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DEVELOPMENT OF OPC BASED SCADA SYSTEM USING SIEMENS CPU 224 FOR EDUCATIONAL PURPOSES

ABSTRACT

It is a well known fact that laboratory work has big importance to prepare automation students for difficulties of industrial world. With this purpose, in this study, local control of OPC (OLE for Process Control) based SCADA (Supervisory Control And Data Acquisition) system of which prototype constructed in laboratory environment is realized for educational purposes using Siemens CPU 224. The OPC standard allows users to monitor and control different types and models of devices by utilizing the OPC server. Control of the developed system from the visual screen and communication of this system with the other units are implemented using Delphi package program. With the use of the prototype which is set up in the laboratory environment, it is enabled that the students interested in automation have the opportunity to learn OPC and SCADA technologies. And so, application based teaching is provided. Consequently, it is provided that some infrastructures in technical men who will be trained for industrial automation world are formed.

Keywords: OPC, PLC, SCADA, Education, Automation

SIEMENS CPU 224 KULLANILARAK OPC TABANLI SCADA SİSTEMİNİN EĞİTİM AMAÇLI GELİŞTİRİLMESİ

ÖZET

Otomasyon öğrencilerini endüstri dünyasındaki zorluklara karşı hazırlamak için laboratuar çalışmasının büyük önemi olduğu iyi bilinen bir gerçektir. Bu amaçla, bu çalışmada, eğitim amaçlı Siemens CPU 224 kullanılarak laboratuar ortamında prototipi hazırlanan OPC tabanlı SCADA (Gözetleyici Denetim ve Veri Toplama) sistemi gerçeklenmiştir. OPC standardı kullanıcıların OPC sunucusunu kullanarak farklı çeşit ve modeldeki cihazları görüntülemesini ve kontrol etmesini sağlamaktadır. Geliştirilen sistemin görsel ekrandan kontrolü ve bu sistemin diğer birimlerle haberleşmesi Delphi paket programı kullanılarak gerçeklenmiştir. Laboratuar ortamında hazırlanan prototipin kullanımıyla, otomasyon ile ilgilenen öğrencilere OPC ve SCADA teknolojilerini öğrenme fırsatı verilmiştir. Ve böylece, uygulama temelli eğitim sağlanmıştır. Sonuç olarak, endüstriyel otomasyon dünyası için yetiştirilecek olan teknik elemanların alt yapılarının bir kısmı oluşturulmuştur.

Anahtar Kelimeler: OPC, PLC, SCADA, Eğitim,Otomasyon

1. INTRODUCTION (GİRİŞ)

Among the different automation disciplines, the Programmable Logic Controller (PLC) programming and the Supervisory Control and Data Acquisition (SCADA) development are very relevant issues, since they are used in many of the automation solutions implemented in most of the industries worldwide [1].

In companies, the role of process management is rather important for increasing the efficiency to maximum level during the manufacturing process. With the increasingly competitive environment, the survival of automation companies depends on their basic facilities and process control architectures.

In process management, the companies renewing their basic facilities with the developing technology can gain an advantage over their competitors and become market leaders in their area. Therefore, companies spend a lot of money for industrial automation area to develop their basic facilities. If we have a look at process management historically; In the 1950s, development trends focused on electro mechanics, the diffusion of standard signals, bringing field instruments closer to the process, and reading and monitoring process data near the process level [2]. The situation of process management in 1950s is illustrated in Figure 1. Trends of the 1970s were integrated circuits and programmable logic controllers (PLC). The development of analog systems reached its peak, distributed digital systems (DDS) gained ground, and control rooms became increasingly complex [2].

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In the 1990s, the integration of electronic components and microcomputers into process management has continued to grow, and intelligence has been distributed to field technology devices. Field instrument and field bus development projects have been initiated, changed, and merged together [2].

In process management, especially in data bus, big revolutions were lived in 2000s. The system became open to be controlled from any points in the world by using satellite systems. With the use of this architecture, any changes occurred in the system can be seen easily and interfered as soon as possible. The situation of process control is shown in Figure 2.

Figure 1. The situation of process management in 1950s [3]
(Şekil 1. Süreç yönetiminin 1950'lerdeki durumu)

In 2000s, using web technologies is another factor affecting the process management directly. Using web technologies in SCADA systems provides the remote control and monitoring the systems easily. The internet is now providing a new and increasing important medium for distributing information world wide without time constraint, permitting information to be displayed numerically and graphically on any client platform. This has generated the concept of 'Web-Based Supervision and Control System' to allow end users to access the real-time data and to control the instruments via a web browser [4].

