased requirement for access to and from remote locations.

In the case of telephone traffic, remote access has been through T1 digital trunk groups leading either to the public telephone network or to other locations in the organization's private network. LAN traffic has been handled by routers or bridges, connected either by leased fractional T1 connections or dial connections such as ISDN (integrated services digital network). Video traffic has not been common, but is being handled economically by the increasing availability of multirate ISDN, which allows switched connections at multiples of 64 kbit/s up to 1.536 Mbit/s.

For EMCS communications, the main need is access by remote workstations, often used by operators in other buildings of a complex or by administrators at central locations. These connections have most often been handled by dialing across the telephone network, but since large private data networks often exist alongside the EMCS, it may be desirable to use the same private network for EMCS communication.

.3 Media Options

The overwhelming choice of medium today is unshielded twisted pair copper wire ("UTP") as found in most LAN cable trays. Category 5 UTP, when properly installed, can handle up to 100 Mbit/s over a distance of up to100 meters. Category 5 is suitable for voice, ISDN, and high-speed data, and is the least expensive medium for these purposes.

Optical fibre is a superior medium in nearly all respects: distance, data rate, security against electronic eavesdropping, and complete protection from electrical interference. 62.5/125 multimode fibre is the medium of choice for in-building fibre installations, giving a maximum data rate of more than 600 Mbit/s. However, fibre cable and fibre connectors are much more expensive than Category 5 components, and fibre end equipment is rarer and more expensive than copper-based equipment.

Fibre is used in cases in which its superior qualities are necessary, but most of the new communications products have capitalized on the great strides made in copper transmission technology. If an organization plans to occupy a building for many years, fibre may be cost-effective, but unless the need for fibre is short-term, copper is usually the better choice, at least to the desktop. In many buildings, copper is run to individual user locations, and fibre may be used as a backbone up the building risers, where there are comparatively few devices to be connected and a high data rate is needed.

A swiftly increasing proportion of installations use wireless technology. Recently adopted 802.11 LAN standards will spur release of more products for high data rate connections where wired media are unsuitable, such as heritage buildings and temporary or moveable equipment installations. Wireless LANs are likely to remain more expensive than wired LANs.

For voice communications, the rise of PCS (personal communications systems) using micro-cellular technology is likely to transform voice communications in commercial buildings. For example, in Sweden, there are some offices that have no telephones on the desks. Each employee carries a wireless telephone that easily fits inside a shirt pocket, so there is no need for any fixed telephones.

Because EMCS devices don't move around the building, wired technology is appropriate. The cabling installed for LANs is suitable for EMCS traffic, as long as the EMCS equipment is designed to use LAN's100m cable lengths, and as long as there is no concern about whether the LAN infrastructure is reliable and secure enough to be depended upon for EMCS security traffic.

The reliability aspect must be investigated case-by-case, since LANs may be installed with or without redundancy and network alarms to increase reliability. In addition, because many LANs use shared media, all transmissions may be overheard by all stations, and the security of EMCS information may not be acceptable on a LAN designed mainly for the data processing community.

However, if integration of EMCS and user workstation communications is needed, it is much simpler to have the two groups of devices sharing the same LAN medium than to have separate communication networks joined by some type of gateway.

.   4
Protocols

.   1
The Question of Common Protocols
Protocols are the rules and procedures used by devices to communicate. The suite of protocols used by a particular device ranges from the physical and electrical connections, e.g., fibre, Ethernet, etc., to the higher-level communications aspects such as correcting transmission errors and handling file transfer and terminal access to remote applications.

EMCS protocols have traditionally been completely different from data-processing communications. Often EMCS communications have been multipoint, in which a single copper cable is daisy-chained from one station to another in a mechanical room. Also, the copper cable used in EMCS communications has often been much lower quality than the cable used for LAN communications, since the bit rate requirements have been much less demanding. At the higher levels of protocols, EMCS communications have often been totally proprietary for each manufacturer.

