Technological advances for controlling indoor environment

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” Intelligent HVAC installations, use of sensors and advantages of Continuous Commissioning”

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Agenda

- Intelligent HVAC installation
- Sensor and Networks
- Security aspects
- Continuous Commissioning

Intelligent Buildings

- An Intelligent Building is one equipped with the telecommunications infrastructure that enables it to continuously respond and adapt to changing conditions, allowing for a more efficient use of resources and increasing the comfort and security of its occupants.
- An Intelligent Building provides these benefits through automated control systems such as: heating, ventilation, and air-conditioning (HVAC); fire safety; security; and energy/lighting management.

Control of HVAC system

- Proper control of building systems is essential to maintain
  - the most efficient systems operation,
  - sustain the highest level of indoor environmental quality,
  - and respond appropriately to external forces.
- Current practices fall short of achieving optimal operations due to
  - the disparate nature of the building industry,
  - and a lack of understanding of how complex building systems interact with their environment.

Control of HVAC system

- HVAC systems are generally controlled by Building Automation Systems that can:
  - permit individual occupants to adjust workspace temperatures, airflow
  - monitor temperatures, and adjust according to a usage profile;
  - adjust indoor air quality based on room occupancy and building standards;
  - adjust humidity, temperature and air flow speeds;
  - And use either variable air volume or constant volume air distribution designs.

