IoTIwC: IoT Industrial Wireless Controller

Tassnim Awad, Walaa Mohamed, and Mohammad M. Abdellatif

Abstract Industrial controller systems are crucially essential to the cutting edge power systems industries. Industrial controllers link the integrated technologies of a computer, communication devices, and electric devices. The communication systems act as a physical intermediary layer for transferring, controlling, and acquirement of data within the system from distant locations. This chapter discusses the Supervisory Control And Data Acquisition (SCADA) systems and proposes a similar system that is an IoT based industrial wireless controller. The proposed system can control multiple devices through the network without the need to be physically near the devices. Because it uses simple and cheap devices, the system is low cost and easy to install. Additionally, the system is modular because extra microcontrollers can be easily added to the system to control more devices should the need arise.

Keywords IoT · Industrial controller · IIoT · SCADA

1 Introduction

A SCADA (Supervisory Control And Data Acquisition) is an automation control system that is used in industries such as energy, oil, gas, water, power, and many more. Normally, the system has a centralized location that monitors and controls entire sites, ranging from an industrial plant to a complex of plants across a whole country. SCADA could be defined as the process of controlling and supervising data collection and processing. This word is used to describe real time systems where data is gathered, processed, and maintained in real time. Some examples may include monitoring over a power plant or an irrigation system. To further illustrate the example above and to show how the system works, a home station could be fitted with that system to monitor different substations or remote stations. If an error occurs in one of the stations, the home station could analyze the data and make sure that the error may not be critical and fixable. The system uses a client server architecture

T. Awad · W. Mohamed · M. M. Abdellatif (✉)
Electrical Engineering Department, The British University in Egypt, Cairo, Egypt
e-mail: Mohammad.Abdellatif@bue.edu.eg

A. E. Hassanien et al. (eds.), *Machine Learning and Big Data Analytics Paradigms: Analysis, Applications and Challenges*, Studies in Big Data 77,
https://doi.org/10.1007/978-3-030-59338-4_27

and has several elements, most notably, input–output sever, SCADA server, Human machine interfaces, and a control server.

The first generation of SCADA systems was designed with no networking infrastructure as it wasn't quite developed by that time. Then came the Next generation of SCADA system where the concept of networking was introduced. SCADA systems utilized networking for load balancing for efficient resource use and for increasing the dependability of the system. The third generation of SCADA system followed the same design principles as the previous generation but it became a more open system architecture compared to the self-tailored versions done by the companies. There are a-lot of transmission technologies used in SCADA systems, for example, coaxial cables which are used by TVs providers to send data, twisted metal pair as in telephone lines, fiber optic cables which is a relatively expensive option but allows real time communication and disaster recovery because of the high speeds it could transmit data through, it could also utilize satellite communications. All these communication methods require a solid infrastructure and to deploy them in a rural area would cost a fortune. So, we need to relay on wireless communication to reduce the Installation cost.

As the current SCADA systems use the same frequency as those of the TV channels. There was a conflict with major TV companies as it may negatively affect their income from advertisements, It uses the channels between 54 and 862 MHz for maximum coverage which also happens to be the TV channels, The bandwidth is about 6–8 MHz per channel and It identifies the free channels and send on those only to prevent any conflict with any used TV brands. Another method that is used is utilizing the already existing infrastructure of the cellular networks as one of the building blocks for wireless SCADA systems, with base stations connecting to the main network and sending data through it. The base stations can utilize components in the SCADA system to identify the free bands to send data upon so it won't interfere with any Calls or bands which are quite busy at the time. This would allow the SCADA system to cover about 100 km of area and it could provide the same level of service relative to DSL. However, this will add extra cost to the system because of the subscription charges of the cellular service.

This chapter proposes an IoT based SCADA system which is made with low cost devices and that can be controlled wirelessly through Wi-Fi from any device in the network. The proposed system is modular which simplifies expanding the system to control more devices without the need of reconfiguring the system as a whole.

The rest of the chapter is organized as follows. Section 2 gives a background and literature review on SCADA systems. Section 3 describes the system architecture. Section 4 presents ideas for future work. And finally, Sect. 5 concludes the chapter.

2 Background and Literature Review

In this section, we describe some of the earlier work done on web-based remote monitoring as well as some of the state of the art available on the same topic.

2.1 Web-Based Remote Monitoring

One of the early work done on the subject was that of Bertocco et al. [1], where the authors described client–server architecture for remote monitoring of instrumentation over the Internet. The proposed solution allowed multi-user, and multi-instrument sessions by means of a queuing and instrument locking capability. A queue mechanism has been added to the remote environment along with the possibility for each client to query the actual server load. The communication between the server and clients can be obtained either at instrument level or by means of encoded requests in order to reduce the network-imposed overhead.

Tso et al. [2] presented a study that indicates that a while a number of frameworks related to global systems have been described in contemporary publications, the detailed structure and formulation of the central-monitoring mechanism of such a partnership system has not received as much attention as it deserves. The proposed framework of a service network is characterized by its coordinating as well as monitoring capabilities. The main feature of the presented system is its rule-based reasoning capability to convert a job request from clients into basic tasks which are to be carried out by a group of virtual agents equipped with various defined capabilities.

