**Building automation**

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*This article is about automation within commercial buildings. For automation within residences, see* [*Home automation*](http://en.wikipedia.org/wiki/Home_automation)*.*

**Building automation** describes the functionality provided by the control system of a building. A building automation system (BAS) is an example of a [distributed control system](http://en.wikipedia.org/wiki/Distributed_control_system). The control system is a computerized, intelligent [network](http://en.wikipedia.org/wiki/Computer_networking) of electronic devices, designed to monitor and control the mechanical and lighting systems in a building.

BAS core functionality keeps the building climate within a specified range, provides lighting based on an occupancy schedule, and monitors system performance and device failures and provides email and/or text notifications to building engineering staff. The BAS functionality reduces building energy and maintenance costs when compared to a non-controlled building. A building controlled by a BAS is often referred to as an [intelligent building system](http://en.wikipedia.org/w/index.php?title=Intelligent_building_system&action=edit&redlink=1).



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**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=1)**] Topology**

Most building automation networks consist of a *primary* and *secondary* [bus](http://en.wikipedia.org/wiki/Bus) which connect high-level controllers (generally specialized for building automation, but may be generic [programmable logic controllers](http://en.wikipedia.org/wiki/Programmable_logic_controller)) with lower-level controllers, [input/output](http://en.wikipedia.org/wiki/Input/output) devices and a [user interface](http://en.wikipedia.org/wiki/User_interface) (also known as a human interface device).

The primary and secondary bus can be [BACnet](http://en.wikipedia.org/wiki/BACnet), [optical fiber](http://en.wikipedia.org/wiki/Optical_fiber), [ethernet](http://en.wikipedia.org/wiki/Ethernet), [ARCNET](http://en.wikipedia.org/wiki/ARCNET), [RS-232](http://en.wikipedia.org/wiki/RS-232), [RS-485](http://en.wikipedia.org/wiki/EIA-485) or a [wireless network](http://en.wikipedia.org/wiki/Wireless_network).

Most controllers are [proprietary](http://en.wikipedia.org/wiki/Proprietary). Each company has its own controllers for specific applications. Some are designed with limited controls: for example, a simple Packaged Roof Top Unit. Others are designed to be flexible. Most have proprietary software that will work with [ASHRAE](http://en.wikipedia.org/wiki/ASHRAE)'s open protocol [BACnet](http://en.wikipedia.org/wiki/BACnet) or the open protocol [LonTalk](http://en.wikipedia.org/wiki/LonTalk).

Inputs and outputs are either [analog](http://en.wikipedia.org/wiki/Analog_circuit) or [digital](http://en.wikipedia.org/wiki/Digital) (some companies say [binary](http://en.wikipedia.org/wiki/Binary_data)).

Analog inputs are used to read a variable measurement. Examples are [temperature](http://en.wikipedia.org/wiki/Temperature), [humidity](http://en.wikipedia.org/wiki/Humidity) and [pressure](http://en.wikipedia.org/wiki/Pressure) [sensor](http://en.wikipedia.org/wiki/Sensor) which could be [thermistor](http://en.wikipedia.org/wiki/Thermistor), [4-20 mA](http://en.wikipedia.org/wiki/4-20_mA), 0-10 [volt](http://en.wikipedia.org/wiki/Volt) or platinum [resistance thermometer](http://en.wikipedia.org/wiki/Resistance_thermometer) (resistance temperature detector), or [wireless sensors](http://en.wikipedia.org/w/index.php?title=Wireless_sensor&action=edit&redlink=1).

A digital input indicates if a device is turned on or not. Some examples of a digital input would be a 24VDC/AC signal, an air flow [switch](http://en.wikipedia.org/wiki/Switch), or a volt-free [relay](http://en.wikipedia.org/wiki/Relay) contact.