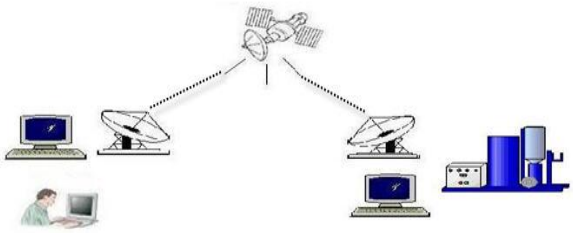

Figure 2. Process control in 2000s
(Şekil 2. 2000'lerdeki süreç kontrol)

In this study, an application prototype is implemented utilizing OPC standard one of the developments in process management systems at the end of 1990s for educational purposes. With this prototype, it is aimed that the students educated in automation area can improve themselves about SCADA and OPC architectures.

2. RESEARCH SIGNIFICANCE (ÇALIŞMANIN ÖNEMİ)

In this study, local control of OPC based SCADA system is realized for educational purposes using Siemens CPU 224. The OPC standard allows users to monitor and control different types and models of devices by using the OPC server. Control of the developed system from the visual screen and communication of this system with the other units are implemented using Delphi package program. The main goal of this system is to guide the students interested in automation to learn PLC, SCADA and OPC and how to integrate these components. The prototype which is prepared in the laboratory environment provides the students to learn what PLC, OPC and SCADA are and how and where they can use them.

3. WHAT IS SCADA? (SCADA NEDİR?)

With the increasingly competitive environment, the survival of automation companies depends on their basic facilities and process control architectures. Because of this goal, Supervisory Control And Data Acquisition (SCADA) systems have become the most common process control architecture for companies and associations.

SCADA is the acronym for "Supervisory Control And Data Acquisition". SCADA systems are widely used in industry for supervisory control and data acquisition of industrial processes. The term supervisory control and data acquisition SCADA was first introduced in the 1960s at Bonneville Power Administration and was first published in the PICA _Power Industry Computer Applications Conference Proceedings [5].

SCADA was meant primarily for remote monitoring and/or control function of a number of widely distributed sites. Utility industries have been heavily depending on SCADA since long. However, its form and applicability has been matured gradually overtime according to the availability of new generations of software and hardware. SCADA packages are available or can be tailored for applications to many processes such as [6]:

- Water Supply
- Irrigation System
- Sewage lift station
- Oil field and pipeline control
- Power generation/transmission automation (Energy management system or EMS)
- Power distribution automation (Distribution management system or DMS)
- System control of communication network (SYSCON)
- Security system
- Early warning siren system
- Mass transit system, to name a few. [6]

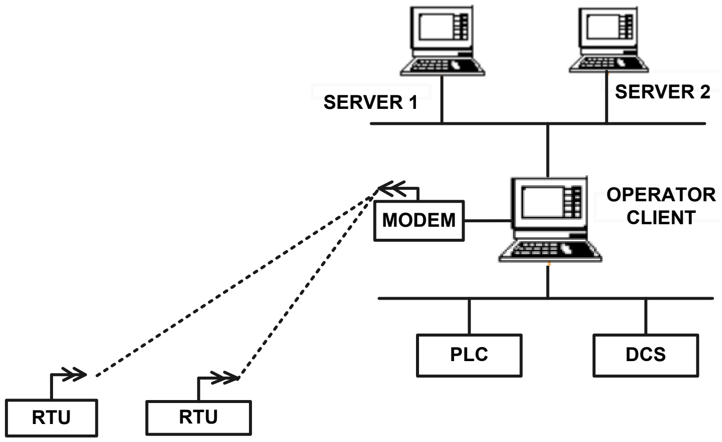

Figure 3. An example of today's SCADA systems
(Şekil 3. Günümüzdeki SCADA sistemlerine bir örnek)

Today, SCADA which takes its place in indispensable systems of industrial automation world, continues its development with technology from past to today.

Today's SCADA system is a combination of data collection and Telemetry systems [7]. With this developed architecture, data of the systems which have thousands of kilometers distance are collected in one center. Monitoring, analyzing, and data sending operations can be realized from the center. In local systems, user can reach the necessary data using infrastructure of network (profibus, fieldbus, modbus and so on) while in remote systems, user can reach the necessary data using infrastructure of RTU (Remote Terminal Unit). An example of today's SCADA systems is shown in Figure 3.

