Tools for the Implementation of an Inmotic System in the Imperial Hotel in Santiago de Cuba, Cuba

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Abstract. Given the inefficiency of the control systems present in many hotels in Cuba and the need to automate and intelligently manage the electrical energy of the Imperial Hotel in Santiago de Cuba, the design and implementation of an imotic control using Tac technology is carried out View of Schneider Electric. The implemented system has a decentralized, scalable, modular, sustainable, and upgradeable architecture, which allows migrating to other similar or superior technological variants if necessary. In the design and implementation of the system, the different field sensors, the programmable robots, and the specific purpose controllers were selected, which communicate through Lonworks and TCP/IP protocols with the SCADA created using the Tac Vista 5.1.9 software. As a result of the investigation, the supervision and control of the lights, the bathroom odor extractor, and the temperature in the rooms are achieved. In addition, the automatic control of the lights in the corridors and exterior areas of the hotel is achieved, and finally, the sequence of automatic switching on or off of the air conditioning units in the lobby and restaurant respectively is programmed. All this leads to greater comfort, energy savings, and quality of the services provided, which at the same time becomes a tool for the management of the hotel by the people in charge.

Keyword. Automatic, sensors, control systems, controllers.

1. Introduction

Because in Cuba the main source of income to the country's economy is tourism, it has become necessary to build new hotels and modernize existing ones [1, 2]. The main tourist areas of the country are present in cities such as Havana, Varadero, Holguín, and the northern keys of the center of the territory, being served by national and foreign companies such as Gaviota, Cubanacan, Gran Caribe, Meliá, among others [3, 4].

In [2] the design of an inmotic system capable of achieving automation of the residential blocks of the 5-star Hotel plus Santiago de Cuba is carried out, where the networks used, their architecture, and topologies based on a distributed system where structured cabling is described Horizontal is achieved.
with UTP twisted pair and vertical cabling with optical fiber, as control elements programmable logic controllers and different field elements are used for the measurement and execution of control actions where supervision is carried out through a SCADA. In [5] a prototype of an automated system to open or close blinds or curtains that allow natural light to enter the rooms of a building is developed using a logical and electromechanical architecture for its operation, comparing the advantages of this method with the traditional.

In [6] a study of energy saving in different spaces using the Unified Modeling Language (UML) and the simulation of multiple agent systems is presented. The work demonstrates the benefits of using artificial intelligence and modern information and communication technologies for energy management.

Furthermore, in [7] an architecture is proposed that uses the Internet of Things (IoT) to control buildings using free technologies.

In [8] an automation system is designed and implemented to control the processes within a solar conversion unit using a programmable logic controller from Schneider Electric. Finally, the startup, operation, and shutdown sequences could be solved in safe conditions, as well as monitoring the working parameters of a Stirling motor together with a solar concentrator to increase the energy efficiency of the installation.

The Imperial Hotel is a majestic building that is located in the central Enramadas street in the center of the city of Santiago de Cuba and is considered one of the jewels of the city's architecture, figure 1. This hotel has just been subjected to a capital maintenance process, which took into account the current state of the hotel situation in the province and the country, and which also met international standards in terms of beauty and comfort. The Hotel is made up of a lobby bar, three living floors with a total of 42 rooms, including 3 suites and one room for the disabled, it has a Snack-Bar-Grill and a Roof Garden.

![Figure 1. Vista del Hotel Imperial. (Source: https://images.app.goo.gl/ouUHuNkNeW42Td379)](https://images.app.goo.gl/ouUHuNkNeW42Td379)

In the Imperial Hotel, although all the luminaires installed in the common areas use Led technology, they are switched on and off utilizing on / off switches, so these luminaires are switched on in the afternoon and switched off in the morning. The same happens with the luminaires inside the rooms, which will remain on if the guest does not decide to turn them off.

The air conditioning systems installed in the 42 rooms are multi-split, that is, with a single compressor, more than one space can be air-conditioned. These Split have their temperature regulation using a thermostat that sends a signal to the compressor when it reaches the temperature selected by the host. This system works correctly, but it is not very efficient, since the guest can leave the room and leave the air conditioning on, spending energy unnecessarily.

A common in this Hotel, as in most Cuban hotels, the odor extractor systems in the bathrooms are directly connected to the switch that controls the lighting on and off, so its operation is conditioned to the luminaire remaining On, and once it is turned off, the extractor stops, even if it has not evacuated all
odors. Practice is that the host leaves the luminaire on so that the extractor continues to operate, which causes unnecessary expense and excessive use of the equipment [4].

