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SERIES Y: GLOBAL INFORMATION
INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS
AND NEXT-GENERATION NETWORKS, INTERNET OF
THINGS AND SMART CITIES

ITU-T Y.4550-series – Smart sustainable cities – Intelligent sustainable buildings

ITU-T Y-series Recommendations – Supplement 31

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Supplement 31 to ITU-T Y-series Recommendations

ITU-T Y.4550-series – Smart sustainable cities – Intelligent sustainable buildings

Summary

The concept of "intelligent buildings" has been around for a number of years and has relied on the ability of individual systems within the buildings to communicate, to integrate and to perform in a manner allowing for numerous and complex controls to generate a much-enhanced response to many kinds of stimuli. Thus, the argument of intelligence can reasonably be associated with the ability of these buildings to function in an enhanced manner yielding many benefits for the occupants, the operators and the owners. Supplement 31 to ITU-T Y.4550-series Recommendations provides a number of examples of "intelligent buildings", while describing the benefits and efficiencies generated by such integration.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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The implementation of intelligent and sustainable buildings is another key step in the journey to smart sustainable cities. To understand the scale of the issue, buildings are responsible for 40% of global annual energy consumption and up to 30% of all global energy-related greenhouse gas (GHG) emissions. Also on a global basis, the building sector is responsible for one-third of humanity's resources consumption, including 12% of all fresh-water use and produces up to 40% of our solid waste. As buildings become more intelligent and more sustainable, the possibility exists to reduce this impact dramatically.

Definitions of intelligent buildings have been proposed by different user groups and have also evolved during the last few years. Some view the ultimate benefits of intelligence to be the provision of a more efficient and effective working environment for the occupants while others define such intelligence as providing greater economics for the building operators. However, some others conclude that automated responses, in particular to security and emergency situations, are of particular importance.

Intelligent building technologies open the opportunity to facilitate the monitoring of a building's overall condition. Transducers and sensors are available to measure most building related parameters and in any given situation there may be particular needs driving their specific use.

It is also evident that the standards applicable to the provision of an Internet protocol (IP) infrastructure are one possible mechanism by which an intelligent building can be implemented. Depending on the jurisdiction, there may be a need that some of the systems require special considerations in order to comply with all aspects of the building code (e.g., fire safety code or electrical code).

Depending on the particular structure, its purpose, the technologies which are prevalent in the building and other factors, there will often be different objectives. With ever rising energy and labour costs it is obvious that if those costs can be kept in check, or preferably reduced, opportunities for financial savings will provide an immediate return on any extra investment in building an intelligent building. A building which is operated continuously, e.g., a hospital, or which is operated by individuals who pay fees such as condominiums are less likely to see immediate benefits from the functions available in intelligent buildings.

Many modern buildings today have heating, ventilating and air conditioning (HVAC), lighting, security and communication systems that use information and communication technology (ICT) networks for management and control. This can provide the foundation to develop intelligent buildings. It is therefore possible to implement policies that enhance building efficiency and effectiveness consistent with changing business requirements and user needs.

In addition, climate change related severe weather events are increasing in frequency and severity. These severe weather events include urban floods, extended heat waves, ice storms, extended cold spells and high winds/tornadoes/hurricanes.

These weather events have both a long term and short impact on the building infrastructure in cities. During short-term events, building infrastructure may be impacted by major structural damage, damage to a building's support and utility systems, closure and loss of revenue among other items. Over the long term, severe weather and more extreme temperatures lead to accelerated degradation of a building's envelope, utility systems and infrastructure.

Steps need to be taken to maintain the building's exterior and envelope to prevent damage to the building and its equipment. At the same time, the design and intelligent infrastructure of the intelligent building can assist in minimizing the effects of extreme events.

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ITU-T Y.4550-series – Smart sustainable cities – Intelligent sustainable buildings

1 Intelligent sustainable buildings

1.1 Introduction to "intelligent sustainable buildings"

Cities cannot become smart and sustainable unless the issues of the built environment and in particular of buildings are addressed. On a global basis, buildings are responsible for 40% of global annual energy consumption and up to 30% of all global energy-related greenhouse gas (GHG) emissions. Also on a global basis, the building sector is responsible for one-third of humanity's resource consumption, including 12% of all freshwater use and produces up to 40% of our solid waste [b-UNEP]. In order to address the issue of climate change through the reduction of GHG emissions the impact of buildings must be reduced. It is therefore important for buildings to become more intelligent and more sustainable in order to dramatically reduce this environmental impact.