In today's classical SCADA system shown in Figure 3, client computer placed in definite stations for informing the operator, collects the necessary data from local and remote systems and transfer these data to the server computer existing in the center. In central structure, at least two server computers should exist [7].

4. WHAT IS OPC? (OPC NEDİR?)

In industrial automation world, various software applications (DCS, ERP...) for different necessities can be used with the SCADA systems. Example, Supervisory Control And Data Acquisition (SCADA) software systems, one of the typical applications in automation industry, are used for industrial measurement, monitoring, and control systems, especially by electricity and natural gas utilities, water and sewage utilities, railroads, telecommunications, and other critical infrastructure organizations. Although most of the currently existed SCADA software systems are developed by using component techniques, due to without using public accepted interfaces, these components are always designed by one company in their specific system. They are unable to be reused by others. It's worthy of deliberating on how to design a set of standard, industrial automation domain components so that these components can be reused in similar system at best [8].

Figure 4 shows an example of communication architecture between three different software applications and three different process control devices used in manufacturing industry. To be able to communicate with devices in the system, every software application used in the system has to have the driver of the related device. This obligation brings financial load to the system and makes data transfer complicated [9].

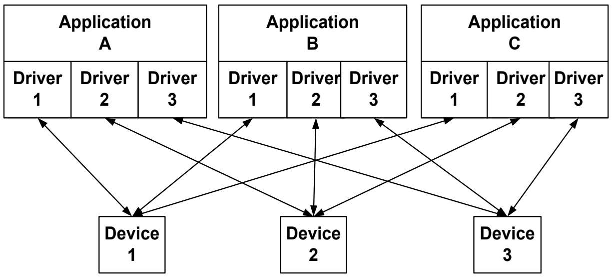

Figure 4. Conventional communication architecture[9]
(Şekil 4. Gelenemksel haberleşme yapısı)

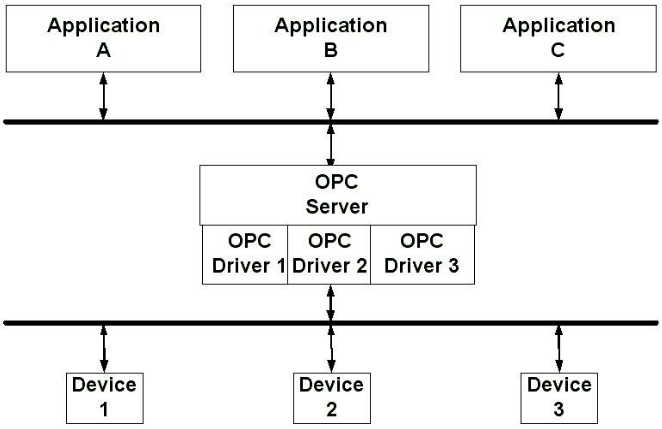

Figure 5. Communication architecture of OPC standard [9, 10 and 11]
(Şekil 5. OPC Standardının haberleşme yapısı)

In industrial automation, complex communication architecture shown in Figure 4 and restrictions of choice of device caused manufacturing sector to find new solutions. For this reason, Fisher-Rosemount, Rockwell Software, Opto 22, Inellution and Intuitive Technology companies came together to form an organization named as "OPC Foundation" in 1996. This organization developed OPC Standard. It started with 5 companies at the beginning, but now it has over 300 members from around the world, including nearly all of the world's major providers of control systems, instrumentation, and process control systems. The OPC Foundation's forerunner - a task force composed of Fisher-Rosemount, Rockwell Software, Opto 22, Intellution, and Intuitive Technology - was able to develop a basic, workable, OPC specification after only a single year's work. A simplified, stage-one solution was released in August 1996 [12].

Figure 5 shows the communication architecture obtained by OPC standard. If this architecture shown in Figure 5 is analyzed, OPC server enables direct communication between the devices used in the system and software applications [10 and 11]. Furthermore, OPC has the possibility to communicate with software applications used in the system. And it enables the companies to produce various properties such as forming visual interface, storing data by using third party software (Delphi, Visual Basic, Visual C…).

OLE/COM technology which is the most important client/distributor technology of Microsoft is used in the basic facility of OPC standard. OPC standard provides easier communication between the applications related to the devices used in the system. OLE and COM objects of Microsoft are available in Microsoft Visual Basic, Visual C++ package programs and Borland's Delphi package program.

In the OPC, client-server communication structure is accepted as the backbone of the whole system. The client applications will not be directly involved in the management of devices, and they have to go through server application by standard interfaces. The server application will be responsible for managing devices. Therefore, the hardware providers and software developers have been different [13].