In contrast, data-processing communications have been moving towards universal high-performance standards, both at the physical/electrical level and at the higher levels. The overwhelming migration at the physical/electrical level has been towards the Ethernet family of LANs, and at the higher levels the TCP/IP (transmission control protocol/internet protocol) family of protocols has dominated recent network installations. TCP/IP is the suite of protocols on which the Internet is based.

.2 EMCS Protocols

Most of the installed EMCS protocols are proprietary, although in a growing number of cases, the controls vendors are transmitting their proprietary protocols over data-processing LANs such as Ethernet. This approach allows both type of equipment to use the same wiring infrastructure, but does not permit direct communications between them.

BACnet is an emerging ASHRAE standard for EMCS communications that includes many options. BACnet, however, does not include the use of TCP/IP protocols for reliable transmission. This means that BACnet can operate successfully over a single LAN but cannot use the common internet routers (e.g., Bay Networks, Cisco, etc.) that connect nearly all data processing LANs. A special router is needed to connect BACnet LANs.

LONTalk is an open industry standard that is based on a single type of silicon chip currently manufactured by two vendors. It can run over many types of physical network, but, like BACnet, requires special routers to communicate between networks.

CAB (Canadian Automated Building Protocol) is a Canadian government standard that consists of an EMCS-specific high-level protocol carried over normal TCP/IP networks. It can be carried by any type of physical network, but the Ethernet family is specified in the standard. Its packets can be handled by TCP/IP data-processing networks that include routers and bridges, without need for any special hardware or software.

The question of protocols is key. The EMCS industry is small compared to the data processing and Internet communities, which build the major data networks. Hence, if EMCS traffic is to be integrated with other traffic in and between buildings, it is much more likely that this approach will be successful if all types of traffic use the same data communications protocol for reliable delivery of data. It is unlikely that BACnet and LONTalk will be integrated into other networks if they require special routers, so they may be restricted to communications on single LANs in individual buildings if integrated communications are required.

7- Facilities Management

1. A number of facility management programs are available on the market. They vary in complexity as well as in their ability to integrate complex systems such as:

    - CAD drawing records of floor and office layouts;
    - Furniture inventory;
    - Maintenance management programs for M&E equipment
    - Preventive maintenance of building structures;
    - Real time data acquisition on equipment run time;
    - Dynamic energy consumption totals per tenant;
    - Historical data storage;
    - Cost control and budgeting capabilities;
    - Analytical programs.

2. The Intelligent Building's role in this system is to allow communication between the overall facility management program and specialized management sub-programs such as the EMCS, the M & E Maintenance Management or the Preventive Maintenance to gather data or convey user complaints.

3. This communication flexibility in IB installations allows the allocation of specific management systems on the basis of areas of specialization, competencies or individual buildings of a complex while maintaining capabilities for overall centralization of data and control.

4. The IB communication capabilities can also facilitate interchange with accounting or other Networks to import or export pertinent data whether in-house or outsourced.

8- Energy Management

.1   General
Energy management forms an integral part of the Intelligent Building and should be an built into the EMCS system to allow Real Time and dynamic interaction with the energy consuming elements of the building. EMCS manufacturers offer such programs with varying levels of sophistication and complexity.

.2   Basic Considerations
    .1   Electrical Demand Control
        No energy management program can be effective unless critical energy consuming areas are monitored individually and allow the energy management program the required intervention capabilities such as turning equipment on/off or limiting its capacity where possible through electrical load shedding or load stabilization routines.

    .2   Program Scheduling
        The ability to schedule operation of any significant energy consuming equipment on the basis of season, occupancy load, time of day, statutory holidays, daytime natural light availability, etc is possibly the most significant energy saving feature to incorporate in an EMCS installation. Again the program can only be effective if the necessary points are included in the point schedule.