Tommila et al. [3] discussed new ways of implementing existing functions and defined that new functionality, e.g. management of hierarchical structures and exception handling should be included in the basic control platform and engineering tools. The current 'flat' collection of application modules like loops and sequences had to be organized in a more hierarchical fashion based on process structure. Each process system is seen as an intelligent resource capable of performing different processing tasks. The interaction mechanisms between different automation activities are defined on the basis of object-oriented analysis and design and emerging international standards. A standardized distribution middleware takes care of the needs specific to the control domain. Above that, a higher level working environment for the other system components of the control platform is needed.

Yang et al. [4] reported a study on Networked Control System (NCS) historical review, recent revolution and research issues on NCS. Fast development and major use of the Internet, a global information platform has been created for control engineers allowing them to do the following:

- Monitoring the condition of machinery via the Internet.
- Remotely control machine.

  They also addressed many new challenges to control system designers. These challenges are summarized as follows:
- Overcoming Web-related traffic delay, i.e. dealing with Internet latency and data loss.
- Web-related safety and security, i.e. ensuring the safety and security of remote control and stopping any malicious attacks and misoperation.
- Collaborate with skilled operators situated in geographically diverse location.

Kalaitzakis et al. [5] developed a SCADA based remote monitoring system for renewable energy systems. It is based on client/server architecture and it does not require a physical connection, e.g. through network, serial communication port or 14 standard interface such as the IEEE-488 of the monitored system with data collection server.

Kimura et al. [6] reported remote monitoring system as one component of manufacturing support system. The proposed remote monitoring system can support single-night unmanned night time operations for diversified manufacturing from the operator's home as the remote site. According to the results, the remote monitoring system performed quite well for providing backup of manufacturing systems during unmanned nighttime operation.

Crowley et al. [7] experimentally explored the implementation of a wireless sensor network with Global system for Mobile (GSM) based communication for real-time temperature logging of seafood production. Subsequently, the network was developed and applied to the monitoring of whelk catches from harvest to delivery at the processing plant. The GSM communication was shown to have performed very well, especially in circumstances where problems with poor network coverage were expected to be encountered.

De la Rosa et al. [8] addressed the challenges and trends in the development of web-based distributed Power Quality (PQ) measurement and analysis using smart sensors. Registered users can configure the sensors, adjust sensitivity levels, and specify deployment location and email notification addresses. The developed website also provides a number of ways to view data from single or aggregated monitors. The authors addressed low cost Internet power monitor, which is cost-effective at the single user level. In addition, the reliance on standard web browsers eliminated the need for significant investment in software and hardware infrastructure that is typically required for other measurement systems.

Ong et al. [9] demonstrated existing SCADA with Java-based application in power systems. The authors also addressed the design issue in Graphical User interface (GUI). The proposed Web-based access tool can not only be used for SCADA Systems via intranet, or internet, but also can be readily used for information exchange among market operators via Internet.

Sung et al. [10] designed a test bed for an Internet-based Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM) system. It was specifically designed to be a networked, automated system with a seamless communication flow from a client-side designer to a server side machining service. This includes a Web-based design tool in which Design-for-Manufacturing information and machining rules constrain the designer to parts that can be manufatured, a geometric representation called SIF-DSG for unambiguous communication between client-side designer and server-side process planner in an automated process planning system with several sub modules that convert an incoming design to a set of tool-paths for execution on a 3-axis Computer Numeric Control (CNC) milling machine.

Altun et al. [11] presented a study on Internet based process control via Internet. The study is to show that any process can be managed remotely with ease. Need for remote managing could appear in health-critical or dangerous conditions, being far away from job, etc. It could be extremely useful for managers to check, administer, or just for taking information as if using visual phone.

The scope of Internet based process control has been clearly specified by Yang et al. [12]. Internet-based control is only an extra control level added to the existing process control hierarchy. The objective is to enhance rather than to replace computer-based process control systems. Six essential design issues have been fully investigated which form the method for design of such Internet-based process control systems. The design issues include requirement specification, architecture selection, web-based user interface design and control over the Internet with time delay, concurrent user access, and safety checking.

Su et al. [13] presented a two WAN model on distribution management system. An integrated DMS consists of networked hardware and software capable of monitoring and controlling the operations of substations and feeders. Building a communication model allows one to determine if leased line capacity or system hardware speeds will cause a bottleneck in the system. The model contains sufficient details about the traffic load and their performance characteristics. WAN modeling is aimed to verify whether hardware design could accommodate the communications load and to avoid overpaying for network equipment. Simulation results indicate that, to cover feeder automation functions, a WAN with distributed processing capability would provide better SCADA performance than an extension of the old centralized system.

