Integrated Controls & Monitoring System for Luxury Villas

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INTEGRATED CONTROLS & MONITORING SYSTEM FOR LUXURY VILLAS

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1 General

1.1 SYSTEM INTEGRATION

The System provider shall furnish and install a fully integrated Villa Controls & Monitoring System, incorporating distributed control techniques and standard open communication networks. The system shall be implemented as an integrated, open solution, which enables Service Center connectivity through standard Building Operating System (BOS) interface.

The functionality shall include the following subsystems:

- Cooling control
- Ventilation control
- Control of pumps
- Consumption measurements of water, electricity, gas and cooling energy
- Lighting control
- Curtain control
- Irrigation control
- Other electrical controls
- Leakage/moisture alarms
- Smoke/heat alarms
- Gas alarms
- Access control
- Intruder alarms
- Camera surveillance and digital video recording
- IP intercom (optional)
- Audio/video system (optional)

All systems shall be integrated with the open Building Operating System (BOS) platform as described in the System Architecture. The BOS shall provide standard connectivity to the Service Center, which shall be capable of providing advanced maintenance and security services.

1.2 USER INTERFACES

The villa owner/user shall be able to use the system easily with a graphical browser-based User Interface, using touch screen panel PC's, tablet PC's, IPTV, home computers, laptops, PDA's and mobile phones. The User Interface shall comply with requirements defined in the System Architecture.

The browser-based User Interface shall be generated automatically and shall utilise latest web technologies, such as AJAX. The user interfaces shall provide easy access to frequently needed functionality, such as lighting controls, temperature setpoint modifications, alarms, and configuration of scenes and modes of the residence (e.g. home/away). The same user interface functionality shall be usable through any device with a browser.

The User Interface shall allow for at least the following actions:

- Changing the mode of the home (e.g. home/away/party)
- Modifying the mode settings of the controlled devices
- Changing the setpoints
- Modifying the control settings (e.g. dimming level)
- Manual controls
- Door controls
- Camera views
- Alarm list browsing

Villa systems shall be accessed through the Building Operating System (BOS).

The system shall also enable a client-based User Interface for professional usage and for central monitoring of systems (Service Center usage). The professional User Interface shall allow for at least the following:

- Alarm monitoring and alarm handling by multiple operators
  - Intruder alarms
  - Fire alarms
  - Alarms from electrical and mechanical systems
  - System maintenance alarms
  - Video monitoring
- Remote diagnostics, energy optimization and trending
  - Setpoint adjustment
  - Control optimization
  - Peak load management
  - Trending
  - Remote diagnostics of system/devices
  - Preventive maintenance
  - Consumption reports for energy management and billing
- Logs and reporting
- User profile and role management
- Access rights management

The professional User Interface shall be implemented as a client application, which includes an automatically adapting tree structure of the building, building's parts, individual spaces, different systems and parts of systems. The tree structure can be used for navigation through the system.

All systems connected to Building Operating System can be accessed through the same graphical User Interface. The client software can be installed to unlimited number of remote computers or laptops. The client software shall allow for remote Internet usage of several sites using the same client.

The professional User Interface shall show system views, floor plan views, trend view, alarm view and event log view per building and system layer. Any alarm shall be shown in red color in both graphical views and tree structure. Each alarm message shall include shortcut to relevant graphical system and floor plan view.

1.3 SYSTEM ARCHITECTURE

The System Architecture shall consist of three levels:

- Control Level
- Management Level
- Service Level

The system offered shall be completely modular in structure and freely expandable at any stage. Each level of the system shall operate independently of the next level up as specified in the system architecture. For example, Control Lever shall operate independently without support from Management Level.

The system shall be fully consistent with the latest industry standards. To enable efficient functional system integration and to provide maximum flexibility and to respond to changes in the building use, the system offered shall support the use of LonWorks, Ethernet TCP/IP and Internet communication technologies.

1.3.1 Control Level

The Control Level shall consist of a distributed network of smart control nodes, which are connected to LON field bus. Nodes shall include all the intelligence of the system. Each node shall be capable of handling several different systems in parallel through flexible distribution of I/O points. Nodes shall be capable of operating autonomously independently of Management Level. For example, all systems must be able to react to alarms on the Control Level without interference from upper levels. All communication shall be event based.

1.3.2 Management Level

Management Level shall provide a uniform view to all systems through the open Building Operating System (BOS) platform. All the systems - controls of cooling, ventilation and lighting, consumption measurements, access controls, intruder alarms, fire alarms and DVR systems - shall be integrated with the BOS using device drivers.