    .3   Motion detectors
        Motion detectors when installed at every work station can be used to turn off lights or reset ambient HVAC control set points after a prescribed period. They reactivate all involved systems instantly when renewed occupancy is detected. They can also be interfaced with the security system to provide enhanced supervision. When interfaced with the Fire Alarm system they can alert the building operator to a particular room occupancy under an alert condition.

        Motion detectors cost, particularly when used in conjunction with Intelligent Lighting control systems, have been reduced sufficiently in recent years to justify this option on much shorter owning and operating cost evaluations. They must however be analyzed taking into consideration the benefits evolving to all systems such as Lighting, HVAC, Security as well as benefits accrued on maintenance and repair through reduced run time.

        Indirect benefits accrued from the generalized use of motion detectors in a building could include resetting of minimum outdoor air standards in stages to reflect appreciable reductions in occupant density.

.4 HVAC Equipment Operation
Energy management should be used to modify sequences of operations based on one or more of the following conditions:

- Enthalpy;
- Outdoor wind velocity conditions;
    - Building pressurization:
    - Occupancy and lighting loads;
    - Optimal start/stop programs
    - Terminal unit demand;
    - Occupancy scheduling;
    - Supply fan demand;
    - Seasonal conditions;
    - Electrical energy demand;
    - Etc...

.5 Maintenance Management
Maintenance management programs are also available from EMCS manufacturers and form an integral part of the Intelligent Building requirements . These programs are intended to plan and schedule maintenance of M&E systems including in some instances elevators. The prime objective is to minimize or eliminate major breakdowns.

To maximize efficiency maintenance chores should be based on the manufacturer's recommended schedule for both calendar time and run time totals of the equipment in the same manner as car maintenance is scheduled. Run time totals are a no cost feature provided on all EMCS systems. Critical equipment such as chiller bearings or emergency generator battery status should include local monitoring devices to over ride equipment run time totals because of their critical role in the safe and sustained operation of the building.

Non critical elements offering some latitude in response time such as filter change may be programmed for execution in periods of lower activity. These may include filters, induction unit or fan coil cleaning, lubrication, etc...

Annual maintenance items such as duct or pipe cleaning, valve and pump repacking can be programmed during periods when additional manpower is available such as during summer season.

9- Structured Cabling in the Intelligent Building

.1 Cabling Philosophy

In cabling any building, the overriding principle is that, long after all the equipment for which the cabling system was installed has been retired, the cables remain. Hence, planning cabling systems for the future rather than the present is crucial. If, for example, it is anticipated that there will be a future requirement to have optical fibre installed, it may be much less expensive to install the fibre when the building is erected, even if the fibre initially is left unused. A similar principle is to cable the building to accommodate whatever equipment locations may exist in future, i.e., to cable many more locations than will be occupied in the short term. Since retrofit installations are far more expensive than initial installations, over-cabling is usually cheaper in the long run. The only exception to this philosophy is the case in which a building is leased for a short time, such as two years, when the extra costs would not be recouped.

Whether or not a building is intelligent, *structured* cabling is important. As far as cabling is concerned, the main differences between intelligent and unintelligent buildings is that the intelligent buildings have more devices to be connected. For example, thermostats, lighting controls, and VAV boxes are located at various heights above the floor.

The advantage of using structured cabling in any building (other than very small ones) is that there is only one cabling system to administer, and one set of standards for quality of transmission medium. As a result, the building owner has much more flexibility in moving, adding, or changing devices during the life of the cabling. Life-cycle costs of buildings using structured cabling systems are lower than for unstructured buildings.

In the intelligent building, the structured cabling system can be used to integrate EMCS equipment with all other types of equipment in the building. However, there may be cases in which security or safety functions must operate on separate wiring to avoid problems of reliability and security that would arise from sharing cabling with end users.