The concept of a "smart" or "intelligent" building may seem to be an oxymoron. Intelligence is normally indicative of a human (or animal) attribute in which individuals are capable of making interpretations, deductions or inductions, related to observations and to stimuli. Great individuals, such as Einstein, have been described as extraordinarily "smart" or intelligent" and so at first glance, it may seem that making these associations with inanimate objects such as buildings is an inappropriate association.

The concept of "intelligent buildings" has been around for a number of years and has relied on the ability of individual systems within the buildings to communicate, to integrate and to perform in a manner allowing for numerous and complex controls to generate a much-enhanced response to many kinds of stimuli. Thus, the argument of intelligence can reasonably be associated with the ability of these buildings to function in an enhanced manner yielding numerous benefits for the occupants, the operators and the owners. This Supplement will provide a number of examples of "intelligent buildings", while describing the benefits and efficiencies generated by such integration.

Definitions of intelligent buildings have been proposed by different user groups and have also evolved over the last few years. Some view the ultimate benefits of intelligence to be the provision of a more efficient and effective working environment for the occupants, while others define such intelligence as providing greater economics for the building operators and yet others conclude that automated responses, in particular to security and emergency situations, are of particular importance.

The following definitions for intelligent buildings should be considered:

- The use of integrated technological building systems, communications and controls to create a building and its infrastructure which provides the owner, operator and occupant with an environment which is flexible, effective, comfortable and secure;
- Use of technology and processes to create a building that is safer and more productive for its occupants and more operationally efficient for its owners;
- A building in which, those responsible for its operation, those benefitting from its operation and those ultimately responsible for the safety of all its occupants can share a view and a vision of the building status at all times;

- "Smart" buildings should take advantage of dynamics, characteristics of building shell and HVAC systems, automation, communications and data analysis technologies in order to operate in the most cost-effective manner¹.

Clearly, these definitions are not very different. Additionally, these definitions require an understanding of the building's systems and their abilities to interact with each other.

1.2 The fourth utility

Traditionally building structures, all around the world, are built in accordance with similar principles in which individual specifications and typically vendors, devise and implement operational components of the building in a manner, which is often described as "the three utilities." In traditional buildings, these three utilities are electrical, mechanical and plumbing, which are integrated with the base building. In such traditional constructions, the tenants become responsible with respect to a variety of different plans for implementing their "tenant improvements" which are fed from the three utilities and which have been integrated with the building.

Notably, communications are traditionally omitted from the base building services and it is the responsibility of the base building utility providers to install any communication services necessary for the provision of those utilities. As examples, the reader should consider elevators, which clearly include significant communications requirements dedicated to the elevator and which are an independent installation used exclusively for this one application. The communications requirements for the heating, ventilating and air conditioning (HVAC) mechanical systems, monitoring of electrical usage and potentially other systems are equally repetitive, isolated and not able to promote or address the abilities for these systems to become a true basis for any form of intelligence.

The thesis of intelligent buildings, therefore, is that base building systems shall be designed in a manner which permits their intercommunication and which also allows for communication between the building and individual tenant. The benefits are not always the same for each group of interested parties, nor are all the benefits evident when not all buildings include all the same features. This Supplement describes some buildings in which such systems have been employed and which have, in most cases, functioned successfully for a number of years, allowing for many parties to enjoy some of the benefits.

Consider some of the following examples of the benefits and opportunities which these intercommunications, or intelligence, can provide.

1.3 Access control and security systems

The access control system should be integrated with the fire system, lighting system and the HVAC system. With these forms of integration, the system "intelligence" can allow a user to enter the building and the information that this user has presented in terms of his credentials will be signalled to a number of independent systems. As a result, when the user approaches his/her workspace, the lighting, HVAC controls (and potentially other systems) can each have been adjusted to meet that user's preferences. In the hotel industry, for example, empty rooms are normally not ventilated or lit so as to reduce energy usage. When the room is "rented", the necessary adjustments can be made long before the new occupant reaches his/her temporary front door.

When the fire alarm notifies the access control system of an emergency, provision can be made that no unauthorized individuals can enter the building while everybody who is already in the building can exit without constraint. Alarms caused by magnetic locks which have been released owing to

¹ ASHRAE, The American Society for Heating, Refrigerating and Air-Conditioning Engineers as part of their Technical Committee 7.5 (<http://tc75.ashraetcs.org/>).

the fire alarm, will be ignored and lights throughout the building can be automatically energized so that first responders are not faced with a situation wherein they looking for the light switches.