The BOS shall offer at least the following common services to be used by all connected systems:

- Alarms
- Historical trending
- Logs and reporting
- User profile and role management

To ensure fault-tolerant system functionality, the Management Level shall not be responsible for any controls. The Control Level shall function independently also without the Management Level. The Management Level shall enable existence of Service Level as specified herein.

The BOS shall collect trends from defined points, collect and forward alarms from the systems. The BOS shall enable efficient management of user rights. The BOS shall be capable of forwarding alarms to mobile phones using SMS, local alarm printers or to Service Center. It shall be possible to browse the alarm history for reporting and statistical purposes.

BOS shall provide standard connectivity to the Service Center, which is capable of providing advanced maintenance and security services.

The BOS shall include a structured XML object model of the building, its parts and spaces, its connected systems, system parts and effect areas of each system. The XML object model shall comply with COBA XML schema.

The BOS shall include an open interface for other applications to interact with the connected systems. Communication method between BOS and Client applications shall include at least Java Messaging Service (JMS). No other primary interfaces are recommended. Web interfaces shall be used for light-weight clients, e.g. automatically generated browser-based user interfaces in residences for Panel PC's, PDA's or IPTV.

The network technology shall be based on the IT standards, such as TCP/IP, and be compatible with latest LAN/WAN technology. The operating system of the BOS server must be Linux. The BOS shall be capable of supporting current and future building management protocols through implementation of network interface drivers. The BOS shall be capable of current and future systems and devices through implementation of device drivers.

1.3.3 Service Level

Service Level shall allow the systems to be connected without additional software to one or several Service Center(s), for providing centralized remote monitoring, alarm and fault detection of connected building management and security systems.

The Service Center shall be capable of accessing remotely the systems through a standard interface through the BOS platform. The standard connectivity shall enable providing advanced maintenance and security services, such as security alarm monitoring, maintenance alarm monitoring, remote diagnostics, main user capability, remote control and optimization of all systems, energy optimization, trending and reporting services.

The Service Center shall support connectivity of multiple sites in multi-operator environment. Predefined alarms from connected sites – e.g. intruder alarms, dirty filter notifications or leakage alarms, for example – shall appear in the alarm list with a specified priority. Alarms shall be stored in the central database.

Remote diagnostics of site systems and devices shall enable proactive maintenance of technical systems, energy optimization and efficient management of the infrastructure. Centralized monitoring of all

connected sites with main user capability shall enable e.g. set point changes, manual overdrives and camera controls by using the remote connection.

2 Home Automation System

Home Automation System - including cooling control, ventilation control, lighting controls, curtain controls, irrigation control and other electrical controls, consumption measurements, access control, intruder alarms, smoke/heat alarms, leakage/moisture alarms, gas alarms, cameras and video monitoring, IP intercom and audio distribuition - shall be integrated using the Building Operating System (BOS) as the integration platform. The BOS shall provide functionality as described in the System Architecture.

2.1 MODES OF RESIDENCE

Home Automation systems shall be functionally integrated. All systems shall react to pre-defined modes, as well as occupancy information and other conditions as applicable. Villa systems shall be controlled through the following modes: Home, Away, Away (long), Night and Party. All systems shall react to these modes adjusting automatically into the predefined configuration. Modes are turned on through indication from access control system and through dedicated push buttons. Modes shall enable functionality as described in the following.

- **Home:** When arriving home and showing the access control tag and/or finger to the access reader, the following takes place automatically: Burglary alarm system is turned off, doors are opened, ventilation becomes need-based instead of minimum level, set point of cooling is at the optimum level, and the default lighting scene and music is automatically switched on.

- **Away:** When leaving the residence, the following takes place automatically, with one single button touch: Doors are locked, burglary alarm system is turned on, ventilation is turned down, set point of cooling is allowed to be higher to allow for energy savings, and all lights and speakers are automatically switched off.

- **Away Long:** When leaving the residence for a longer time, the following takes place automatically, with one single button touch: Doors are locked, burglary alarm system is turned on, ventilation is turned down, set point of cooling is allowed to be much higher than normally to allow for energy savings, all lights and speakers are automatically switched off.

- **Night:** With one single button touch from the master bedroom the house is set to night mode. Doors are locked and cover protection system is activated. Adequate cooling and ventilation are ensured especially in the bedrooms. Only selected lights stay on as night lights, all others are turned off.

- **Party:** Apartment is cooled and fresh air is produced more efficiently than normally. Specially selected party lighting scenes, music settings and other special settings can be applied.

Alarms shall be shown on the Central User Interface of the facility and forwarded to Service Center, when applicable. Alarms can be also forwarded to defined GSM phones.