2.2 *State of the Art*

There are many implementation of the classic SCADA system. For example, the SCADA framework that the Lexington-Fayette Urban County Government (LFUCG) [14] depended on to run a system of 80 pump stations and two wastewater treatment plants has worked dependably for almost 20 years. In any case, time was incurring significant damage as new parts were progressively hard to discover and a great part of the framework was out of date. A large number of the current SCADA PCs and HMI programming running the plant's checking framework were old and in the need of substitution. Following a necessary appraisal, LFUCG chose to overhaul the electrical and SCADA frameworks at the Town Branch and West Hickman Creek wastewater treatment plants and supplant every one of the 80 remote terminal units (RTU) at each pump station.

Since LFUCG had a few unique offices engaged with the venture (IT, administration, tasks from each plant and pump stations gathering, and so on.) CDM Smith led workshops with all LFUCG partners and nearby gear producers to learn and decide the proper SCADA framework design and programming required for the undertaking. P&ID illustrations were produced starting with no outside help to demonstrate the current treatment plant process, joined with instrumentation and control frameworks which help convey control works amongst process and SCADA architects, and additionally the general temporary worker.

CDM Smith assessed the current telemetry framework; gave suggestions to supplanting gear; and assessed a few pump stations, the repeater and antenna wire area, and the general surveying programming/equipment. Because of this assessment, LFUCG continued with a full plan for the substitution of existing equipment at 80 pump station destinations. As a major aspect of the outline, our group built up a methodology so all destinations stayed in task amid the entire switchover process.

Changes incorporated the utilization of cutting edge SCADA gear at both wastewater treatment plants for reliability, institutionalization, and long term viability; SCADA control usefulness for West Hickman (the current SCADA framework checked plant activity just); and update the current restrictive RTUs with a Rockwell RTU-based framework and the radio correspondence hardware.

The system mentioned above is shown in Fig. 1. It is bulky and requires special installation expertise to function as intended. The new SCADA framework configuration gives numerous advantages, including disentangled tasks, equipment/programming institutionalization over the whole association, new control plans, capacity to effectively oblige future development, promptly accessible help and extra parts, and equipment/programming adaptability through open design items. Moreover, the new frameworks perm it remote control and progressed mechanized methodologies at LFUCG's WWTPs and pump stations like composed pump station task, and enhanced staff efficiency. Different advantages incorporate protection of staff time and vitality, enhanced unwavering quality, improved basic leadership, and tempest readiness and recuperation bolster planning LFUCG for the following two many years of administration.

Advancement of SCADA frameworks, lately, shows the nearness of a few unmistakable pattern s. Progressively heterogeneous structure applies to their development, both as far as equipment assets, and as far as correspondence systems utilized as a part of them. The regularly reason structure in vast SCADA frameworks circulated in extensive topographical locales is PC—PLC approach with the incorporated WEB server. In littler frameworks, especially in inquire about research centers and labs for remove adapting frequently connected PC—DAQ board or installed control board approach.

The transmission of communication through the Internet permits worldwide access and remote observing of the framework. This has just turned into a standard element in present day SCADA frameworks. Electronic SCADA framework utilizes the Internet to exchange information between the RTUs and the MTU as well as between the administrators' workstations and the MTU. The association over the Internet requires the utilization of extra assets to shield the framework from unapproved access and programmer assaults.