5. OPC BASED LOCAL SCADA SYSTEM FOR SIEMENS CPU 224 (SIEMENS CPU 224 İÇİN OPC TABANLI YEREL SCADA SİSTEMİ)

As mentioned in section 3, to be able to get necessary data from the related device in the field, software used in automation world have to own communication interface of that device. Siemens's SCADA software WINCC can be given as an example package program used common in this area. WINCC has definite drivers to access to various control devices in the field. For example, Siemens S7-300/400 family include MPI driver to access to the PLC. However, it does not include a driver structure having authority to access to S7-200 which is the other device of Siemens family directly. Because of high prices of package programs like WINCC, a SCADA system which is set up in laboratory environment costs too much. Therefore, an OPC based SCADA system using S7-200 CPU 224 is developed in laboratory environment for educational purposes.

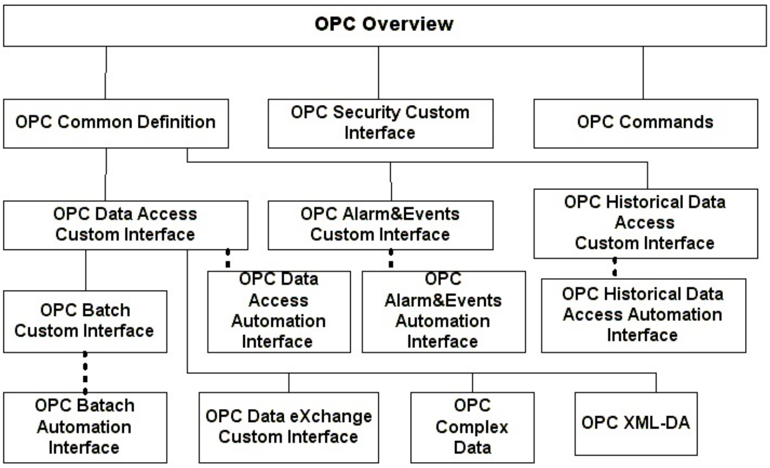

Figure 6. Overview of the OPC family [8 and 9]
(Şekil 6. OPC ailesinin genel görünümü)

Goals of this system are;

- To introduce OPC and SCADA systems to the automation students
- To impose the advantages of OPC and SCADA systems on automation students.
- To develop OPC based SCADA system for SIEMENS S7-200 family.

The products based on OPC Specifications have more than 600. The existing OPC Specifications and those being developed include a serial of key issues in industrial automation fields, such as Data Access, Alarms and Events, Historical Data Access, Batch, Security, XML, Complex Data, and OPC Data eXchange etc. (Figure 6) OPC Specification has become de facto standard for automation industry [8].

The OPC Data Access Server consists of four parts: Server's objects & interfaces, data storage area, GUI (graphical user interface), hardware driver, as shown in Figure 7 [9 and 14].

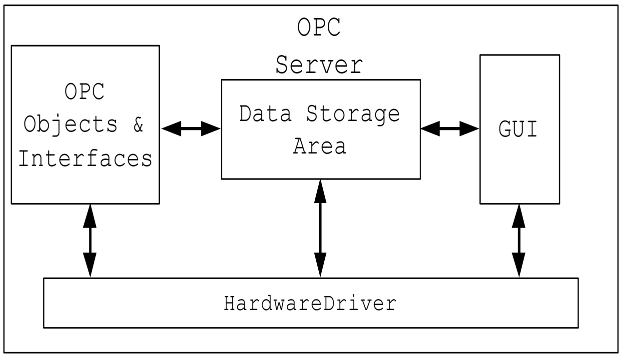

Figure 7. General OPC server architecture [9 and 14]
(Şekil 7. Genel OPC sunucu yapısı)

This setup includes a model winch, a Siemens S7-200 CPU 224 PLC, a PPI communication cable and a computer. The application prototype in Figure 8 is used for only experiments done in this study, but if it is required it can be used in different types of systems.