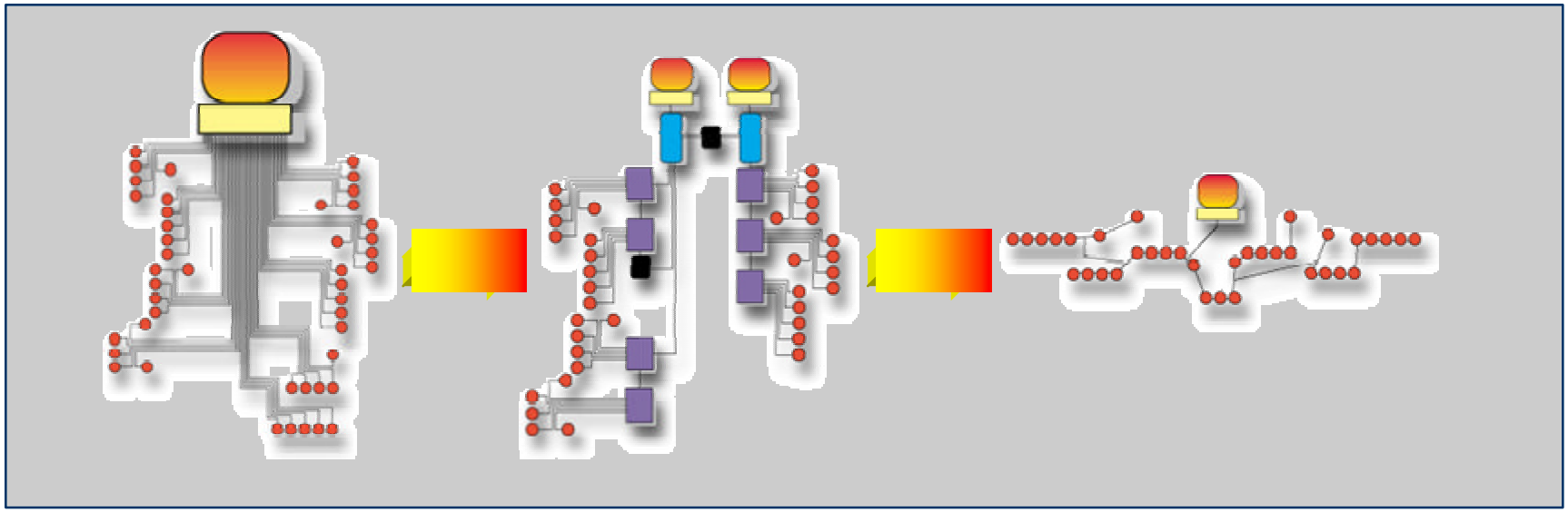
Control System Evolution

- Master/slave
- Stand-alone controllers
- Closed, single-vendor

Distributed systems

Networks

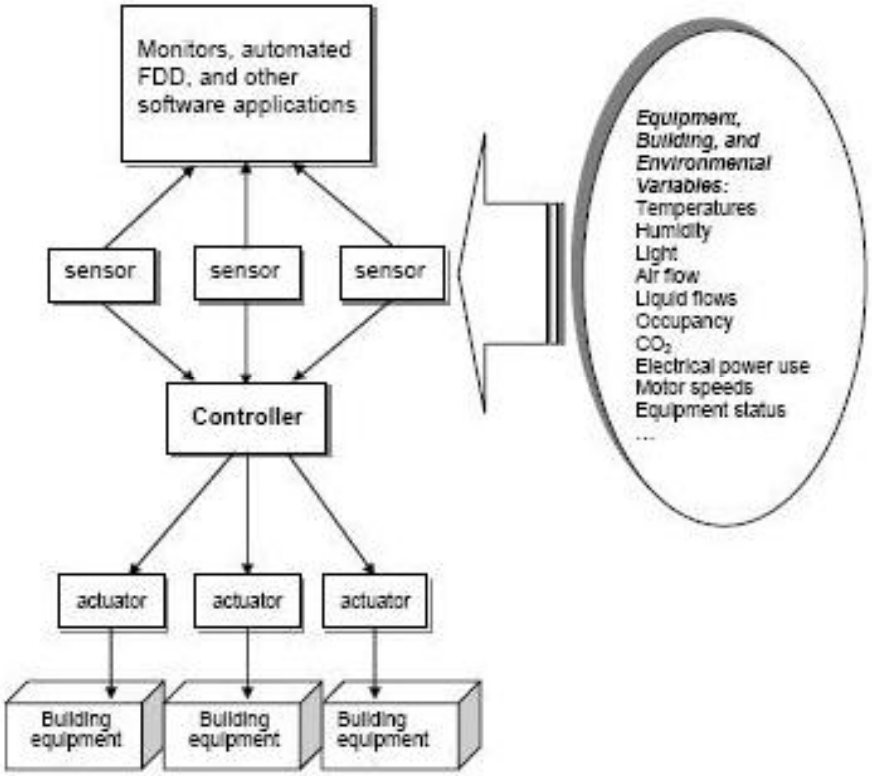
Open, multi-vendor



Intelligent HVAC installation

- The essence of Buildings Automation Systems is in the control technologies, which allow:
  - integration, automation, and optimization of all the services and equipment that provide services and manages the environment of the building concerned.
- HVAC installations can be intelligent with their automation and integration:
  - Different systems will be combined and integrated like lighting systems (lighting, sockets), HVAC (heating, ventilation, air conditioning/cooling), security systems (fire and burglar alarm, surveillance cameras, access control),
  - Systems that can learn about the interactions of the HVAC with the building and self-develop algorithms that learn building behavior without additional programming.
  - Algorithms and instructions that can take advantage of distributed intelligence within control systems.
- To make HVAC installations more intelligent, we need:

Intelligent HVAC installation



- A generic monitoring and control system consist of four generic component systems:
  - sensors,
  - controls,
  - actuators,
  - and other software.