2.2 DISTRIBUTED INTELLIGENCE

The intelligence of the systems shall be distributed into Smart Control Nodes, which are connected to LON field bus. The following systems shall be monitored and controlled by Smart Control Nodes: cooling, ventilation, lighting, curtains, irrigation, consumption measurements, intruder alarms, smoke/heat alarms, leakage/moisture alarms and gas alarms.

Smart Control Nodes must be commonly used during past 10 years not only in homes but also in large scale commercial facilities, such as offices, business centers or hotels. Control nodes, which have not been used in large scale implementations are not acceptable.

It shall be possible to integrate the systems on Control Level without interference of Management Level, according to System Architecture.

Communication between Smart Control Nodes shall be peer-to-peer communication via a Free Topology (FTT-10) Local Operating Network (LON) with the Standard Network Variables Types (SNVT). All communication shall be event based. Nodes shall be intelligent modules, capable of operating autonomously independently of Management Level. For example, all systems must be able to react to alarms on the Control Level without interference from upper levels.

Each node shall have about 10 I/O points to achieve maximum reliability and flexibility. Each node shall be capable of handling several different systems in parallel through flexible distribution of I/O points. The I/O points of the Control nodes shall be as follows:

- DI: Digital indication, from potential free contact
- DO: Digital control, open collector
- AI: Analog input, standard measurements 0-10 VDC, PT1000 or Ni1000-LG.
- AO: Analog control, 0-10 VDC or 20 mA

The Control nodes shall include PID controllers and ON/OFF (thermostat) functions for implementing the control loops used in engineering system process controls. Logical functions shall be implemented using configurable software objects in the Control nodes.

Field devices are connected to Control nodes using the common industry standards:

- PT-1000 for temperature
- 0-10 V for other sensors and actuators
- Potential free contacts for ON/OFF indications and push buttons
- 24 V relays for ON/OFF controls
- Impulses for consumption measurements

To guarantee openness, flexibility and cost-efficient maintenance of the integrated systems, the field devices shall not include independent control logic.

Control nodes are placed to the nearest electric cabin, side of air-handling units or in separate cabins when adequate. All systems shall use the same control network cabling, which uses free topology to maximize flexibility for future modifications and to minimize the need for cables. Electrical design utilizes free or star topology cabling to maximize flexibility for changes and to minimize the use of cables.

2.3 COOLING AND HEATING ENERGY CONTROL AND MONITORING

Cooling energy shall be produced centrally and distributed to the villas via district cooling network. Each villa shall have Heat Exchanger (HEX). Control valve at primary side shall be controlled so that supply temperature for secondary side supply network is kept at set point. This set point is curve compensated by outdoor temperature and increased or reduced depending on the mode of the residence (home/away/etc). This enables maximizing of return temperatures at secondary and primary sides and will increase operating efficiency of central chillers.

It is recommended to produce hot water from waste heat of chillers with heat pump and distribute and control it the same way as chilled water. This hot water should be used in each villa for heating domestic hot water, reheating the supply air at Air Handling Unit and heating supply air at duct mounted zone heating coils.

Cooling and heating systems shall be monitored and controlled by Smart Control Nodes, which are connected to LON. Heating and cooling energy consumptions will be measured as explained later in this specification. Cooling controls shall be integrated with ventilation controls, lighting controls, security systems and fire alarm system as specified in the System Architecture. Cooling controls shall be integrated with BOS.

2.4 HVAC CONTROLS

2.4.1 Air Handling Unit Controls

Each villa shall include an Air Handling Unit (AHU). The AHU shall bring fresh air into building, cool and dry the supply air and filter particles from the indoor air. The Air Handling Unit shall consist of fresh air

and return air dampers, filter section, cooling coil, reheating coil and variable frequency driven fan. AHU shall be equipped with Variable Frequency Drive (VFD) driven rotating Cooling Recovery Unit to maximize energy savings. The Air Handling Unit shall provide clean, dry, cooled air for Variable Air Volume (VAV) dampers, which control the indoor climate in each zone of the villa.

The Air Handling Unit shall be controlled according to temperature, relative humidity, carbodioxide (CO2) measurements and modes of the residence as explained in the following.

Air handling controls shall be integrated with cooling controls, lighting controls, security systems and fire alarm system as specified in the System Architecture. Air handling controls shall be integrated with BOS.

