

Review of System Controller for Smart Homes/Building Applications

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Abstract—SCADA systems have been used during the last years in order to control and supervise industrial processes within a long distance, thus considerably reducing the loss of information, apart from offering a higher speed and security of data. Nowadays, due to the fast development of Internet of Things, of wireless communication and of electronics, a better efficiency in industrial processes has been established, this being possible due to the use of specialized protocols and software, which, have been able to expand to house and building applications because of the easiness of their programming protocol and graphic interface, together with a low cost. The objective of this work is to show the different and mostly used control systems for applications in houses and smart buildings.

Index Terms—communication protocol, SCADA systems, smart building, smart home, system controller

I. INTRODUCTION

The term SCADA (Supervisory Control and Data Acquisition) refers to software designed to remotely control industrial processes. It is very used nowadays to maximize the functionality in closed environments. SCADA networks are special networks for computer and other devices that look forward to control and supervise infrastructures and industries. They are integrated by data collection systems, data transmission systems and software for man-machine communication. These systems allow data input and output. Another application of these networks is the collection of data for textual or graphic deployment through a central computer. By doing this, it is possible to perform the control of processes remotely. SCADA networks usually consist of both software and hardware. Commonly used hardware consists of a “Master Station Unit (MSU)” or “Master Station” arranged in the control center, several “Sub-MSUs” or “Master Substations”, “RTUs” or “Remote Terminal Units” distributed in certain sites

in order to control sensors and actuators, and devices for communication between the equipment [1-6].

Certain SCADA networks do not use Sub-MSUs to make the connection, but direct connections are made between the Master Station and the remote devices. RTUs provide a direct interface for the monitoring and control of equipment and sensors, and the MSU is able to control the connected control stations. In general, remote stations have a local programming, so they are able to work independently of the MSU. The role of the MSU consists of the storing and processing of data inputs and outputs of remote units, while they remain in operation. The software used is programmed to inform the network which variable and how often that variable should be monitored, the range of expected values for each variable, and which response should be displayed when the parameters are outside the range of expected values. The different control systems have very similar forms of operation. The so-called “Distributed Control Systems (DCS)” are often used to centrally control distributed plants, unlike SCADA networks, that are used for areas with a greater geographic coverage. The communications in the DCSs are done through “Local Area Network (LAN)”, which provides a greater speed and confidence than the communication systems at a greater distance used by SCADA networks. The communication systems used by the SCADA networks are designed to solve problems of communication at a greater distance, such as the loss of information and delays caused by the equipment used. Due to the increasing use of SCADA systems, a migration to an IP-based communication systems has been occurring, leaving aside the serial communication model. Similarly, the used of wireless communication has increased [7-10].

It is necessary to first consider the construction of the communication software in order to be able to describe the function of the communication protocols. The communication software has the task of translating the inputs and outputs of the system into ones that are capable of being managed by the

hardware, in addition to supervising the transmission process [11]. Each layer limits what it reaches to encompass (all internal circles), and the functions it must provide to the next layer. These levels, as mentioned, are known as levels of abstraction or layers of software, and increase proportionally with respect to others according to their functionality [11]. For a layered communication software system, a protocol describes how communication is performed within each layer of the mentioned software, so a consensus is required on the part of all participants with respect to it. The protocol specifies the rules for dictating how to coordinate communication between the source and the target location within a layer. An interface, in turn, describes the services that a layer provides to the next layer, for example, how to request certain functions or the way of feed-backing the results [11].

Protocols are standards that guarantee the compatibility between the different equipment that can communicate, and these are established by international organizations. Among the various functions of the protocols the next ones can be found: establishing and terminating communication and sending, detecting, and correcting errors [12]. For the different SCADA systems there are about 200 different protocols. The most used protocols are MODBUS, DNP3 e IEC 60870-5-101 [13]. A protocol frequently used in wireless sensor network applications is Zigbee™. Zigbee™ is a good option to be used in this type of applications because it has a data transmission rate suitable for communication from sensors (250 kbps) [14].

A good criterion for choosing the protocol to be used in the network is that of the conditions of the environment, for example, if there is a network where connected equipment is left in the outside, or if these equipment is left inside a certain building. In addition, it will be necessary to consider certain technical aspects of the communication network, such as the frequency of transmission or the size of the information to be sent.

II. APPLIED CONTROL SYSTEMS

At present, due to the rapid development of IoT and the constant search to improve the efficiency of the industrial processes, and in order to develop more sophisticated levels of control, different equipment have been developed that fulfill these tasks. Also, the companies that develop these equipment's have implemented specialized software to facilitate the use of the equipment by diverse users.

The following are some of the control systems mostly used for their implementation in houses and smart buildings.