.2 Standards Used in Structured Cabling

The main standards used in North America are published by TIA/BIA (Telecommunications Industry Association/Electronic Industries Association) in the U.S., and CSA (Canadian Standards Association) in Canada. The Canadian federal government has modified the CSA standards to create TBITS (Treasury Board Information Technology Standards), which reflect the government*s view of how technology should be applied in government buildings.

The following standards should be consulted if a true understanding of the basis for structured cabling is desired:

.1 TIA/EIA Standards:
- TIA/EIA 568, Commercial Building Telecommunications Wiring Standard
- TIA/BIA TSB 63, Reference Guide for Fibre Optic Test Procedures
- TIA/BIA TSB 67, Transmission Performance Specifications for Field Testing of Unshielded Twisted-Pair Cabling Systems
- TIA/ETA TSB 75, Additional Horizontal Cabling Practices for Open Offices

.2 CSA Standards:
- CAN/CSA T528-93, Design Guidelines for Administration of Telecommunications Infrastructures in Commercial Buildings
- CAN/CSA T529-95, Telecommunications Cabling Systems in Commercial Buildings
- CAN/CSA T530-M90, Building Facilities, Design Guidelines for Telecommunications

.3 Government of Canada Standards:
- TBITS 6.9, Telecommunications Wiring System in Government-Owned and Leased Buildings

In addition to the government and industry standards, various manufacturers publish their own guidelines for structured cabling. These generally follow the standards, but sometimes add features, such as methods for distributing several four-pair cables from a 25-pair binder group to a number of workstations in a small area. The manufacturers also describe good installation practices that will avoid overall performance problems that would be revealed only during testing after installation.

The manufacturers sell complete product lines of structured cabling components, and the installation and design guidelines are meant to support sales of the cabling products. The common product lines include NORDX/CDT*s IBDN (integrated building distribution network) and Lucent Technologies* Systimax.

.3 Main Elements of Structured Cabling Within a Building

.1 Copper Media

The current standards include Category3 and Category 5 unshielded twisted pair (UTP). Although many existing installations consists of Category 3 UTP, all new installations use Category 5, which is intended for use at up to 100 Mbit/s over distances of 100 m. This is consistent with the design of UTP structured cabling, in which the maximum

distance from a telco room to an end device is 100 m.

More advanced UTP is being manufactured, but there is no widely accepted standard for use of copper media at data rates above 100 Mbit/s.

The performance of the entire cabling system depends on more than the quality of UTP. for 100-Mbit/s applications, proper connectors, patch panels, and installation practices must be used. In the last five years, test procedures have been created that allow certification of overall installed performance, which is critical for high-bit-rate applications.

.2 Optical Fibre Media

For applications requiring bit rates higher than 100 Mbit/s, distance greater than 100 m, security against eavesdropping, or operation in environments with high levels of electromagnetic interference, fibre optic cable is required.

For several years, most fibre installed in buildings has been the 62.5/125 multimode type. This type of fibre has distance and bit rate capability that normally handles anything required within a building, and uses much less expensive connectors than the alternative, single-mode fibre. Single-mode fibre is used in all outdoor fibre applications because of its low loss and limitless bit rate capability (the capability appears limitless because there are no optical sources and detectors capable of reaching whatever limit may exist).

.3 Other Media

Previous structured wiring schemes have called for coaxial cable and shielded twisted pair (STP). These media are obsolete, and have been removed from TBITS 6.9. For reasons given earlier in this document, wireless media are not considered further here.

.4 Telco Rooms

The telco room is the room located on each floor at the risers, in which telecommunications cabling is terminated and connected to concentration devices. It is also known as a wiring closet. In this room are located LAN concentrators, telephone cross-connects, ISDN network terminations, multiplexors, and any other telecommunications equipment that must be connected to end devices on that floor of the building.

.5 Vertical Backbone Cabling

The vertical cabling that links concentration equipment on each floor through the risers may be either UTP or fibre. In buildings without much conduit space between floors, fibre has the advantage of much smaller cross-sectional area than UTP. Fibre is also capable of transmitting signals over the long vertical distances in tall buildings, which has particular application in EMCS, since penthouses and basements are often far apart.