Analog outputs control the speed or position of a device, such as a [variable frequency drive](http://en.wikipedia.org/wiki/Variable_frequency_drive), a I-P ([current](http://en.wikipedia.org/wiki/Current_%28electricity%29) to [pneumatics](http://en.wikipedia.org/wiki/Pneumatics)) [transducer](http://en.wikipedia.org/wiki/Transducer), or a valve or damper [actuator](http://en.wikipedia.org/wiki/Actuator). An example is a hot water valve opening up 25% to maintain a [setpoint](http://en.wikipedia.org/wiki/Setpoint).

Digital outputs are used to open and close relays and switches. An example would be to turn on the parking lot lights when a [photocell](http://en.wikipedia.org/wiki/Photocell) indicates it is dark outside.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=2)**] Infrastructure**

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=3)**] Controller**

Controllers are essentially small, purpose-built computers with input and output capabilities. These controllers come in a range of sizes and capabilities to control devices commonly found in buildings, and to control sub-networks of controllers.

Inputs allow a controller to read temperatures, humidity, pressure, current flow, air flow, and other essential factors. The outputs allow the controller to send command and control signals to slave devices, and to other parts of the system. Inputs and outputs can be either digital or analog. Digital outputs are also sometimes called discrete depending on manufacturer.

Controllers used for building automation can be grouped in 3 categories. Programmable Logic Controllers (PLCs), System/Network controllers, and Terminal Unit controllers. However an additional device can also exist in order to integrate 3rd party systems (i.e. a stand-alone AC system) into a central Building automation system).

[PLC's](http://en.wikipedia.org/wiki/Programmable_Logic_Controller) provide the most responsiveness and processing power, but at a unit cost typically 2 to 3 times that of a System/Network controller intended for BAS applications. Terminal Unit controllers are usually the least expensive and least powerful.

[PLC's](http://en.wikipedia.org/wiki/Programmable_Logic_Controller) may be used to automate high-end applications such as clean rooms or hospitals where the cost of the controllers is a lesser concern.

In office buildings, supermarkets, malls, and other common automated buildings the systems will use System/Network controllers rather than PLC's. Most System controllers provide general purpose [feedback loops](http://en.wikipedia.org/wiki/PID_loop), as well as [digital circuits](http://en.wikipedia.org/wiki/Digital_circuit), but lack the millisecond response time that PLC's provide.

System/Network controllers may be applied to control one or more mechanical systems such as an Air Handler Unit (AHU), boiler, chiller, etc., or they may supervise a sub-network of controllers. In the diagram above, System/Network controllers are often used in place of PLCs.

Terminal Unit controllers usually are suited for control of lighting and/or simpler devices such as a package rooftop unit, heat pump, VAV box, or fan coil, etc. The installer typically selects 1 of the available pre-programmed personalities best suited to the device to be controlled, and does not have to create new control logic.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=4)**] Occupancy**

Occupancy is one of 2 or more operating modes for a building automation system. Unoccupied, Morning Warmup, and Night-time Setback are other common modes.

Occupancy is usually based on time of day schedules. In Occupancy mode, the BAS aims to provides a comfortable climate and adequate lighting, often with zone-based control so that users on one side of a building have a different thermostat (or a different system, or sub system) than users on the opposite side.

A temperature sensor in the zone provides feedback to the controller, so it can deliver heating or cooling as needed.

If enabled, Morning Warmup (MWU) mode occurs prior to Occupancy. During Morning Warmup the BAS tries to bring the building to [setpoint](http://en.wikipedia.org/wiki/Setpoint_%28control_system%29) just in time for Occupancy. The BAS often factors in outdoor conditions and historical experience to optimize MWU. This is also referred to as Optimised Start.

An override is a manually-initiated command to the BAS. For example, many wall-mounted temperature sensors will have a push-button that forces the system into Occupancy mode for a set number of minutes. Where present, web interfaces allow users to remotely initiate an override on the BAS.