1.4 Elevators and escalators

Through suitable programming, the number of elevators being used at any one time can be optimized to address schedules, loads and potentially, emergencies; e.g., if paramedics require an elevator, it can be automatically configured to provide exclusive use for such purposes under an emergency situation. There are many advances in elevator programming which have been pioneered by some of the large elevator manufacturers, e.g., provision of call buttons on the main entrance floor which allow random selection of elevators which will provide express rides to the floors identified by each individual's access credentials. Thus, different users going to the same floor will all be channelled into a common elevator cab, which will then go directly to that, or those, selected floors. The primary benefit as a result of this intelligence will be the ability to use fewer elevator cabs, i.e., lower energy costs and provide a faster service.

1.5 Lighting

The traditional large office buildings in which light switches are "hidden" are probably a thing of the past. The current trend to individually controlled lights, with the ability for each individual user to select their preferred lighting levels, is potentially a significant power saver and the use of more modern lighting technologies also reduces the amount of heat generated by more efficient luminaires. These trends can be integrated with many additional benefits, some of which have been noted in the foregoing comments; e.g., when an individual arrives, the lights in that person's area may be illuminated. When the individual goes home, the lights will be extinguished. In an emergency, activation of all lights will enhance the ability for responders to attend to any situation without themselves having to activate any lights.

Furthermore, the use of automated lighting controls allows an evaluation of the lighting utilization so that any re-lamping procedures can be scheduled based on actual hours of usage and not based on calendar activities. Such lighting systems also permit potential charge backs from the building owners to the tenants based on the actual electricity used. The system can monitor any lights which have failed and which can automatically be reported to those responsible for maintenance.

Needless to say, the addition of such intelligence will also identify room occupancy and allow for the measurement of lighting levels and the automated compensation of lighting settings as a result of daylight shining in through windows or skylights (daylight harvesting). Automated blinds can also be used to adjust lighting levels to the desired value. It can be noted that electrical switch manufacturers have brought very economical, motion activated light switches to the market, thereby allowing for some measure of intelligence in the simplest of applications.

1.6 Signage

There have been evident changes applicable to signage technology. Signage can readily be shown on screens and can include any required graphics thereby ensuring that language and situational variations are readily addressed. Thus standard signage can carry routine messages including hours of operation or the length of line-ups or delays. Such signs already appear in large buildings such as hospitals, universities and museums. The public is surrounded by these "computerised" signs in transportation systems, such as airports, highways, police checkpoints or customs applications. Nobody thinks twice about the information presented on luggage carousels at airports, which change continuously (and are not always 100% accurate) and the concept of having time-dependent signage or situation-dependent signage does not come as a surprise. Thus, particularly in Europe, where great emphasis is placed on visitors to buildings being well-informed upon arrival, of how they may need to exit if an emergency arises, automated signage is widespread. For example, electronic signage can be changed in an instant, should a building evacuation be necessary, so as to point out the emergency stairs as opposed to the elevators.

1.7 Building condition monitoring

Intelligent building technologies open the opportunity to facilitate the monitoring of a building's condition. Transducers and sensors are available to measure most building related parameters and in any given situation, there may be particular needs driving their specific use. Under appropriate conditions some or all of the following may be appropriate and would then be communicated to a central monitoring facility.

- Areas with heavy snowfalls or other weather extremes may wish to monitor snow load or wind load on roofs;
- Exhibition halls or bridges may wish to monitor key structural components affected by wind loads, suspension of exhibits, loudspeakers (in musical performance facilities);
- Moisture detectors can be laid beneath membranes protecting roofs (especially green roofs which are now mandated in many cities) or bridges;
- Monitoring the temperatures of electrical panels, switch gear and transformers;
- Metering current flow in electrical conductors;
- Providing sub-metering for tenants;
- Monitoring oil condition in bearings, transmissions, etc.;
- Monitoring pressure drop across filters, etc.;
- Measuring hours of usage of many components, such as filters, belts, lamps and pumps;
- Routine testing of critical devices such as pumps, loudspeakers, alarms, etc.

No further comment needs to be made with respect to some disasters which have occurred and which might have been prevented if some or all of the building monitoring technologies alluded to above had been in place.

Clearly it can be added that these concepts are consistent with measuring and monitoring practices which have evolved dramatically within recent years.