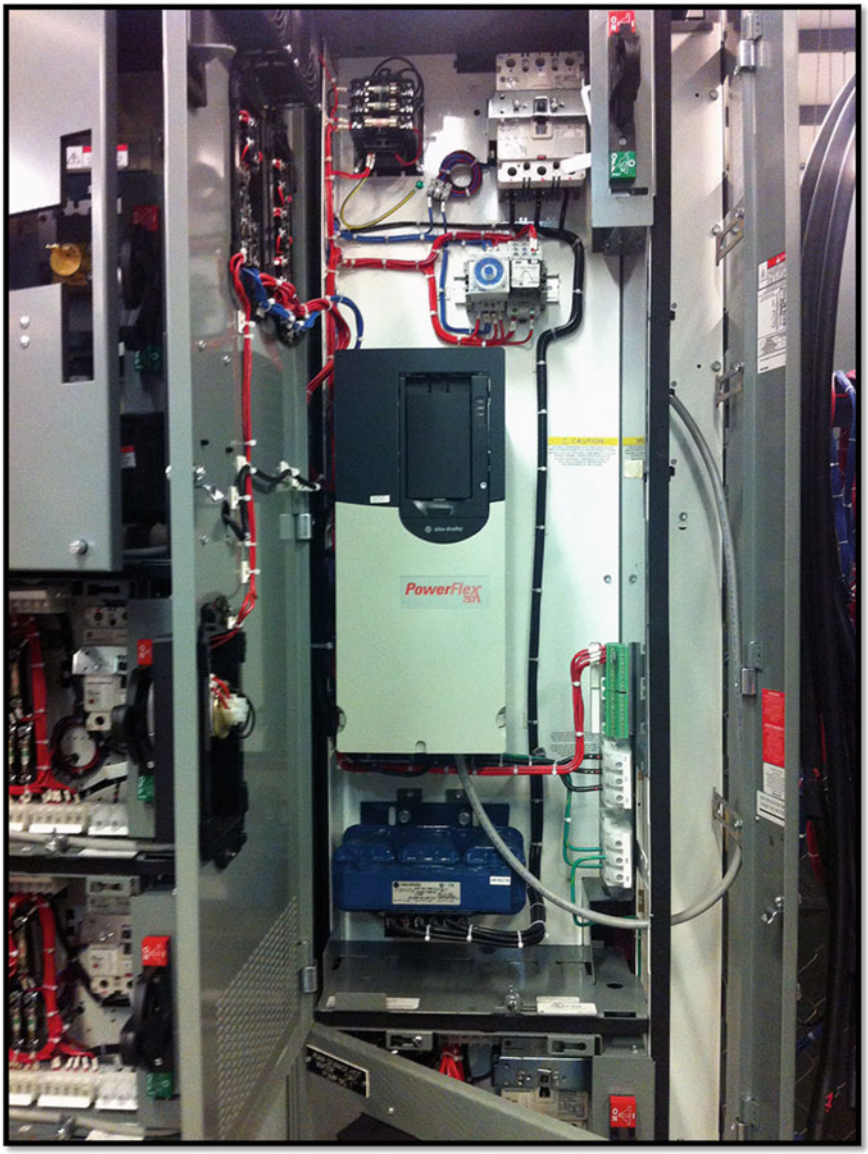

Fig. 1 Smart motor control centers (MCC) [13]

Remote interchanges is quickly developing fragment of the correspondences business, with the possibility to give fast and top notch data More and all the more regularly in SCADA frameworks a remote correspondence innovations are utilized for short range (Wi-Fi, Bluetooth, ZigBee), and for long range (Private Radio Networks—PRN, Satellite, 3G, 4G) information transmission. Remote SCADA replaces or stretches out the Fieldbus to the Internet. It is required in those applications when wire line correspondences to the remote site are restrictively costly or it is excessively tedious, making it impossible to build wire line interchanges. It can lessen the cost of introducing the framework. It is likewise simple to grow.

New patterns in educating and learning techniques, in which mixed learning is a standout amongst the most encouraging, can profit by remote labs as significant academic additional items. Examinations led in a genuine research facility are without a doubt the basic learning background. In any case, remote lab offices enable the understudies to get to the research center framework at nonworking hours. From the perspective of the instructing foundation that offered administrations, this satisfies the understudies in particular.

As it were: mechanization or programmed control of the utilization of various control frameworks for gear, for example, apparatus, plant procedures, boilers and heaters for warm treatment, combination of phone systems, administration and alteration of boats, air ship and different applications, and vehicles with a negligible human mediation which permits a completely robotized process.

Mechanization is accomplished by different means, including, pneumatic, mechanical, water driven, electrical, and electronic and PC gear, for the most part also. Confounded frameworks like present day industrial facilities, planes, and ships, which are frequently joined with every one of these procedures the upsides of mechanization are work sparing, practical power, sparing material expenses and enhancing quality, exactness and accuracy.

2.3 Industrial Internet of Things (IIoT)

With the increasing popularity of the Internet of Things, the idea came to incorporate SCADA systems with the internet of things. This gave birth to the so called Industrial Internet of Things (IIoT) [14].

The industrial internet of things refers to interconnected sensors, instruments, and other devices networked together with computers' industrial applications, including manufacturing and energy management. This connectivity allows for data collection, exchange, and analysis, potentially facilitating improvements in productivity and efficiency as well as other economic benefits. The IIoT is an evolution of a distributed control system (DCS) that allows for a higher degree of automation by using cloud computing to refine and optimize the process controls.

IIoT has all of SCADA capacities. The connection between the whole frameworks through the system, in which all gadgets of the framework can gather/trade information with each other. Obviously, this information can be broken down and prepared when SCADA is working.

IIoT is a much cheaper replacement due to the cost reduction in both the price of the equipment and the installation. Additionally, since most of the communication will be done wirelessly, there is another cost reduction from the lack of wired connections.

Moreover, the system can easily incorporate sensors as well as actuator to monitor and control a large spectrum of devices. And there are always new sensors and actuators that are being built to handle the need of the user.

However, as the connection is wireless, security may be an issue as these wireless devices can be hacked remotely if they are not secured well enough.