Based on the particularities of the Hotel and the knowledge of the working modes of its systems, strategies were designed to ensure that the proposed inmotic system fulfilled the task of automatically turning the lights on and off, depending on the presence of people in the room, that conditions the operation of the air conditioning to the presence of people and that, in addition, the control of the bathroom odor extractor does not depend on the switch that controls the lighting on and off. On the other hand, it is necessary that the system achieves the automatic on and off of the luminaires in the interior corridors depending on their use, as well as achieving control of the lighting of the exterior façade lamps depending on the level of existing lighting, or the schedule of the day. Finally, and of great importance for the saving of energy carriers, the sequential on and off of the air conditioners is required automatically.

2. Materials and methods

When analyzing the main technology manufacturers associated with the world of automation and control, which, in addition, had a presence in our country and complied with the requirements of Cuban standards for the construction and automation of hotel facilities, the technological solution was chosen that best suits the specific needs of the hotel [4], in this case, the TAC Vista of Schneider Electric.

The TAC Vista is a building management system that allows you to monitor and control different systems, such as lighting, access control, security, among others. Based on the Lonworks open protocol, it is among the most adaptable systems in the industrial sector and with simple computer technologies. Its open architecture enables seamless integration with third-party products and offers full interoperability.

The TAC Vista supervision and control system controls and manages the hotel's automation system, facilitating the functions of the graphic display of processes, automatic alarm distribution, and a wide range of different data analysis functions [9, 10, 11, 12]. It is a distributed system composed of 3 levels of hierarchy, figure 2.

- Supervision Level (1): Central Supervision and Control System supported on the SCADA “TAC Vista 5 with Terminal application Server, Workstation and Webstation, communicating with Router CEA-709 / IP-852, communication gateway with LON protocols and Modbus over Ethernet TCP / IP, which allows the integration of Xenta controllers in the management system.
- Control Level (2): Xenta 121 FC parameterizable controllers and Modicon M241 programmable controllers that carry out distributed control of the hotel.
- Field instrumentation level (3): Group of sensors and final action elements that act directly with the processes to be controlled and supervised.

![Figure 2. Automation pyramid at the Hotel Imperial](image-url)
2.1. Protocols and Topologies

The communication configuration between the different hierarchy levels is made up as follows: a central computer with the TAC Vista 5 software as supervisor and rector of all the systems; all rooms use the TAC Xenta 121 as a controller, which is a parameterizable specific-purpose controller, where the presence sensors, door and window contacts are connected, as well as the STR150 temperature sensor [13, 14, 15, 16, 17, 18].

All these room controllers are connected via a Lonworks network and reach a RouterCEA-709 / IP-852 placed on each floor, which performs the function of a gateway and transmits via Ethernet to SCADA [19, 20, 21, 22, 23]. The other systems are governed by an M241 PLC that communicates via Ethernet with SCADA [24, 25, 26, 27, 28, 29, 39]. Figure 3 shows the communication network implemented in the hotel.

2.2. Control of systems in rooms

The objective of the automatic system in the rooms is to control the lights, the bathroom exhaust fan and turn the air conditioning on or off once the desired temperature is reached, with the premise of achieving and maintaining comfort parameters, as well as controlling energy consumption rates of the installation to optimize operating costs and extend the life of the equipment. In the rooms, the temperature and the presence of people in it are taken as variables to measure, in addition, the state of opening of doors and windows is taken into account. The devices on which the controller operates are the lights in the room, the power in the outlets, and the switching on or off of the air conditioning compressor, see figure 4.
The rooms have the Xenta 121 specific purpose parameterizable controller, to which the signal of the Argus 360o presence system is connected. Bticino magnetic contacts detect the opening of doors and windows and also send the signal to the Xenta 121 FC controller. For the control of the bathroom extractor, it has an iRTC time relay A9E16067, parameterizable from 0.1 seconds to 100 hours.

The room temperature is measured and indicated through the temperature sensor with display STR 150, this sensor is the one that sends the SCADA the temperature values that are displayed in the mimics. Figure 5 specifies the location of the sensors within the rooms.

2.3. Xenta 121 FC Controller Operating Modes

The Xenta 121 FC Specific Purpose Controller has three basic modes of operation and a set of programmable exceptions:

1. Busy: When the presence sensor detects that there are people, the controller automatically goes into busy mode. In this state, it is not operated on any control element, it will be the guest who
decides at will if he wants to turn the lights on or off. The control of the air conditioning is carried out through the same multi-split equipment, where the guest can choose the temperature they want, this temperature is displayed on the SRT 150 wall module and sent to SCADA.

2. Unoccupied: This mode is activated once the time set in the controller has elapsed without the presence sensor having detected people in the room. In this state, it is actuated on a control contactor that is located in the electrical distribution box in the room, deactivating the main circuit that controls the bedroom lights and outlets. The room temperature setpoint value is also changed to 26 °C. To exit this state, it is necessary to activate the presence detector or to open the door.