2.4.1.1 Temperature control

Temperature of the supply air is measured and kept in the predefined setpoint by controlling the valves of the cooling coil and the reheating coil in the Air Handling Unit. Reheating coil valve is enabled only when relative humidity control is overcooling the air. Supply and return air temperature setpoints are varied depending on the mode of the residence (home/away/night etc). For example, in Party mode the setpoints are very low, in the Home mode it is reasonably low, and in Away modes the setpoint is much higher to save energy. Deviation from the return air setpoint is used to increase or decrease the supply air setpoint. The predefined setpoint is deviated according to prevailing outdoor temperature. For example, when the outdoor temperature is very high, the deviated setpoint is a few degrees lower, and when the outdoor temperature is low, the deviated setpoint is a few degrees higher. The purpose is to keep air amounts similar in different outdoor conditions to avoid draught or excessive noise in the residence.

2.4.1.2 Humidity control

Relative humidity of the supply and return air is measured. Relative humidity of return air has a predefined setpoint. This setpoint is used to select the setpoint of supply air relative humidity (PID control with linear compensation). Supply air relative humidity is kept in this setpoint by controlling the valve of the cooling coil.

2.4.1.3 CO2 control

Amount of fresh air intake is controlled by measuring carbondioxide (CO2) level from supply air and controlling proportionally fresh and return air damper positions. This guarantees freshness of supply air and minimizes energy consumption.

2.4.1.4 Fan speed control

Fan speed is controlled by controlling Variable Frequency Drive (VFD) by measuring pressure difference in the supply duct. Setpoint of pressure difference is varied based on the mode of the residence (home/away/night etc). For example, in Away modes the pressure setpoint will be lowered to save energy. If any of the VAV dampers is fully open, the pressure difference setpoint will be increased, and if maximum damper position of all dampers is no more than 80%, the pressure difference setpoint will be lowered. Alarms from fan and VFD shall be monitored.

2.4.1.5 Air filtration monitoring

Air Handling Unit shall be equipped with High Efficiency Particulate Air (HEPA) filter with eSorb capability. Filters will be equipped with charger and UV-light. HEPAeSORB filter must be able to filter both particulate and gaseous contaminants efficiently with low pressure drop. This will provide healthy indoor air by preventing particulate matter, VOCs, ozone, odours, bacteria and viruses from entering the room air. Low pressure drop and long and long loading capacity will provide low operating cost. Filter shall be monitored via pressure difference sensor. Alarm limits shall be sliding according to fan speed.

The HVAC control system shall optimize the indoor air quality by ensuring adequate amount of fresh air, taking into account the mode of the residence (home/away/etc), occupancy information and the prevailing levels of carbondioxide (CO2) and relative humidity. Default settings shall be possible to modify using the browser user interface.

2.4.2 Zone Controls

The target of zone controls is to optimize indoor conditions in each zone by controlling the VAV damper and the control valve of duct mounted post-heating coil. The VAV damper position and control valve are adjusted to maintain excellent indoor air quality, by optimizing temperature, relative humidity and carbondioxide concentration.

2.4.2.1 Temperature control

The temperature of each zone is controlled by measuring the space temperature and adjusting the incoming air amount through VAV dampers, in order to keep the temperature at the setpoint. For example, when the space temperature exceeds the setpoint, the VAV damper opens accordingly to provide more cool air.

2.4.2.2 Humidity control

To reach the target level (setpoint) of relative humidity in each zone, the air amount will be increased through adjusting the VAV damper opening according to measured relative humidity of the return air. When dehumidification control takes over VAV control the control valve of post-heating coil is enabled and temperature control will open heating control valve, if the space temperature lowers below the setpoint more than hysteresis.

2.4.2.3 CO2 control (in living room, dining room, reception, etc)

To reach the target level (setpoint) of carbondioxide (CO2) concentration in each zone, the air amount will be increased through adjusting the VAV damper opening according to measured carbondioxide (CO2) concentration of the return air. When CO2 control takes over VAV control the control valve of post heating coil is enabled and temperature control will open the heating control valve if space temperature lowers below the setpoint more than hysteresis.

2.4.2.4 Dew point control

Dew point calculation method is used in order to avoid condensation of water in the terminal equipment of zones. The dew point of each zone is calculated according to space temperature and the relative humidity of return air. The dew point is given as the setpoint for the zone supply air temperature control. When the temperature of the supply air is lower than the setpoint (i.e. dew point), the post-heating coil valve is opened accordingly.

2.5 LIGHTING CONTROLS

Lighting shall be controlled by by Smart Control Nodes connected to LON field bus. Lighting controls shall be integrated with other automation and security systems. Lighting groups are on/off controlled and dimmed as follows:

- Using local push buttons (on/off, on/off/up/down, lighting scenes)
- On movement detection (occupancy)
- Based on illumination level (dusk)
- Time schedules
- In connection with modes of the residence
- Using the browser user interface

Lighting controls shall be integrated with BOS.