1.8 Underlying philosophy

The preceding examples are comparatively superficial with the potential of an intelligent building concept providing far greater benefits. The single spine is usually represented by physical security information management (PSIM). The significant advantage of intelligent buildings is that they can constantly monitor current operations in context and automatically adjust resources for optimum efficiency while identifying and accurately informing key decisions in a timely manner. This can range from the routine such as variance to preventative maintenance schedules to automated restocking and repair according to changes in the normal pattern of use.

For example, the Canadian Forces Station (CFS) Alert shown in Figure 1, is the most northerly, permanently inhabited location in the world, located only 817 kilometres from the geographic North Pole. CFS Eureka is a intelligent building that advises the Canadian Department of Defence Headquarters in Ottawa, Canada when it is in use and automatically compiles its resupply and repair requirements for each season deployment to the High Arctic. The expectation is that it will in the future inform and enable change of use capabilities, enhancing value through its lifetime.



Figure 1 – Canadian forces station alert

Photo credit: courtesy of IBI Group

Thus, the most important components for the purposes of providing an intelligent building are:

- A diverse, reliable and accessible communications system;
- Use of devices and systems which adhere to communication standards which provide bi-directional signalling;
- A clear commitment by the building owners, operators and designers to work together in order to ensure the provision of opportunities for the exploitation of communications infrastructure and;
- Recognition of the roles played by each of those participating in the design, implementation and operation and maintenance of these systems.

The benefits which accrue to the building have been briefly described and may be summarized by:

- A more efficient building;
- Implementation of communications as a "fourth utility" which results in only one communications backbone for all applications (in some jurisdictions, fire or other life safety systems may need to be segregated into an additional communications infrastructure to comply with local ordinances) and;
- Energy savings, maintenance savings and staffing savings will generally arise as an indirect benefit of each of the individual efficiencies.

1.9 Standards, codes and initiatives

Communications standards are well documented in many environments. For the purpose of the systems contributing to a building, there have been various initiatives. Different manufacturers have all promoted proprietary solutions at different times, leading to incompatibilities and non-standardized solutions. If the communications infrastructure is built in accordance with recognized standards, the interfaces developed by other industries generally become applicable. These approaches have allowed the development of niche solutions, all of which operate using standards such as:

- RS 232;
- RS 485;
- Ethernet-TCP/IP;
- BACnet;
- LONworks.

Interfaces for each of these communications protocols are well-defined. As a result, an infrastructure capable of reaching all parts of any building, can readily be provided and can interface with each of the building's systems.

Typically, most of the communication requirements are interpreted as different layers in the "OSI 7-Layer Communication Model".

Using the approach of the open system interconnection (OSI) layers, it is possible for proprietary communications to be carried over a common and shared backbone. This common shared backbone, or communications highway, can easily be made redundant allowing for numerous components to automatically fail and switch over to alternative devices, thereby ensuring that the building systems are not at risk of losing their integrity.

The concept of using a digital IP backbone, which can interface to almost any control or monitoring system has gradually become pervasive. Solutions carried over IP networks are sometimes well-publicized and at other times well-hidden from the public. Examples of systems which are readily compatible with an IP backbone include:

- Audio paging;
- Fire alarm systems;
- Telephone systems;
- HVAC systems;
- Surveillance systems;
- Access control and intrusion alarms;
- Lighting control systems;
- Elevator control systems.

Based on these systems and others, each of which have the ability to communicate over this common backbone, it is evident that the standards applicable to the provision of an IP infrastructure are one possible mechanism by which an intelligent building can be implemented. Depending on the jurisdiction, there may be a need that some of the systems require special considerations in order to comply with all aspects of the building code, fire safety code or electrical code. The discussion in this Supplement will not address any constraints imposed by such regulations. However it does provide an assurance that there are solutions which are available for all requirements.

2 Intelligent sustainable building roadmap

Cars are very heavily integrated with alarms and information messages all displayed through a single driver interface which may inform the driver of issues related to tire pressure, bulbs which have failed, engine performance issues and many other components.

Current generation airplanes are all designed to operate using "fly by wire" meaning that communications for all of the operational aspects of the aircraft are carried over one or more communication backbones in a manner not dissimilar to that being advocated for an intelligent building.

The difference between these two examples and the building industry is however the legislative requirements for reliability, safety and accountability which do not apply in the same manner in the heavily divided building industry.

Many of the concepts which have been described briefly in this document may be found in documents such as the Technology Roadmap [b-IC] adopted by Industry Canada and subsequently updated and reissued through the continental automated building association (CABA) which has been a market driver in the development of industry discussion and cooperation related to intelligent building technologies.