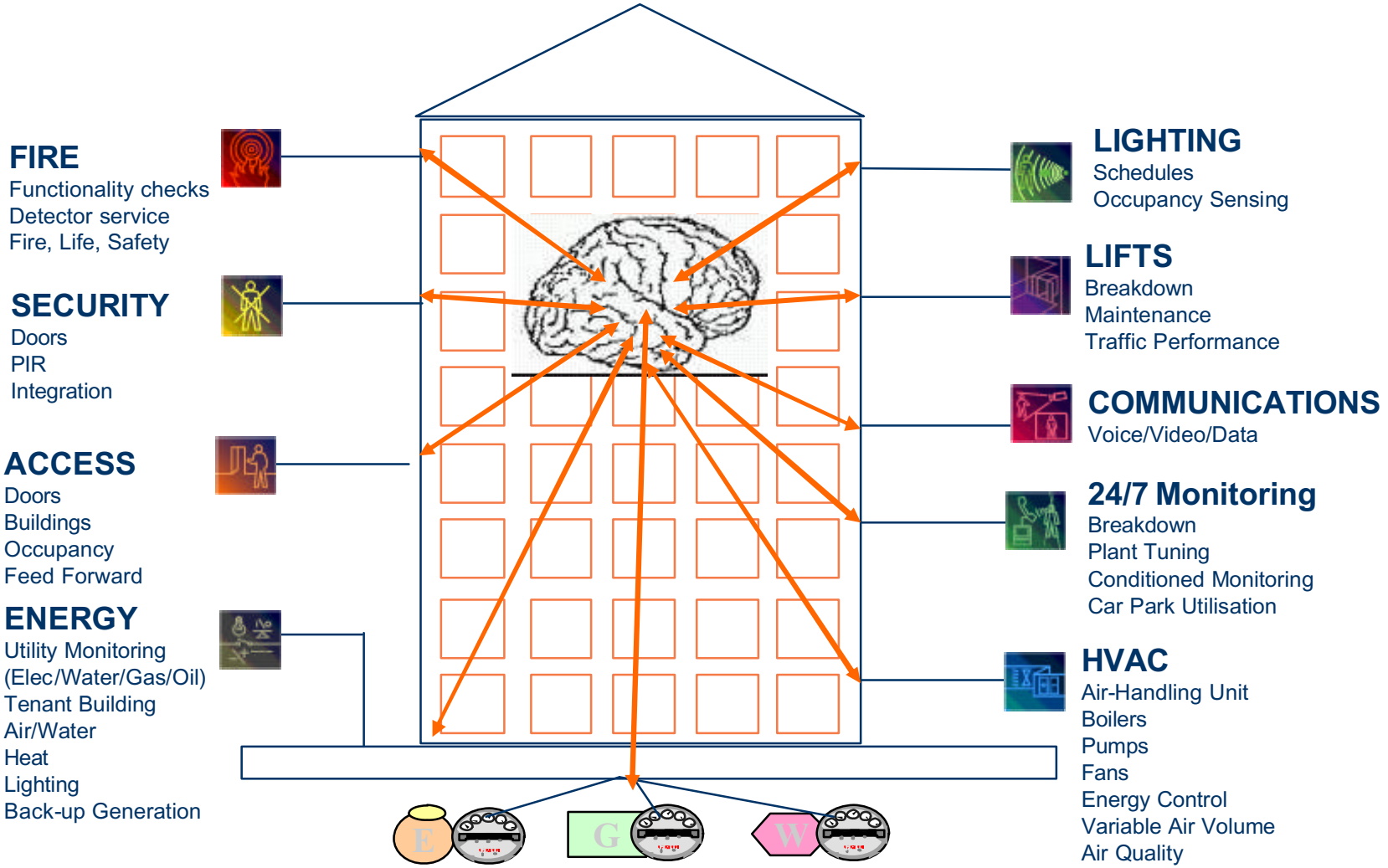
Sensors

- With the high number of components in large, complex commercial building, it is difficult for operation staff to remain fully aware of equipment and system conditions.
- Without automated monitoring and fault detection, and the sensors and controls on which they rely, performance can degrade.
- The number and range of types of sensors installed in commercial buildings today is inadequate to provide sufficient automated monitoring.
- Installed costs of sensors need to be reduced and decision makers need to become informed regarding the benefits they can derive from better sensing and control.

Future needs

- Improvements to existing sensors and features of new sensors should include:
  - self-calibrating, self-testing, self-diagnosing, and self-reporting sensors
  - low-cost power meters for sub-metering
  - low-drift and low-cost RH sensors
  - sensors that automatically detect the need for a measurement
  - peripatetic sensors that automatically provide measurements from mobile objects or people and that can automatically be detected by sensor networks
  - incorporation of low-cost processing and memory on sensor elements to generate information from raw data and to store that information, reporting data only when anomalies occur
- New types of sensors are needed for building applications:
  - volumetric airflow sensors
  - affordable VOC and particulate sensors
  - mold sensors
  - sensors for security issues (chemical, biological, and nuclear hazards).
  - low-cost sensors that detect occupancy.
  - inexpensive sensors for IAQ assessment.