2.6 CURTAIN CONTROLS

Curtains shall be controlled by by Smart Control Nodes connected to LON field bus. Curtain controls shall be integrated with other automation and security systems. Curtains can be opened/closed as follows:

- Using local push buttons (open/close)
- Based on illumination level
- Time schedules

- In connection with modes of the residence
- Using the browser user interface

Curtain controls shall be integrated with BOS.

2.7 CONSUMPTION METERING

Consumptions of water, electricity and cooling and heating energy shall be measured in each villa. BTU meters shall be connected direct to control network using LON or MBUS. Water and electricity meters shall be equipped with impulse outputs. Impulse outputs are connected to Smart Control Nodes, which are connected to LON. All consumptions shall be trended into BOS's database for generating regular consumption reports.

2.8 LEAKAGE ALARMS

In case of leakage or moisture the system gives an alarm, which is relayed through BOS to Service Center and to specified mobile phones. Service Center checks the alarm and forwards a request to maintenance company, if necessary.

2.9 GAS ALARMS

In case of leakage of gas the system gives an alarm, which is relayed through BOS to Service Center and to specified mobile phones. Service Center checks the alarm and forwards a request to maintenance company, if necessary.

2.10 FIRE ALARMS

Fire alarms shall be generated upon detection of smoke/heat. The alarms shall be relayed to BOS, shown in the integrated graphical user interfaces and forwarded to Service Center for further actions. Service Center checks the alarm and forwards a request to the closest service person and/of civil defence, when necessary. It shall be easy to identify false alarms, because all the zone temperature measurements shall be possible to view from integrated user interface. Ventilation is shut down in the area concerned.

2.11 ACCESS CONTROL

Access control shall be implemented with proximity readers, control nodes, electronic keys and electronic locks. Users are classified so that they have access only to the spaces they are allowed to enter. The access control system is connected to BOS for full control and reporting and integrated into graphical user interface.

Access control system shall be integrated with cooling and ventilation controls, lighting and curtain controls as well as with other security systems using the Building Operating System (BOS) as the integration platform. Access rights can be managed centrally from the Service Center.

2.12 INTRUDER ALARMS

Intruder alarm system shall include cover protection and indoor surveillance. Intruder alarm system includes cover protection and indoor surveillance. Doors and windows are monitored with magnetic contacts. Movement detection with presence indicators are also used for indoor surveillance. Movement detectors shall be sensitive enough for presence detection of a single person, so that they can also be used for lighting controls and air-conditioning controls.

In case of burglary the system gives an alarm, which is relayed through BOS to Service Center and/or to specified mobile phones. Granted access disarms the alarm zones automatically. Arming the zones change automatically the mode of the residence into Away mode. Intruder alarms shall be integrated with cooling and ventilation controls, lighting and curtain controls as well as with security systems using the Building Operating System (BOS) as the integration platform.

2.13 VIDEO MONITORING

Camera surveillance shall be implemented with conventional digital and IP-cameras. Camera surveillance shall be implemented with Digital Video Recording (DVR) system. The DVR system shall be integrated to BOS server so that e.g. an intruder alarm event can trigger DVR recording and prerecording or other functions. Usage can be done both via DVR system's own User Interface Client and the integrated User Interface of the BOS. When equipped with DVR, the system shall record digital images of events caused by intruder alarm system, access control, CCTV or any other system integrated to BMS.

2.14 IP INTERCOM

2.14.1 Internal IP calls

It shall be possible to integrate IP Intercom with BOS. Usage can be done both via the integrated User Interface of the BOS and conventional IP phones. The system shall enable IP calls inside the villa.

2.14.2 Door Intercom

The door intercom shall convey the door camera picture to the BOS User Interface in the touch screen(s). Upon doorbell ring the system shall initiate door camera view in the BOS User Interface. The user can then open two-way audio connection between the door unit and the touch screens, and open the door using the touch screen.

2.15 AUDIO/VIDEO SYSTEM

Selected spaces (e.g. living room, master bedroom) shall be equiped with media server for audio and video. The server shall be able to connect other network resources such as centralized media library located on Network Attached Storage (NAS). Media server controls shall be possible to integrate with BOS. Usage of the system can be done both using audio system's own User Interface on TV, remote controller and the integrated User Interface of the BOS. User shall be able to use same user interface to control media server and BOS connected systems e.g. lights, room temperature and cameras.

------END OF SECTION------