.6 Horizontal Cabling

The horizontal distribution system is the cabling that connects the end devices on a particular floor to the telco room cross-connects and concentration equipment. The standards are intended to accommodate all type of equipment and traffic, specifically including LANs, telephones, and ISDN devices.

The maximum distance from an end device to the equipment in the telco room is 100 m, the constraint being the LANs, which have the most difficult transmission constraints due to their high bit rates. To create a single wiring scheme, this constraint is applied to all end devices.

Each end device is wired to the telco room by a single run of four-pair UTP cable. Each user work location is always equipped with two such cables terminated in a dual outlet using two RJ45 8-pin modular telephone jacks.

.7 Cabling Management

The basic level of cabling management consists of planning the identification of each cable, cross-connect point, and end devices outlet connector. No standards exist, but the standards suggest some things that must be included in labeling systems. The requirements are different for horizontal and vertical cables.

The best structured design is useless if it does not accurately reflect how devices are actually connected after the building has been operating for several years and the end devices have changed. Anything other than a very small building needs a computer-based cabling management system. There are no standards for cabling management systems, but the need is clear.

.4 Limitations of Structured Cabling Standards for Intelligent Buildings

The intelligent building requires that EMCS and non-EMCS equipment be able to communicate. If structured cabling is to be used as a common fabric in the entire building to handle all types of communications, the same cabling

scheme must accommodate both types of equipment. Three points in the standards are not well adapted to some cabling schemes used by controls vendors.

First, some mechanical-room wiring has been multipoint, in which several devices are daisy-chained on the same cable. Although multipoint wiring is inexpensive, it conflicts with the basic premise of structured cabling, which is that each end device should be wired separately to the telco room (or whatever room is used to connect and switch the end devices).

Second, the standards require that each end device be attached with an RJ-45 modular telephone plug, which allows the building owner to move, add, or replace end devices without fuss. EMCS equipment is often semi-permanent, which may make the RJ-45 approach less attractive.

Third, the standards specifically prohibit connections in ceiling spaces, which is precisely where EMCS equipment such as VAV boxes may be located.

As a result, some of the standards requirements for structured cabling may be relaxed for some aspects of cabling the intelligent building. However, the overall structured cabling approach will benefit the users of the intelligent building

10- Conclusions

The Intelligent Building concept represents a new trend in office building planning and one more step towards the future through added flexibility and adaptation to market and communication globalization. This concept regroups worker and building management needs in a common and manageable communication infrastructure. The basic IB objective is improve worker satisfaction and productivity through enhanced work space environment and communication capabilities.

Including the IB concept in the initial planning stages of the modern office building will provide substantial flexibility for the mid and long term life of the building particularly to communication intensive user clients. In most instances it will reduce tenant fit up costs down the road and provide enhanced flexibility and management capabilities while reducing energy consumption.

Full implementation of all IB systems may not be necessary in the initial fit-up of a building. It is, however, mandatory to recognize the basic overall concept and implement a full communication cabling back bone structure from the onset in order to accommodate future user needs. The communication back bone must be distributed to strategically located communication rooms (Telco rooms) on each floor as part of the initial design.

Subsequent floor distribution associated to any new or upgraded IB system could be achieved, via the suspended ceiling space with minimal cutting and patching.

Justification for the IB concept must be analyzed independently for each building or fit-up and must take into account all derived benefits including increased productivity, flexibility, improved comfort and worker satisfaction as well as potential future savings over the projected life cycle of the building.

Application of the basic Intelligent Building concept in today's modern office building should lead to positive Cost to Benefit evaluations when weighed in terms of increased user satisfaction and productivity and improved energy efficiency or flexibility.

11- Financial Considerations

Costs associated to the implementation of the Intelligent Building concept in new or renovated buildings must be evaluated on a project by project basis taking into account the overall project size, the number of intended work stations and the nature of each IB system to be implemented.