Extensive instrumentation in future buildings

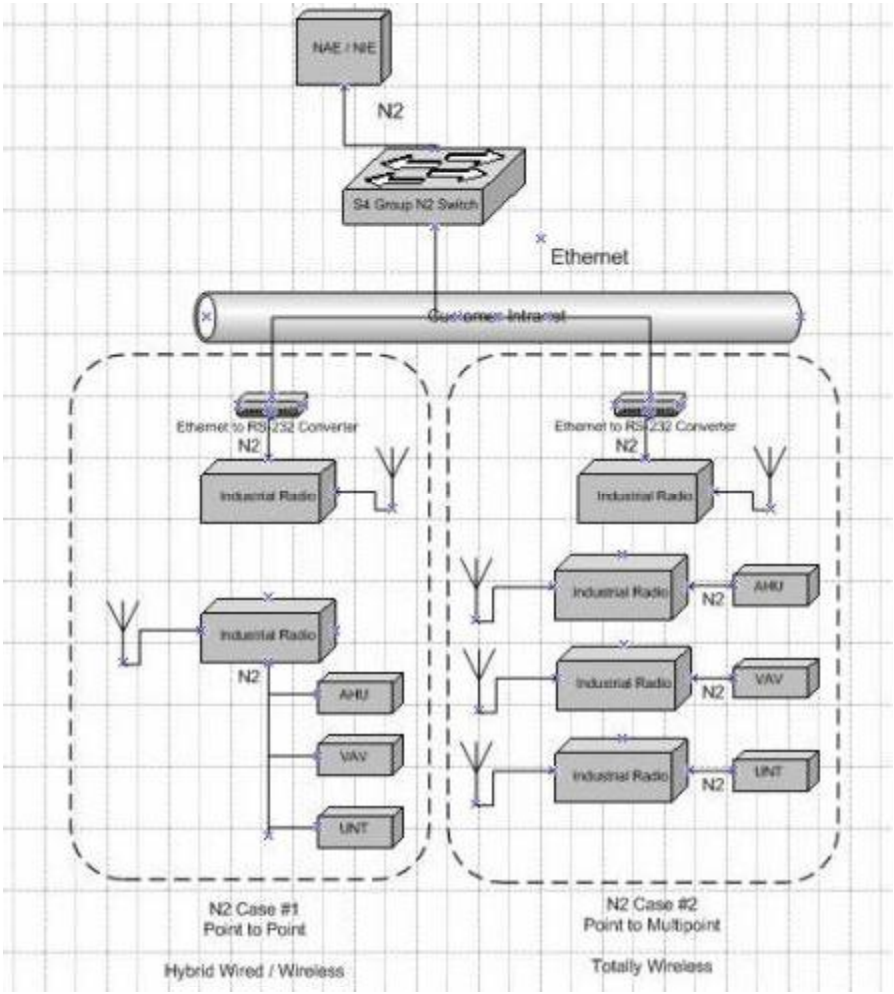


Communication Modes: Wired vs. Wireless

- Wireless technology in building operation reduce the cost of installing control systems by eliminating the control wires.
  - Installation of wiring can represent 20% to 80% of the cost of a control point in HVAC or lighting control networks
  - The availability of low-cost wireless sensor and control systems lead to increased use of sensors and control devices

Features	Benefits
No wiring	Avoidance of wiring cost significantly reduces the installation cost.
Improved flexibility	Not necessary to locate sensors near wires. Wireless sensors can be easily relocated as the indoor space undergoes re-configuration. For instance, a wireless light switch can move with the interior wall.
Ease of servicing	Wireless sensors can be easily removed from their location for re-calibration or replacement in case of failure.
Extendability of existing wireless network	Once a wireless network is established, additional sensors and controllers can be easily added at the cost of an additional wireless device.

Wireless communication



Using Wireless communication

- Wireless sensors are relatively new to the buildings automation industry.
- Confidence needs to be gained that wireless sensors and controls will work reliably and perform as designed.
- To find acceptability in the building automation industry, the following challenges must be faced:
  - Proven operational reliability:
    - wireless sensors need to gain industry confidence by demonstrati ng reliability in commercial buildings.
  - Invulnerability to interference:
    - as more and more wireless devices are being used in commercial b uildings there is a need to demonstrate that the wireless technologies are not vulnerable to interference by other wireless systems, cellular telephones, and other devices that emit in the electromagnetic spectrum.
  - Power requirements:
    - there is a need to store more power capacity on wireless sensors to maintain reliable operations for five years or more..
  - Integration into existing networks.
    - Today's wireless technology is mostly designed to work in a stand-alone mode. Future wireless networks need to be easily integrated into existing wired control networks.
  - Interoperability.
    - As wireless sensors and control devices become more common there will be a need to develop specifications and standards that assure interoperability.