The IIoT is enabled by technologies such as cybersecurity, cloud computing, edge computing, mobile technologies, machine-to-machine, 3D printing, advanced robotics, big data, internet of things, RFID technology, and cognitive computing. Five of the most important ones are described below:

- **Cyber-physical systems (CPS)**: the basic technology platform for IoT and IIoT and therefore the main enabler to connect physical machines that were previously disconnected. CPS integrates the dynamics of the physical process with those of software and communication, providing abstractions and modeling, design, and analysis techniques for integrated the whole [15].
- **Cloud computing**: With cloud computing IT services can be delivered in which resources are retrieved from the Internet as opposed to direct connection to a server. Files can be kept on cloud-based storage systems rather than on local storage devices [16].
- **Edge computing**: A distributed computing paradigm which brings computer data storage closer to the location where it is needed [17]. In contrast to cloud computing, edge computing refers to decentralized data processing at the edge of the network. The industrial internet requires more of an edge-plus-cloud architecture rather than one based on purely centralized cloud; in order to transform productivity, products and services in the industrial world.
- **Big data analytics**: Big data analytics is the process of examining large and varied data sets, or big data.
- **Artificial intelligence and machine learning**: Artificial intelligence (AI) is a field within computer science in which intelligent machines are created that work and react like humans. Machine learning is a core part of AI, allows the software to become more accurate with predicting outcomes without explicitly being programmed.

IIoT systems are often conceived as a layered modular architecture of digital technology. The device layer refers to the physical components: CPS, sensors or machines. The network layer consists of physical network buses, cloud computing and communication protocols that aggregate and transport the data to the service layer, which consists of applications that manipulate and combine data into information that can be displayed on the driver dashboard. The top-most stratum of the stack is the content layer or the user interface.

As a rule, when you say “SCADA” consider the generation procedure itself or administration depicted certain guidelines. Basically, the SCADA framework is generally the primary framework through the framework (s) progressively. An exemplary mill SCADA connecting model show is (Controller, Sensor, and Actuator)—(OPC Server)—(SCADA applications)—(once in a while chose parameters over the Internet). Internet of things so far the framework for everything that Internet gets to have. It is perilous to give access to creation line gear specifically finished the Internet.

Web proceeds SCADA (or SCADA Web), where you can carry your framework into the cloud and get in touch with each other. Internet of things represents the Internet of things when it is utilized for modem purposes, it would call it IloT (Internet Industrial of Things). For the most part, individuals contrasted with SCADA IIoT as opposed to the Internet of things.

IIoT has all SCADA capacities. As it were, the SCADA IIoT with extra highlights, that is. The connection between the whole frameworks through the system, in which all gadgets of the framework can gather/trade information with each other. Obviously, this information can be broke down and prepared when SCADA is working.

2.4 IoT Versus IIoT

Pros of Internet of Things

I. Cost savings
The electronic gadgets impart effectively, spare and spare expenses and vitality; this is the reason it is valuable for individuals in day to day schedules. By empowering information and correspondence between electronic gadgets and their interpretation in a coveted way, the IP gadget makes our frameworks more effective.

II. Monitor
The second most merit of the online group is the follow up. The correct measure of consumable or air quality in your home can likewise furnish you with more data that has not yet been gathered. For instance, in the event that you realize that you have a low measure of drain shading or printer, sooner rather than later you will spare another outing to the store. What's more, checking the item stream can likewise enhance security.

Cons of Internet of Things

I. Safety
Envision if a famous programmer changed your income. Or on the other hand, if the store consequently sends an equal item you don't care for or an item that has officially lapsed. Thus, security is at last in the hands of shoppers to confirm the whole mechanization.

II. The prospects for low employment
With online computerized substance and day by day exercises, there will be less interest for HR and less instructed representatives, which can make an issue of work in the public eye.

Pros of IIoT

I. Accuracy
Generation and execution information is accessi ble progressively and is transmitted carefully. There is no compelling reason to enter or translate the bomb and the chief, paying little mind to whether it is a Pumper or a Senior Office.

II. Reliability
Remote observing encourages administrators to wait for tools. Thus, the creation levels are more solid. Tank levels are all the more even. The wear on the hardware is limited.

Cons of IIoT

I. Price.
Remote observing encourages administrators to wait for gear. Thus, the creation levels are more solid. Tank levels are all the more even. The wear on the hardware is limited.

II. Network Performance
On the off chance that you pick remote observing, you should realize that the information is accessible. Guarantee that you have a framework that delivers issues identified with crest utilization, scope organization, dormancy, unwavering quality, and security. A fragmented or separate system keeps away from an assortment of activity loads coming about because of non-associated applications.

The institutional Internet group is as of now a major piece of regular daily existence, and a large number of us don't know it. As the innovation step by step to progress and advance, the utilization of the online group is likewise utilized for some essential associations. It is our errand to choose the amount of our everyday life is prepared to control the innovation. At the point when this is done legitimately, it naturally adjusts to our necessities and advantages society in general.

SCADA remote checking has numerous persuading points of interest. By comprehension and tending to challenges, administrators can effectively actualize this innovation and utilize their prizes.

3 System Architecture

In this section, we discuss the proposed IIoT system that we have given the name IoT industrial Wireless Controller. A block diagram of the proposed IIoT system is shown in Fig. 2.

The system is compromised of a PC, multiple microcontrollers, relays, and multiple electric devices to be controlled.