Some buildings rely on occupancy sensors to activate lighting and/or climate conditioning. Given the potential for long lead times before a space becomes sufficiently cool or warm, climate conditioning is not often initiated directly by an occupancy sensor.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=5)**] Lighting**

[Lighting](http://en.wikipedia.org/wiki/Lighting_control_console) can be turned on and off with a building automation system based on time of day, or on occupancy sensors, photosensors and timers.[[1]](http://en.wikipedia.org/wiki/Building_automation#cite_note-0) One typical example is to turn the lights in a space on for a half hour since the last motion was sensed. A photocell placed outside a building can sense darkness, and the time of day, and modulate lights in outer offices and the parking lot.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=6)**] Air handlers**

Most air handlers mix return and outside air so less temperature change is needed. This can save money by using less chilled or heated water (not all AHUs use chilled/hot water circuits). Some external air is needed to keep the building's air healthy.

Analog or digital temperature sensors may be placed in the space or room, the return and supply [air ducts](http://en.wikipedia.org/wiki/Air_duct), and sometimes the external air. Actuators are placed on the hot and chilled water valves, the outside air and return air dampers. The supply fan (and return if applicable) is started and stopped based on either time of day, temperatures, building pressures or a combination.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=7)**] Constant volume air-handling units**

The less efficient type of air-handler is a "constant volume air handling unit," or CAV. The fans in CAVs do not have variable-speed controls. Instead, CAVs open and close [dampers](http://en.wikipedia.org/wiki/Zone_damper) and water-supply valves to maintain temperatures in the building's spaces. They heat or cool the spaces by opening or closing chilled or hot water valves that feed their internal [heat exchangers](http://en.wikipedia.org/wiki/Heat_exchanger). Generally one CAV serves several spaces, but large buildings may have many CAVs.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=8)**] Variable volume air-handling units**

A more efficient unit is a "[variable air volume](http://en.wikipedia.org/wiki/Variable_air_volume) (VAV) air-handling unit," or VAV. VAVs supply pressurized air to VAV boxes, usually one box per room or area. A VAV air handler can change the pressure to the VAV boxes by changing the speed of a [fan](http://en.wikipedia.org/wiki/Fan_%28mechanical%29) or [blower](http://en.wikipedia.org/wiki/Blower) with a [variable frequency drive](http://en.wikipedia.org/wiki/Variable_frequency_drive) or (less efficiently) by moving inlet guide vanes to a fixed-speed fan. The amount of air is determined by the needs of the spaces served by the VAV boxes.

Each VAV box supply air to a small space, like an office. Each box has a damper that is opened or closed based on how much heating or cooling is required in its space. The more boxes are open, the more air is required, and a greater amount of air is supplied by the VAV air-handling unit.

Some VAV boxes also have hot water valves and an internal heat exchanger. The valves for hot and cold water are opened or closed based on the heat demand for the spaces it is supplying. These heated VAV boxes are sometimes used on the perimeter only and the interior zones are cooling only.

A minimum and maximum CFM must be set on VAV boxes to assure adequate ventilation and proper air balance.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=9)**] VAV hybrid systems**

Another variation is a hybrid between VAV and CAV systems. In this system, the interior zones operate as in a VAV system. The outer zones differ in that the heating is supplied by a heating fan in a central location usually with a heating coil fed by the building boiler. The heated air is ducted to the exterior dual duct mixing boxes and dampers controlled by the zone thermostat calling for either cooled or heated air as needed.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=10)**] Central plant**

A central plant is needed to supply the air-handling units with water. It may supply a [chilled water system](http://en.wikipedia.org/w/index.php?title=Chilled_water_system&action=edit&redlink=1), [hot water system](http://en.wikipedia.org/wiki/Hot_water_system) and a [condenser water system](http://en.wikipedia.org/w/index.php?title=Condenser_water_system&action=edit&redlink=1), as well as [transformers](http://en.wikipedia.org/wiki/Transformer) and [auxiliary power unit](http://en.wikipedia.org/wiki/Auxiliary_power_unit) for emergency power. If well managed, these can often help each other. For example, some plants generate electric power at periods with peak demand, using a gas turbine, and then use the turbine's hot exhaust to heat water or power an [absorptive chiller](http://en.wikipedia.org/wiki/Absorptive_chiller).