A. Mango™

Mango™ is an open source software developed by LXGroup™ that enables machine-to-machine communications, industrial control and monitoring networks, data acquisition and control (SCADA), home and building automation and energy saving applications. Mango™ allows the users to access and connect to networks for IoT through the use of different protocols, and even to do so simultaneously. In addition, it is possible to make recordings, graph data, program alarms and report information from sensors and other equipment that are connected to the network. Mango™ has an interface based in an internet browser, in Figure 1 an example of configuration of the graphic interface through the web browser is shown. All the registered information comes from the different equipment connected to the network, and is registered directly in the computer where the software installation was done, so that it is certain to have confidentiality in the data. As for Mango compatible computers, there are all those that can obtain information as long as they have a protocol driver. Among the different protocols that Mango™ can handle we can find Modbus™, BACnet™, OPC DA, Dallas 1-Wire, SNMP, SQL, HTTP, POP3, MBus, DNP3, OpenV y VMstat, among others [15].

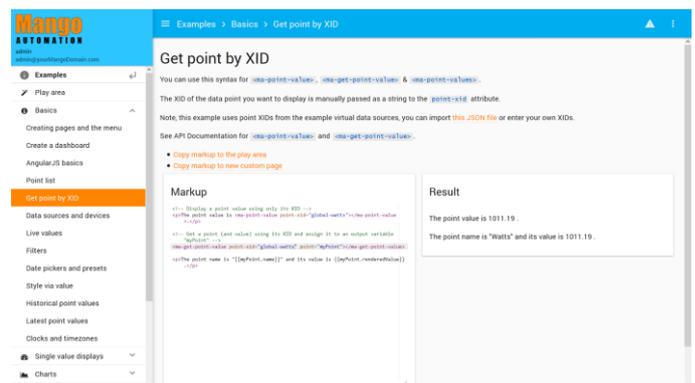


Fig. 1. Graphic interface of Mango™ software.

B. Niagara™

Niagara™ is software designed by the enterprise Tridium™, in the area of IoT that allows you to connect and translate information from different systems and equipment. This software is designed to adapt to the different markets, among the ones where the following can be found: inmotics, the industrial sector, smart cities and government agencies. In the area of inmotics, Niagara™ is used to create smart, more efficient and safer buildings, that are also energy-efficient and with lower costs of operation. Niagara™ allows the users to keep their initial investment in equipment and adapt them with the newer technologies, access and control various and diverse

systems through a standard web browser and combine information from different systems to facilitate information management.

System control is performed using the hardware platform called JACE™ 8000, in Figure 2 the controller designed by Tridium™ for the IoT market is shown. This controller has the possibility to connect to the Internet, and provides control, monitoring, data analysis, alarm configuration and network management. It has the possibility to perform data and graphics exchange, in order to display them in a web browser through an Ethernet or LAN connection, or even remotely through the Internet. The controller has the possibility of expansion of I/O ports, being able to operate even up to 16 modules. This controller operates with the software Niagara 4™, also developed by Tridium™. It has a 1 GB SDRAM memory, as well as a port for SD memory. It requires an electrical input of 24VDC.

This controller has the feature of being modular, in addition to having the ability to connect wirelessly. Its web interface was developed based on HTML5 [16]. In Figure 3 an example of the board of software Niagara 4™ based in HTML5 is shown.



Fig. 2. JACE™ 8000 Controller.

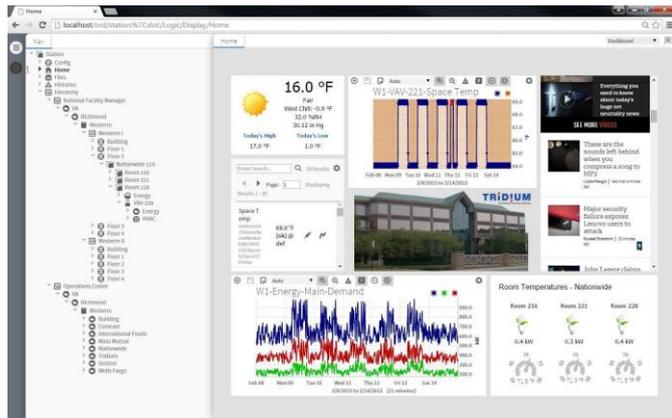


Fig. 3. Board of software Niagara 4™.

C. DGLux™

DGLux™ is software designed by the american enterprise DGLogik™, that allows the users to create applications and “dashboards” that make it easier for the users to interact with the information received by the different sensors and other equipment that are connected to the network. It is possible to access this software through the web browser and to develop the design of the graphical interface through DGLux5™, based in HTML5. Moreover, it allows to achieve communication with the rest of the systems through a series of standard preconfigured protocols like BACnet™ IP, BACnet™ MSTP, Modbus™ TCP, Modbus™ RTU, OPC DA, EnOcean™, Insteon™, SQL™, HTTP Retriever, HTTP Receiver, POP3 Email, among others. Figure 4 shows the data flow programming environment in DGLux5™ for an air conditioner system with the protocol EnOcean™ and in Figure 5 the way of selecting any desired protocol is shown, in order for the device to be able to communicate with the system.