The PC is used to as a terminal that allows the user to control the electrical devices through a local web page hosted on each of the microcontroller. The PC can connect

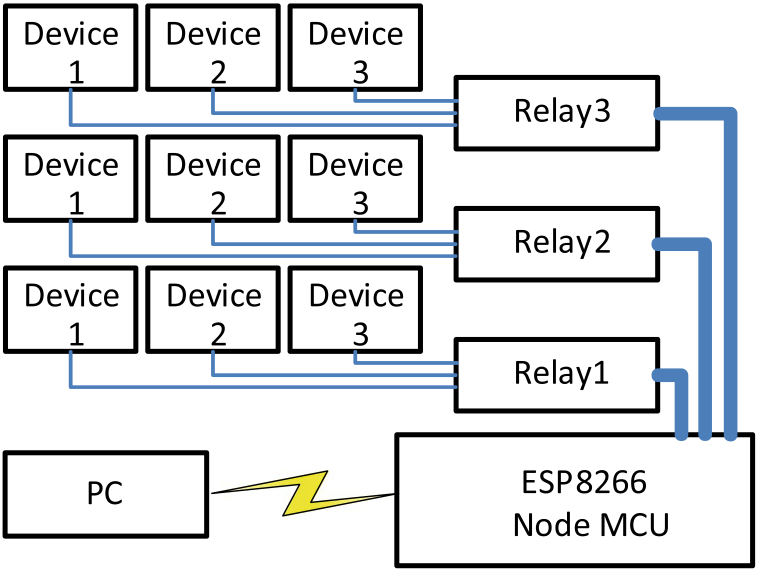

Fig. 2 Block diagram of the SCADA system

to multiple microcontrollers wirelessly using the local WiFi network. Moreover, each of the microcontrollers can connect to multiple devices through relays.

The microcontroller chosen for this work is the ESP8266 Node MCU [18] which is shown in Fig. 3.

NodeMCU is a low cost open source IoT platform. It includes a firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware

Fig. 3 ESP8266 NodeMCU microcontroller

rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It is used in many open source projects, such as lua-cjson and SPIFFS. The ESP8266 became popular in IoT diy projects as it is simple and easy to use.

In this work, the NodeMCU receive commands from the user\s terminal through its Wi-Fi module. Based on these commands, it controls the on/off operation of multiple devices. These devices are connected to the microcontroller through a relay module.

Figure 4 shows the relay module used in this work. Each relay can be connected to up to 4 devices, and each microcontroller can be connected to up to 4 relays. The aim is to place one microcontroller in a room and have it controlling up to 16 devices per room. Should there be more devices to be controlled, additional microcontroller can be easily added.

The user can control the devices from a web page that is hosted on the microcontroller. This page can be accessed from any PC within the same Wi-Fi network. The user will then have the option to switch on or off any device connected to that microcontroller.