3. Standby: This mode starts when the controller has been in idle mode for the time programmed in the controller. In this mode, the temperature setpoint value is changed again up to 28 °C. The controller exits this mode once the presence sensor that detects the presence or the magnetic contacts is activated.

Exceptions are special cases of equipment functionality and are configured to support basic operating modes and maintain comfort parameters. Depending on one or more conditions, they act to activate or deactivate Xenta 121 outputs, send parameters to SCADA, among others. The block diagram corresponding to the operation of the sample controller in Figure 6.

![Figure 6. Block diagram of the operation of the Xenta 121](image)

2.4. Lighting control in corridors

The control system for turning the luminaires on and off in the corridors uses 4 presence sensors of the type MGU3.524.18 and is designed to satisfy visual needs, creating healthy, safe, and comfortable environments. The system works in such a way that if it detects presence, the lighting circuit is activated, and then, after a time of 1 minute without detecting any presence, the circuit in question is turned off. This time can be modified in SCADA. The block diagram is shown in Figure 7.
2.5. Control of external lights

For the control of the external lighting, a redundant control system has been designed, taking as a measurement the signal of two SLO300 luminosity sensors that are located in the East and West parts of the hotel, respectively, and taking into account the schedule in which said lighting is carried out.

Depending on the signal from these sensors, the system will be able to turn on the outdoor lights at night, and on days when the level of natural light is not optimal, generally on very cloudy or rainy days. Figure 8 shows the block diagram of the programming logic used to control the external lighting.
2.6. Control and monitoring of air conditioners

Large fan coils are called air conditioners or air handling units (UTA). This equipment controls the temperature of a room and is used in large spaces such as meeting rooms, hotel lobby, restaurants, among others.

The Imperial Hotel has two air conditioners used in the Lobby and the Restaurant. Each of them has its temperature control so it was not necessary to control this variable, however, this logic was brought to the PLC to automatically turn it on and off, waiting for the command signal sent from the control board, as shown in Figure 9. The operating states of the compressors and fans of both air conditioners are represented in the SCADA, allowing it to change the on/off status.

![Figure 9. Block diagram of the air conditioning on/off control](image)

3. Results and Discussion

The hotel's SCADA communicates through an Ethernet network, created specifically for the implemented imotic system and which is physically separated from the hotel's work network, thus accessing the different PLCs installed on the different levels of the building. The Xenta 121 FC controllers communicate through a gateway that converts the Lonwork network into an Ethernet network, in this case, they are assigned an IP address to achieve communication between them, Figure 10.
3.1. Supervision and Control System

The SCADA created for the supervision and control of the system is made up of a group of screens that represent the different systems of the hotel, which allow remote management from a control room of the different variables. The SCADA is in charge of managing a total of 546 variables distributed in the PLCs and Xenta 121 controllers. Table 1 shows the distribution of the variables by equipment and hotel levels.

| Floors          | PLC variables | Variables Xenta 121 FC | Total Variables |
|-----------------|---------------|------------------------|-----------------|
| Lobby           | 45            | 0                      | 45              |
| First           | 33            | 126                    | 159             |
| Second          | 33            | 126                    | 159             |
| Third           | 33            | 126                    | 159             |
| Roof Garden     | 24            | 0                      | 24              |
| **Total**       | **123**       | **378**                | **546**         |

When starting the application, user authentication is necessary because different levels of the hierarchy have been established and only authorized users can change parameters. It is accessed through the screen shown in Figure 11.
After accessing the hotel supervision and control system, the home screen shown in Figure 12 is displayed, which allows the user to navigate through the different links and also provides information on the status of the lighting, indicating in green that it is switched on.

![Figure 12. Home screen](image)

One of the main tasks of the research was to have a system capable of determining and displaying the electrical energy consumed in the hotel to keep a historical record and make comparisons with energy consumption before the implementation of the system. Figure 13 shows the screen that collects the value of the energy consumed per hour, day, month, and year.

![Figure 13. Energy consumed window](image)

4. Conclusions

The solution provided has been designed so that it works continuously and efficiently, in addition, with the decentralized topology, each system has its independent controller, guaranteeing that, in the event of a fault in one of them, the rest of the systems continue to work uninterruptedly.
All the devices and elements used to belong to the same Tac Vista family, allowing full compatibility between them. On the other hand, the controllers used in the rooms have the same programming, this guarantees their replacement and reprogramming in a short time.

The supervisory system allows us to know about what is happening in the hotel in real-time and to make timely decisions if required. The technical staff has software that allows you to navigate through the different systems of the hotel and that shows their current states. From SCADA you can control and change different parameters of the system, activate the circuits that control the corridor lights, set the waiting times, and know if any of them are in electrical failure, among others. Furthermore, the lighting levels necessary for activating exterior lights and time controls are easily configurable from the supervisory system screens, without the need to reprogram any controller.

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