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=11)**] Chilled water system**

Chilled water is often used to cool a building's air and equipment. The chilled water system will have [chiller](http://en.wikipedia.org/wiki/Chiller)(s) and [pumps](http://en.wikipedia.org/wiki/Pump). Analog temperature sensors measure the chilled water supply and [return lines](http://en.wikipedia.org/w/index.php?title=Return_line&action=edit&redlink=1). The chiller(s) are sequenced on and off to chill the chilled water supply.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=12)**] Condenser water system**

[Cooling tower(s)](http://en.wikipedia.org/wiki/Cooling_tower) and [pumps](http://en.wikipedia.org/wiki/Pump) are used to supply cool [condenser](http://en.wikipedia.org/wiki/Condenser) water to the [chillers](http://en.wikipedia.org/wiki/Chiller). The condenser water supply to the chillers has to be constant so, speed drives are commonly used on the cooling tower fans to control temperature. Proper cooling tower temperature assures the proper refrigerant head pressure in the chiller. The cooling tower set point used depends upon the refrigerant being used. Analog temperature sensors measure the condenser water supply and return lines.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=13)**] Hot water system**

The hot water system supplies heat to the building's air-handling unit or [VAV box](http://en.wikipedia.org/w/index.php?title=VAV_box&action=edit&redlink=1) heating coils, along with the domestic hot water heating coils ([Calorifier](http://en.wikipedia.org/wiki/Calorifier%22%20%5Co%20%22Calorifier)). The hot water system will have a [boiler](http://en.wikipedia.org/wiki/Boiler)(s) and pumps. Analog temperature sensors are placed in the hot water supply and return lines. Some type of mixing valve is usually used to control the heating water loop temperature. The boiler(s) and pumps are sequenced on and off to maintain supply.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=14)**] Alarms and security**

Many building automation systems have alarm capabilities. If an alarm is detected, it can be programmed to notify someone. Notification can be through a computer, [pager](http://en.wikipedia.org/wiki/Pager), cellular phone, or audible alarm.

* Common temperature alarms are: space, supply air, chilled water supply and hot water supply.
* Differential pressure switches can be placed on the filter to determine if it is dirty.
* Status alarms are common. If a mechanical device like a pump is requested to start, and the status input indicates it is off. This can indicate a mechanical failure.
* Some valve actuators have end switches to indicate if the valve has opened or not.
* [Carbon monoxide](http://en.wikipedia.org/wiki/Carbon_monoxide) and [carbon dioxide](http://en.wikipedia.org/wiki/Carbon_dioxide) sensors can be used to alarm if levels are too high.
* [Refrigerant](http://en.wikipedia.org/wiki/Refrigerant) sensors can be used to indicate a possible refrigerant leak.
* Current sensors can be used to detect low current conditions caused by slipping fan belts, or clogging strainers at pumps.

At sites with several buildings, momentary power failures can cause hundreds or thousands of alarms from equipment that has shut down. Some sites are programmed so that critical alarms are automatically re-sent at varying intervals. For example, a repeating critical alarm (of a [uninterruptible power supply](http://en.wikipedia.org/wiki/Uninterruptible_power_supply) in 'by pass') might resound at 10 minutes, 30 minutes, and every 2 to 4 hours there after until the alarms are resolved.

Security systems can be interlocked to a building automation system. If occupancy sensors are present, they can also be used as burglar alarms.

[Fire](http://en.wikipedia.org/wiki/Fire_alarm_panel) and smoke alarm systems can be hard-wired to override building automation. For example: if the smoke alarm is activated, all the outside air dampers close to prevent air coming into the building, and an exhaust system can isolate the alarmed area and activate an exhaust fan to move smoke out of the area. Life safety applications are normally hard-wired to a mechanical device to override building automation control.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=15)**] Room automation**

**Room automation** is a subset of Building automation and like it, is the consolidation of one or systems under centralised control but in this case in just one room .