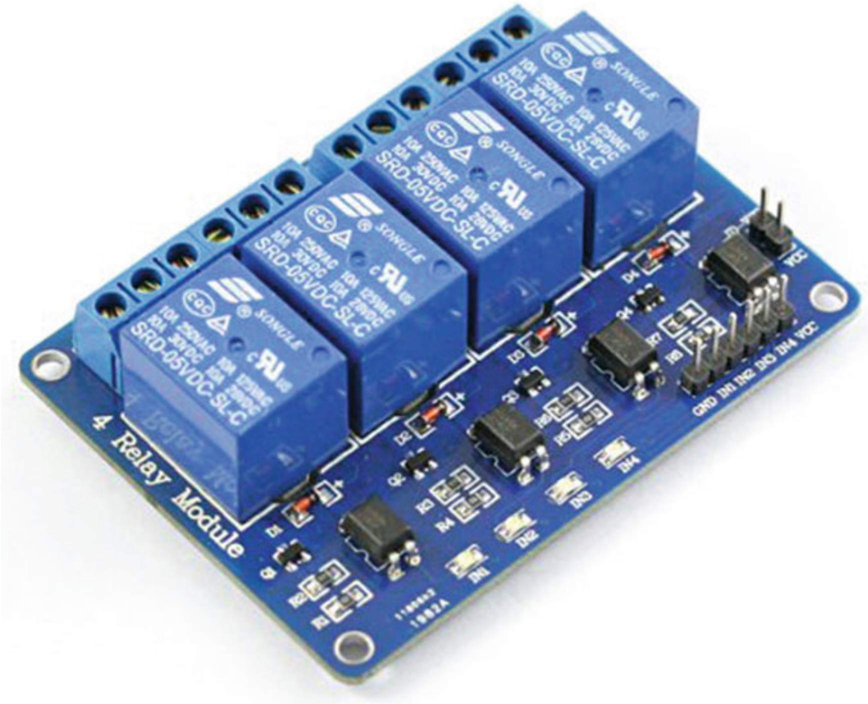

Fig. 4 Relay module

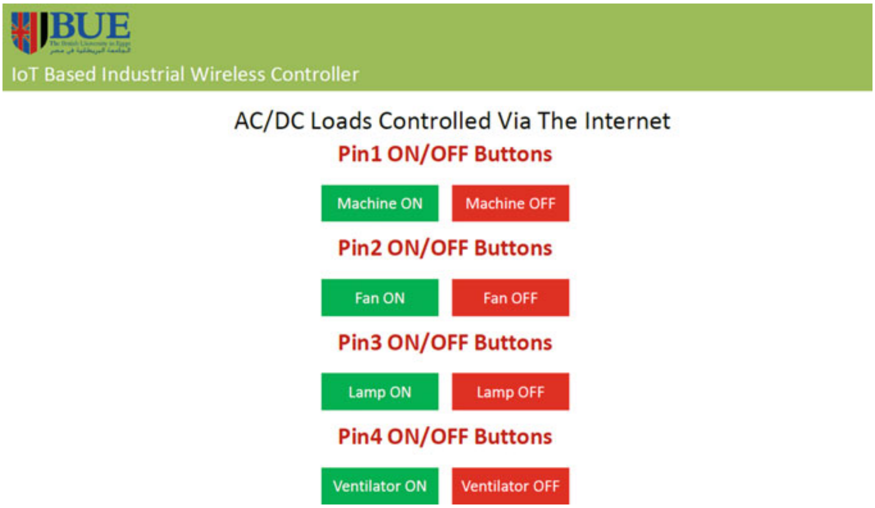

Fig. 5 Example webpage

Once the microcontroller joins the WiFi network, it acquires an IP address. All the user have to do next is to connect to that microcontroller from a browser using that IP address. The webpage will be displayed and allows the user to control all the devices connected to that microcontroller. An example of a basic webpage is shown in Fig. 5.

The figure shows how you can turn on or off four devices that are connected to the microcontroller through a relay. The buttons allows for the control of a device connected to one of the pins of the microcontroller. Pressing the button will send a signal to the connected device to either turn it on or off.

Figures 6 and 7 show an example of the complete setup in real life. The figure show a microcontroller connected to the PC and four relays. Each relay is connected to one device.

The example shows a lamp and a fan connected to two different relays through two different microcontrollers. Once the respective button is pressed on the respective webpage of the respective microcontroller, the device is turned on.

Ideally the microcontroller should be powered by a battery or an independent power source. In the figure, for the sake of simplicity, it is powered by the USB cable from the PC. However the controlling link is still the WiFi link.

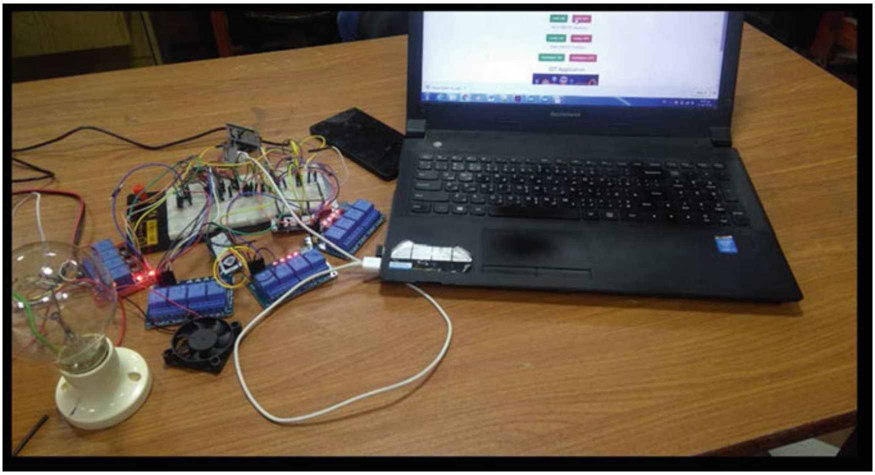

Fig. 6 Complete setup OFF

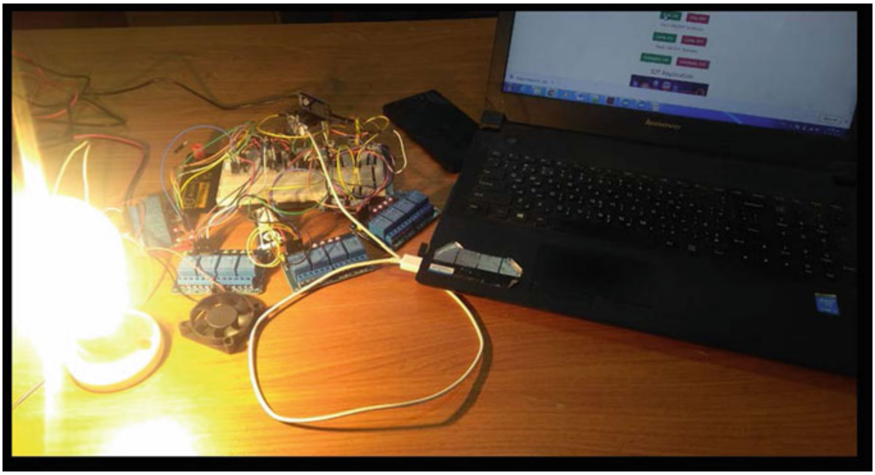

Fig. 7 Complete setup ON

4 Future Work

Since this is in its early stages, the prototype is disorganized and there are many wires. This will all be enhanced in the next stage. The device will be packaged in a way that makes it easier to install and operate.