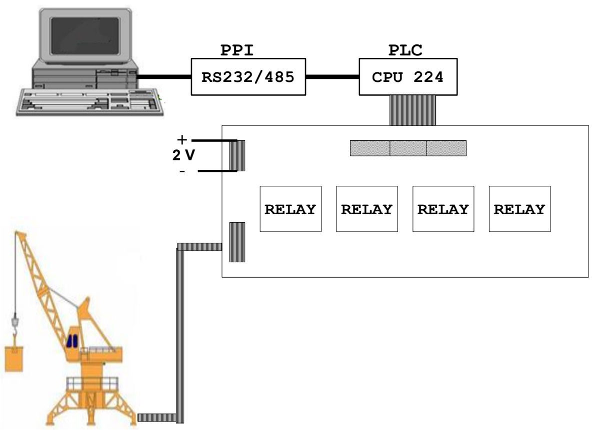

Figure 8. Winch prototype prepared in laboratory environment
(Şekil 8. Laboratuar ortamında hazırlanmış olan winch prototipi)

The data taken from these prototypes by using OPC servers in local control points are given to control mechanism prepared in Delphi package program. Prepared local control screen enables that the operator can follow the system visually and interfere the system when it is necessary. Prepared OPC based SCADA architecture is shown in Figure 9 and Figure 10 [9].

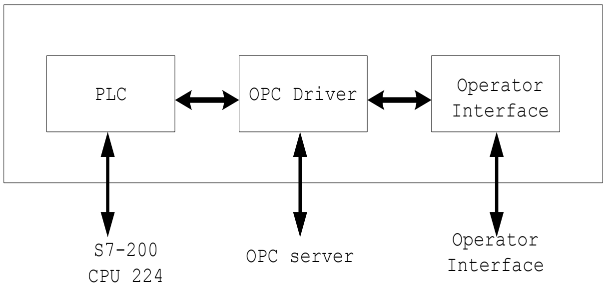

Figure 9. Prepared OPC based control architecture
(Şekil 9. Hazırlanmış olan OPC tabanlı kontrol yapısı)

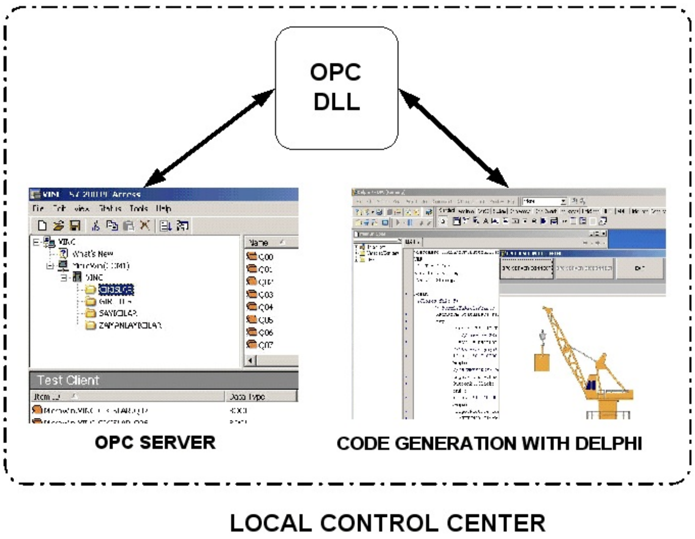

Figure 10. OPC server and code editor in Delphi [9].
(Şekil 10. Delphi'de OPC sunucu ve kod editörü)

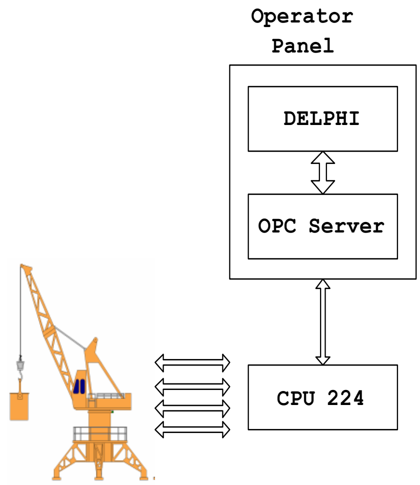

Figure 11. Application prototype data flow chart [9]
(Şekil 11. Uygulama prototipinin veri akış diyagramı)

OPC server used in this system works as a bridge transferring data between control screen (prepared using Delphi package program) and PLC. Data flow chart between the example winch application prototype and control screen is seen in Figure 11 [9].

In the local control screen, the architecture which is necessary for the operator to activate the OPC based SCADA system is prepared. Similarly, the architecture which is necessary for the operator to stop the communication between the prototype and OPC based SCADA is developed. Then, the control architecture that the operator can interfere to the PLC outputs is realized. Therefore, eight different control buttons for eight different outputs of the PLC are developed. These buttons enable necessary function parameter to be sent to activate the related output object which is already in the OPC server. A similar architecture for the operator to deactivate the related output is prepared. In Figure 12, local control screen prepared in Delphi is shown.