Security aspect

- Building Control System Physical Security
  - Limiting access to authorized individuals and preventing criminal or malicious activities.
  - Limiting access to building networks and computer resources to authorized users.
  - Access control related to emergency responders, such as police, fire, or medical personnel. Depending on the type and scale of emergency, it may be necessary to have special procedures for verifying the identity of such emergency personnel.
- Building Control System Network Security
  - Building networks open to outside connections. This exposes the BCS to threats from attacks from outsiders through the corporate firewall.

Advantages of Continuous Commissioning

- It is widely recognized that buildings in general fail to operate as intended by their designers or at the performance level of which the equipment installed in the building are capable.
- A 1994 study of 60 commercial buildings (USA) found that:
  - more than half suffered from control problems,
  - 40% had additional problems with HVAC equipment,
  - and one-third had sensors that were not operating properly.
  - An astonishing 15% of the buildings studied were actually missing specified equipment.
  - And approximately one-quarter of them had energy management control systems, economizers, and/or variable speed drives that did not run properly.
  - Problems also frequently occur on the envelope, structural and electrical systems of many new buildings.

Methods for preventing poor performance

- Performance monitoring
  - involves continuously measuring the behavior of the building in order to assess its performance. Issues include the provision of the necessary sensors and data acquisition, storage, retrieval and visualization.
- Automated fault detection and diagnosis
  - involves the use of software tools to analyze the behavior of the building, determine if the performance is unsatisfactory (fault detection), and then isolate or localize the fault in order to facilitate repair (fault diagnosis).
- Commissioning
  - involves active testing of components and sub-systems as one of its core activities. Commissioning is currently a manual activity involving specific tests that are performed and analyzed by specially trained engineers.
- Automated commissioning
  - is based on active functional tests performed and analyzed by an automated fault detection and diagnosis tool.
- Optimized control–performance
  - may be improved by optimizing the control strategy, either through the use of on-line optimal control or by the use of heuristic strategies that approximate optimal control.

Continuous Commissioning

- CC is an ongoing process to resolve,
  - operating problems,
  - improve comfort,
  - optimize energy use and
  - identify retrofits
- CC focuses on improving overall system control and operations for the building,
- CC ensures that the building and systems operate optimally to meet the current requirements.

Continuous Commissioning

- The process can be:
  - Manual
  - Semi-automated
  - Automated
- Manual CC
  - Manual functional testing procedures
  - Analyzing existing data collected by the BAS
  - Problem: instrumentation levels in buildings are too low. There is a need for extensive instrumentation.

Automated Continuous Commissioning

- The need for development of automatic commissioning came from the request of building actors to decrease the cost and the time involved for commissioning.
- The automation of this task also helps to:
  - Improve the commissioning process itself,
  - Do commissioning of a whole system or building (automatic or semi-automatic tools helps to deal with the complexity of the task),
  - Make commissioning process available for different actors with different skills (experts of control systems in building field are rare).

Methods of Automated Continuous Commissioning

- Two approaches to automated commissioning have been considered in Annex 40:
  - **Passive tests** involve using the control system to monitor and record sensor and actuator signals from HVAC systems operating under normal conditions. This method it is used to perform continuous monitoring (on-going commissioning).
  - ***Active Testing open loop*** involves making artificial specific changes to the systems under control in order to interrogate behavior. Active tests can reveal more information about a controlled system in a shorter time period than passive tests.
  - ***Active testing closed loop*** adapt continuously a sequence of test function of the behaviour of system. This approach usually implies the simulation of the results in real time function of the behaviour of system. The implementation on site is complex and involves a constant communication between the building systems and the commissioning tool.

Automated Continuous Commissioning – future needs

- Building Automation System
  - Integrated CC software in order to do both passive and active tests
  - Better software for analyzing collected operational data
  - Software for optimizing control strategies (simulation assisted control)
- Distributed control system
  - Distributed intelligence
  - Individual controllers will continue to function when some elements of the network or main computer fail.
  - More redundancy and autonomy
- Network system, protocols
  - Wireless system
  - Ethernet
  - Bus system
- Sensors
  - Smaller, cheaper
  - Easy to implement, Plug-and-Play
  - Cost-effective sensors for indoor air pollution, thermal environment including radiation temperature and moisture;
  - Cost-effective sensors for measuring fluid and airflow in HVAC systems;
  - Sensors with improved calibrations and accuracy, including self diagnostic and reduced power consumption;

End of presentation

- Questions?