Additionally, the website is hosted locally on each of the microcontrollers. This means that it can only be controlled from the local network. This is good because it

Table 1 Layered modular architecture IIoT

Content layer	User interface devices (e.g. screens, tablets, smart glasses)
Service layer	Applications, software to analyze data and transform it into information
Network layer	Communications protocols, wifi, cloud computing
Device layer	Hardware: CPS, machines, sensors

increases the security of the system. However, it will mean that the person has to be physically located on the premises to be able to control the devices.

Ideally, the website should be accessed from anywhere in the world. Which means that the security of the system will have to be increased and an authentication method will have to be added.

5 Conclusion

This chapter proposed an IoT based industrial wireless controller system. The proposed system was shown to be able to control multiple devices with the very low overhead and infrastructure. It is easy to install with very low cost as it uses basic devices and microcontrollers. Additionally, it can be controlled through the internet which increases the range of control with no boundaries. Moreover, the system is modular, which means that whenever the need arises to control more devices, another module can be added to the existing system without the need to change the whole system.

References

1. Bertocco, M., et al.: A client-server architecture for distributed measurement systems. IEEE Trans. Instrum. Measur. **47**(5), 1143–1148 (1998)
2. Tso, S.K., et al.: A framework for developing an agent-based collaborative service-support system in a manufacturing information network. Eng. Appl. Artif. Intell. **12**(1), 43–57 (1999)
3. Tommila, T., Ventä, O., Koskinen, K.: Next generation industrial automation–needs and opportunities. Autom.Technol. Rev. **2001**, 34–41 (2001)
4. Yang, T.C.: Networked control system: a brief survey. IEE Proc.-Control Theory Appl. **153**(4), 403–412 (2006)
5. Kalaitzakis, K., Koutroulis, E., Vlachos, V.: Development of a data acquisition system for remote monitoring of renewable energy systems. Measurement **34**(2), 75–83 (2003)
6. Kimura, T., Kanda, Y.: Development of a remote monitoring system for a manufacturing support system for small and medium-sized enterprises. Comput. Ind. **56**(1), 3–12 (2005)
7. Crowley, K., et al.: Web-based real-time temperature monitoring of shellfish catches using a wireless sensor network. Sens. Actuators A: Phys. **122**(2), 222–230 (2005).
8. De La Rosa, J.J.G., et al.: A web-based distributed measurement system for electrical power quality assessment. Measurement **43**(6), 771–780 (2010).
9. Ong, Y.S., Gooi, H.B., Lee, S.F.: Java-based applications for accessing power system data via intranet, extranet and internet. Int. J. Electr. Power Energy Syst. **23**(4), 273–284 (2001)

10. Sung, H.A., et al.: "CyberCut: an Internet-based CAD/CAD system." Transactions of the ASME. J. Comput. Inf. Sci. Eng. **1**, 52–59 (2001)
11. Altun, Z.G., et al.: Process control via internet. J. Integr. Des. Process Sci. **5**(2), 111–122 (2001)
12. Yang, ShuangHua, X. Chen, and J. L. Alty. "Design issues and implementation of internet-based process control systems." Control engineering practice 11.6 (2003): 709–720.
13. Su, C-L., C-N. Lu, and M-C. Lin. "Wide area network performance study of a distribution management system." International Journal of Electrical Power & Energy Systems 22.1 (2000): 9–14.
14. https://www.cdmsmith.com/en/Client-Solutions/Projects/Lexington-Fayette-SCADA
15. Boyes, H., Hallaq, B., Cunningham, J., Watson, T.: The industrial internet of things (IIoT): an analysis framework. Comput. Ind. **101**, 1–12 (2018). https://doi.org/10.1016/j.compind.2018.04.015.ISSN0166-3615
16. Staff, Investopedia (2011–01–18). "Cloud Computing". Investopedia.
17. Hamilton, E.: What is Edge Computing: The Network Edge Explained. cloudwards.net.
18. https://www.nodemcu.com/index_en.html

Mohammad M. Abdellatif is a full-time Lecturer at the British University in Egypt. Dr. Mohammad holds a B.Sc. '04 in Electronics and Communications Engineering from Assiut University, Assiut, Egypt, an M.Sc. '06 in Telecommunication Engineering from King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, and a Ph.D. '15 in Telecommunications engineering from the electrical and computer engineering department of the University of Porto, Portugal. Mohammad has received a four-year scholarship from the Foundation of science and technology of Portugal (FCT) for his Ph.D., as well as a one year CMU Porto joint research project award (SELF-PVP), His research interests are in the fields of IoT, WSN, and wireless communications.