Fig. 4. Programming interface of DGLux5™.

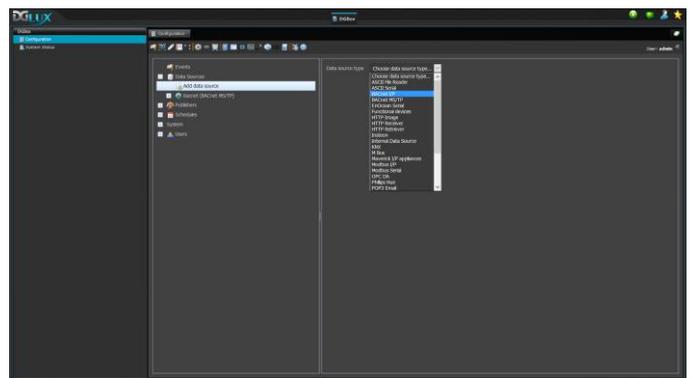


Fig. 5. Communication protocols for data acquisition.



Fig. 6. *DGBox™ Controller of DGLogik™*



Fig. 7. *ENVYSION™ programming interface.*

In the beginning, the enterprise DGLogik™ implemented the software DGLux™ using a controller known as DGBox™, through which it was possible to make the network connections and the interface design, although later they decided to stop the production due to some failures in the fabrication. In Figure 6 the controller is shown, which production was stopped in 2014. It is important to mention that in July 2016, the american enterprise Acuity Brands™ acquired 100% of the shares of DGLogik™ [17].

D. DISTECH CONTROLS™

DISTECH CONTROLS™ is an enterprise dedicated to the design and production of equipment focused in the area of inmotics and SCADA networks construction. These devices have an embedded software called ENVYSION™, which is an adaptation of DGLux™ for its use in DISTECH™ controllers. As it was mentioned before, the same as DGLux™, ENVYSION™ is a graphic design program based in HTML5 and a display interface, that allows the user to have a powerful and visual experience, it is possible to have access in any place, in any moment and in any device, which guarantees a timely response. It also permits to develop the design of the interface through a web browser, and facilitates the read of data coming from equipment such as sensors through the implementation of graphs, tables and other graphical resources.

ENVYSION™ comes in as a really attractive software in the visual aspect due to the integrated widgets and other 2D and 3D models of certain equipment commonly used in the industry. This software is easily visible in other devices like tablets or smartphones, due to the possibility of developing responsive interface designs [11]. Figure 9 shows the programming environment of ENVYSION™.

ENVYSION™ finds itself embedded in the ECLYPSE™ controller, with a modular and scalable platform that provides connectivity through BACnet/IP, wireless and cable IP, as well as having an automation control and a connectivity server, power module and I/O extension modules.

E. ECLYPSE™

ECLYPSE™ is a programmable controller, and provides advanced functionalities like a logical configurable control, web based design and a display interface (because of it having the ENVYSION™ software embedded), credential authentication, and alarms and tasks programming. In general, among the typical applications of the ECLYPSE™ controller, it can be found to serve as a controller for ventilation units or as a small server for buildings and other equipment.

In relation to the system of communication, the controller can communicate through IP to achieve higher speeds, in programming tasks, configuration, creation and display of graphics. Additionally, there is the possibility to carry out the connection of a Wi-Fi adapter to the controller, looking forward to make it able for the user to connect remotely to the controller using a laptop, for example.

The ECLYPSE™ controllers are protected in case of a bad wiring, thus protecting the equipment. The electrical power supply module has an output protection in case of an overload of either voltage or current. The I/O modules have LEDs that indicate the state of the used outputs or inputs, aiming to make the interaction with the equipment easier. The functionality of modularity is easy in these controllers because they have HD-15 connectors, which power and connect the modules. The controller is shown in Figure 10.



Fig. 8. *ECLYPSE™ Controller.*

III. CONCLUSION

The ever increasing use of devices that are able to provide some kind of digital information regarding any aspect of our daily lives, such as sensors, has been the promoter of the development of new devices that are able to use this information in order to make our lives easier. Nowadays, with the boom of Internet of Things, controllers and such devices have been having a huge success, because of the facilities they provide to integrate so many different equipment into a single network where any user can have a quick overlook of the state of the network, facilitating the interaction with the information they provide and the interacting equipment. Also, it is necessary to consider that these controllers can be used in so many different environments (home applications, building application and industrial applications), so it can be said that they result so useful and purposeful. Hopefully, this investigation and development field will continue to excel in design and connectivity, so they can fulfill their role in the development of new technologies.

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