The most common example of *room automation* is corporate boardroom, presentation suites, and lecture halls, where the operation of the large number of devices that define the room function (such as [Videoconferencing](http://en.wikipedia.org/wiki/Videoconferencing) equipment, [Video projectors](http://en.wikipedia.org/wiki/Video_projector), [lighting control systems](http://en.wikipedia.org/wiki/Lighting_control_system), [Public address](http://en.wikipedia.org/wiki/Public_address) systems etc.) would make manual operation of the room very complex. It is common for room automation systems to employ a [touchscreen](http://en.wikipedia.org/wiki/Touchscreen) as the primary way of controlling each operation.

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=16)**] Manufacturers**

* [[Alerton] Technologies](http://en.wikipedia.org/wiki/Alerton)
* [AMX, LLC](http://en.wikipedia.org/wiki/AMX_LLC)
* [ASI Controls](http://en.wikipedia.org/wiki/ASI_Controls)
* [Automated Logic Corporation](http://en.wikipedia.org/wiki/Automated_Logic_Corporation)
* [Beckhoff Automation](http://en.wikipedia.org/wiki/Beckhoff)
* [Carrier Corporation](http://en.wikipedia.org/wiki/Carrier_Corporation)
* [Cisco Systems](http://en.wikipedia.org/wiki/Cisco_Systems)
* [Citect](http://en.wikipedia.org/wiki/Citect)
* [Computrols, Inc.](http://en.wikipedia.org/wiki/Computrols)
* [Crestron Electronics, Inc.](http://en.wikipedia.org/wiki/Crestron_Electronics)
* [Dynalite Intelligent Light Pty Ltd](http://en.wikipedia.org/wiki/Dynalite)
* [e-Home Automation](http://en.wikipedia.org/wiki/E-Home_Automation)
* [EnOcean](http://en.wikipedia.org/wiki/EnOcean)
* [Honeywell Home and Building Control](http://en.wikipedia.org/wiki/Honeywell)
* [Iconics](http://en.wikipedia.org/wiki/Iconics)
* [Invensys Building Systems](http://en.wikipedia.org/wiki/Invensys)
* [Johnson Controls Inc.](http://en.wikipedia.org/wiki/Johnson_Controls)
* [KMC](http://en.wikipedia.org/wiki/KMC)
* [Novar Controls](http://en.wikipedia.org/wiki/Novar)
* [Panduit](http://en.wikipedia.org/wiki/Panduit)
* [Priva](http://en.wikipedia.org/wiki/Priva_BV)
* [Schneider Electric](http://en.wikipedia.org/wiki/Schneider_Electric)
* [Siemens Building Technologies](http://en.wikipedia.org/wiki/Siemens)
* [Staefa Control System](http://en.wikipedia.org/wiki/Staefa)
* [StarDraw control](http://en.wikipedia.org/wiki/StarDraw)
* [TAC](http://en.wikipedia.org/wiki/TAC_%28building_automation%29)
* [Teletrol Systems Inc.](http://en.wikipedia.org/wiki/Teletrol)
* [Trane Global Control Systems](http://en.wikipedia.org/wiki/Trane)
* [Trend Control Systems Ltd.](http://en.wikipedia.org/wiki/Trend_Controls)
* [WAGO Kontakttechnik GmbH & Co. KG](http://en.wikipedia.org/wiki/WAGO_Kontakttechnik)
* [Wonderware](http://en.wikipedia.org/wiki/Wonderware)

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=17)**] Protocols and industry standards**