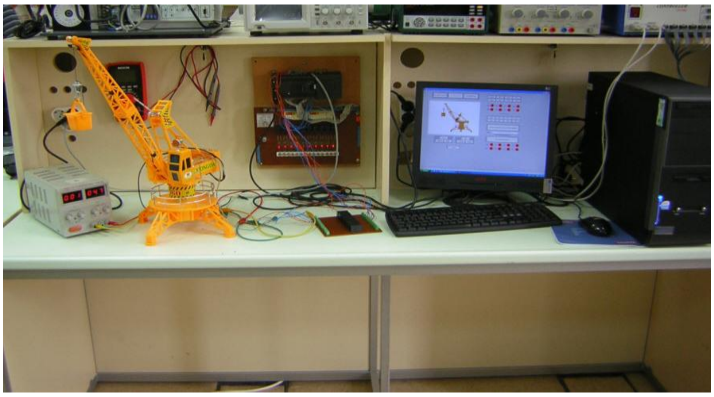

Figure 12. Model winch application prototype prepared in laboratory environment [9].
(Şekil 12. Laboratuar ortamında hazırlanmış olan model vinç uygulama prototipi)

In Figure 12, application prototype prepared in laboratory environment is given [9]. The operator can interfere to the outputs using control screen. And a different architecture for the operator to control the inputs of PLC is developed, too. This architecture provides the operator to get information about which input is active or not.

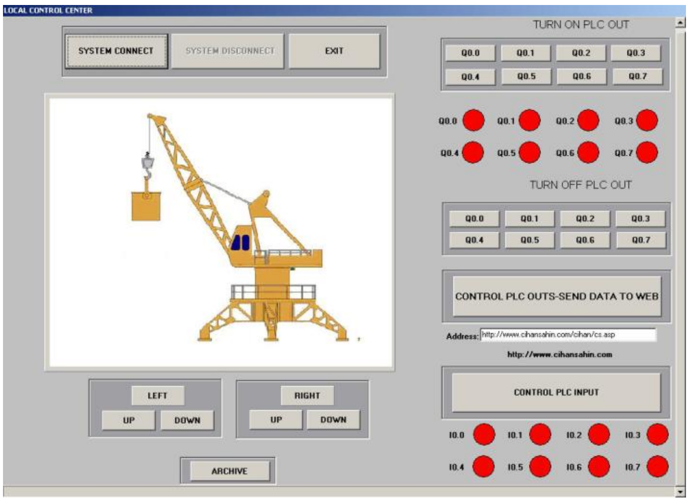

Figure 13. Local control screen of winch prototype [9 and 10]
(Şekil 13. Vinç prototipinin yerel kontrol ekranı)

Control commands (right, left, up, down) belonging to the application prototype (winch system) and graphic animations which give knowledge about the position of the winch to the operator are added to the control screen as seen in Figure 13 [9 and 10].

Finally, internet communication architecture is added to the developed OPC based control architecture. By using this architecture, it is provided that the data taken from the PLC can be transferred to the database on the internet environment. So, the basic facility for remote controlling the system is realized.

6. DISCUSSION (TARTIŞMA)

In today’s world, big and developing firms and associations accept the principle of minimum cost and maximum efficiency. Therefore, establishments and associations improving themselves parallel with the developing technology can stand and climb up to the summit. Firms and associations working with this mentality support their technical staff to improve themselves with developing technology. Good infrastructures make it possible for technical staff and engineers working in industrial environment to go ahead to this direction.

Industrial automation world is an area which needs the technical staff improving themselves very fast and professional or having a good infrastructure most.

In past, interferences made to the local system manually can be realized using the systems like GSM, internet and so on from remote points easily today. In this study, local OPC based SCADA system is developed using OPC system which has been used since 1999 and provides big advantages to the user. With the use of this system, it is provided that the students can learn PLC, OPC and SCADA systems and have chance for applications. Different systems can be adapted to the prototype application realized in laboratory environment. The students can have the advantage to apply their theoretical knowledge and they become ready for the systems which they will meet in industrial environment later.

So, an important contribution is provided to educate automation students with this study. In future, an infrastructure for remote controlling the realized system in laboratory environment is provided by integrating today’s indispensable internet technology.

NOT (NOTICE)

Bu çalışma, 22-24 Eylül 2011 tarihleri arasında Elazığ’da düzenlenen “(ICITS-2011) 5. Uluslararası Bilgisayar ve Öğretim Teknolojileri Sempozyumu”nda sözlü bildiri olarak sunulmuştur.

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