Benefits or savings associated to one IB system often extend to other systems. They will vary considerably with the size of the project and the nature of the IB systems selected. For example installation of motion detectors at each work station would essentially carry the same cost wether it is used for a single or multiple IB systems such as:

- Temperature and air flow reset per on the *HVAC system*,
- Light shut down on the *Lighting system*,
- Occupancy / non-occupancy on the *Security system*.

Costs associated to the implementation of different IB systems or features are generally offset to varying degrees by savings in other disciplines or trades. For example implementation of a IB cabling structure to strategically located Communication rooms eliminates corresponding costs associated to multiple and independent systems such as Video conferencing, EMCS, LANs, Lighting control, Security, etc. In traditional buildings independent and parallel communication cabling was generally provided for each of these systems.

Modern office buildings built or upgraded during the last decade have incorporated, to varying degrees of sophistication, many of the IB system and features addressed in this study. In most instances, however, these systems were designed and installed as stand alone systems with little no intercommunication capabilities. Each system was designed to meet only the specific user client needs at the time of implementation and made no allowance for foreseeable technical or user required upgrades.

In order to assist project managers in the evaluation of first cost premiums associated to the implementation of the Intelligent Building concept we have prepared a summary of budgeting guidelines illustrating budget values per feature and work station.

The values presented in the following are based on a 10 storey office building

with 50,000 square meters of rentable area and 10 sq-m per work station. The following building systems are assumed to be carried in the base building cost estimate:

- S EMCS for HVAC
- S Zone ambient control per 40 sq-m
- S Lighting control by EMCS or central system
- S Centralized Security system
- S Addressable Fire Alarm system

INTELLIGENT BUILDING COST EFFECTS

INTELLIGENT BUILDING SYSTEM	ASSUMED EXISTING PREREQUISITES	FEATURES									
		HVAC INDIV. Rm CONTROL one/wk-stn	LIGHTING INDIV Rm CONTROL one/wk-stn	INTELLIGENT CONTROLLER HVAC-LIGHTS one/wk-stn	OCC/N-OCC Rm TEMP RESET per wk-stn	OCC/N-OCC HVAC & LIGHT SCHEDULING per wk-stn	AIR VOLUME FLOW CONTROL per wk-stn	DATA LAN Outlet one/wk-stn	VIDEO CONF. Outlet one/wk-stn	SECURITY CARD ACCESS one/wk-stn	FIRE ALARM MONITORING per wk-stn
COMMUNICATION	COMMUNICATION BACKBONE			*	*	*	*	*	*	*	*
HVAC	EMCS for HVAC	*		*	*	*	*				*
	COMPATIBLE HVAC SYSTEM	*		*	*	*	*				
	STD. ZONE CTRL One/40 sq-m	*									
	HVAC INDIV. Rm CONTROL one/wk-stn		*	*		*	*			*	*
HVAC & LIGHTING	INTELLIGENT HVAC & LIGHT CONTROLLER						*				
	MOTION DETECTORS one/wk-stn			*	*	*					
LIGHTING	EMCS LIGHTING CONTROL INTERFACE		*	*		*					*
	INTELLIGENT LIGHTING SYSTEM		*	*		*					
	ZONED LIGHTING control/ 40sq-m		*	*		*					
SECURITY	BASE BLDG.. CENTRAL security system									*	
	WORK STN card access									*	
FIRE ALARM	ADDRESSABLE FA SYSTEM										*
	EMCS FIRE ALARM INTERFACE										*
VOICE/DATA LAN	VOICE & DATA Outlet/Wk-station								*		
VIDEO CONFERENCING	VIDEO OUTLETS Avg one/50 sq-m										
BUDGET COST INCREASE per FEATURE & Wk-Stn		$250	$125	$1,500	NIL	NIL	NIL	$100	$200	NIL	NIL