* [ASHRAE](http://en.wikipedia.org/wiki/ASHRAE) (American Society of Heating, Refrigerating and Air Conditioning Engineers) is an international organization for people involved in heating, ventilation, air conditioning, or refrigeration (HVAC&R).
* [BACnet](http://en.wikipedia.org/wiki/BACnet) is a network communications protocol for building automation and control systems that has been adopted worldwide as ISO 16484-5:2003. The BACnet International has reached an agreement with [SoftDEL Systems](http://en.wikipedia.org/wiki/SoftDEL_Systems) to establish an test lab for its BACnet products.[[2]](http://en.wikipedia.org/wiki/Building_automation#cite_note-1). This BACnet lab is [ISO 17025](http://en.wikipedia.org/wiki/ISO_17025) accredited.
* [C-Bus](http://en.wikipedia.org/wiki/C-Bus_%28protocol%29)
* [CIBSE](http://en.wikipedia.org/wiki/CIBSE) Chartered Institute of Building Services Engineers.
* [DALI](http://en.wikipedia.org/wiki/Digital_Addressable_Lighting_Interface)
* [DSI](http://en.wikipedia.org/wiki/Digital_Signal_Interface)
* [Dynet](http://en.wikipedia.org/wiki/Dynalite)
* [Energy Star](http://en.wikipedia.org/wiki/Energy_Star) is program created by the United States [government](http://en.wikipedia.org/wiki/United_States_Environmental_Protection_Agency) to promote [energy efficient](http://en.wikipedia.org/wiki/Energy_efficiency) consumer products.
* [EnOcean](http://en.wikipedia.org/wiki/EnOcean) (batteryless, interoperable, wireless standard)
* [KNX](http://en.wikipedia.org/wiki/KNX_%28standard%29), a system for Home and Building Controls
* [LonTalk](http://en.wikipedia.org/wiki/Lonworks) is a protocol created by [Echelon Corporation](http://en.wikipedia.org/wiki/Echelon_Corporation) for networking devices.
* [Midac](http://en.wikipedia.org/wiki/Midac)
* [Modbus](http://en.wikipedia.org/wiki/Modbus)
* [oBIX](http://en.wikipedia.org/wiki/OBIX)
* [OpenTherm](http://en.wikipedia.org/wiki/OpenTherm)
* [ZigBee](http://en.wikipedia.org/wiki/ZigBee) is a short range, low-powered wireless communication standard targeted at Building Automation.
* [OpenWebNet](http://en.wikipedia.org/wiki/OpenWebNet)
* [Building Management System](http://en.wikipedia.org/wiki/Building_Management_System)
* [Control engineering](http://en.wikipedia.org/wiki/Control_engineering)
* [Control system](http://en.wikipedia.org/wiki/Control_system)
* [Home automation](http://en.wikipedia.org/wiki/Home_automation)
* [HVAC control system](http://en.wikipedia.org/wiki/HVAC_control_system)
* [Lighting control system](http://en.wikipedia.org/wiki/Lighting_control_system)
* [Smart environment](http://en.wikipedia.org/wiki/Smart_environment)

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=18)**] See also**

* [Building Management System](http://en.wikipedia.org/wiki/Building_Management_System)
* [OLE for process control](http://en.wikipedia.org/wiki/OLE_for_process_control)
* [Crestron](http://en.wikipedia.org/wiki/Crestron)
* [Digital home](http://en.wikipedia.org/wiki/Digital_home)
* [Hall Research Technologies](http://en.wikipedia.org/wiki/Hall_Research_Technologies)

**[**[**edit**](http://en.wikipedia.org/w/index.php?title=Building_automation&action=edit&section=19)**] References**

1. [**^**](http://en.wikipedia.org/wiki/Building_automation#cite_ref-0) ["Lighting control saves money and makes sense"](http://www.daintree.net/downloads/whitepapers/smart-lighting.pdf). [Daintree Networks](http://en.wikipedia.org/wiki/Daintree_Networks). <http://www.daintree.net/downloads/whitepapers/smart-lighting.pdf>. Retrieved 2009-06-19.
2. [**^**](http://en.wikipedia.org/wiki/Building_automation#cite_ref-1) ["BACnet alliance with Softdel Systems," 23 March 2006](http://www.automatedbuildings.com/releases/mar06/060324030005btl.htm)
* [Extending Building Automation Data Visibility Using OPC - Whitepaper](http://www.opcda.com/downloads/433/whitepapers/index.aspx)
* [Key Elements in Intelligent Buildings](http://xinca.com/elements-intelligent-buildings-4.html)