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SPORTS FACILITIES LIGHTING SYSTEM BASED ON INTERNET OF THINGS TECHNOLOGIES

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This article provides a platform for a cost-effective, IoT-based intelligent sports facility lighting system, provides data in the cloud for applications, that accelerates understanding and responsiveness. The system includes programmable logic controllers, an IoT gateway, an Android mobile phone application, and a backend that will be deployed on Amazon Web Services (AWS). There are three main services used in Amazon Web Services: Elastic Container Service, Amazon Lambda, and Amazon Relational Database Service. The developed application combines the use of a cloud server, lighting devices and a database to remotely monitor and control the lighting system of a sports stadium. In this work, we present how to design and implement a smart IoT-based sports stadium lighting system using various lighting modes.

Keywords: *lighting system, PLC, IoT, AWS, Java, Python, mobile application.*

Formulation of the problem. In recent years, quite a lot of effort and time has been spent on processing requests and setting up systems for lighting various objects, including sports facilities. Most systems require the operator to be permanently on his work panel in order to continuously monitor and control lighting.

Today, IoT platforms are becoming a driving force in many spheres of human activity, but their practical use in the lighting industry is just beginning to be realized.

Stadium lighting is one of the most important consumers of electricity, therefore energy efficient control is one of the most important tasks in the field of automated control. Lights in stadiums must be turned on at the right time and under any circumstances, therefore it is necessary to ensure trouble-free operation and supervising of the lighting system. It is necessary to know how many floodlights have burned out, if there is electricity at the entrance to the substation, to receive information about breaks in power lines, etc Thus, the problem of remote control and management of the lighting system of a sports facility using the Internet of Things platform, in particular via a web server or a mobile application, is very relevant at the present time.

Analysis of recent research. With the look at continuously growing range of Internet of Things (IoT) use, it is important that people and things work efficiently. The IoT is an addition to the existing means of the Internet for providing communication, connection for working on the Internet between various devices and physical objects, also known as «Things» [1]. With the stormy development of IoT, smart or smart

lighting systems based on IoT are becoming more and more popular. And recent advances in smartphones and affordable open source cloud platforms have enabled the development of low-cost architectures for IoT-enabled lighting systems.

Centralized monitoring and control, easy fast maintenance, energy saving, high reliability and high system efficiency are some of the aspects of lighting technology solutions. Being connected to a single network, the lighting system has specific data on the amount of electricity consumed by each lighting device on a wider level, or even on how much the phase consumes [2].

Purpose of the article. Design a cloud-based lighting system with mobile support to ensure efficiency and comfort, that corresponds the basic requirements of sports stadium lighting.

Presentation of the main research material. The proposed lighting system Fig. 1. uses the concept of an IoT-enabled service platform, which uses an infrastructure consisting of a programmable logic controller (PLC), a fixed operator panel with an HMI interface, an IoT gateway with Lorawan technology to implement a communication channel between PLCs and cloud platforms, and also Android application and backend that will be stored on Amazon Web Services (AWS) [5].

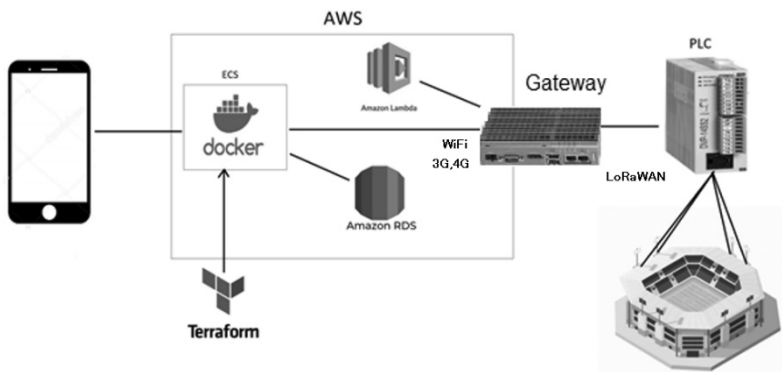

Fig. 1. Block diagram of a sports stadium lighting system based on the Internet of Things platform

The Amazon Web Services environment itself will use three main services:

1. Elastic Container Service (ECS) is a high-performance container management service with high scalability. It is a virtual machine on which we have deployed a Docker container and set up a convenient function for managing and making changes to any configuration of this container.

2. Amazon Lambda - the service is a serverless virtual machine. It will contain an algorithm that will manage the automatic rules for controlling lighting. For example, if the operator was not able to turn off the stadium lighting at a certain time, this algorithm will change the PLC configuration to turn off the lighting and save the stadium lighting costs, or prescribe other settings that can be configured via the mobile application.

3. Amazon Relational Database Service (RDS) - this service is an environment for deploying a relational database, so that you can later save information

for future use, such as: logins and passwords for authentication to a mobile application or a history of all changes in coverage and setting up automatic rules so that you can later use them for automatic management using AWS Lambda based on the engine implemented in Docker Image and based on the PostgreSQL container.

Since the large structure of AWS is a fragile foundation on which the slightest change in configuration can lead to a complete shutdown of the entire system, or to an accident at the stadium itself, it is proposed to use Terraform to save the AWS structure as code, which will help to declaratively manage the infrastructure. In this case, you do not have to manually create virtual machines, networks, etc., in the console of the cloud provider it is enough to write a configuration in which the vision of the future infrastructure will be presented. If you want to change the infrastructure, you need to change the configuration and run the terraform apply command. Terraform will route API calls to the cloud provider to bring the infrastructure into line with the configuration specified in this file [3,4].

Algorithm of the sports stadium lighting system. You can reduce the entire algorithm of the developed system to a block diagram. To begin with, the user has to log into this system from a mobile application. If this user is registered and has access to change values in the programmable logic controller, he successfully logs in to the system and can make changes to the settings windows. When a user submits target values for spotlights, the server receives a message, then saves it to the database and sends the data to the AWS SQS Message Queuing Service [5].

To be able to receive messages from AWS SQS in order to send ready-made messages to the PLC itself, we will use a developed application with a configured microservice that meets the necessary requirements and solves the task. Interaction between AWS and PLCs is implemented through the Moka7 library. For example, if the automatic light off setting is not enabled, AWS SQS receives a message and redirects it to the side of the recipient's server, which generates a request to the PLC. The PLC itself sets the value in its Data Block and displays the lighting simulator.

Creation of an Android application. Applications that extend the functionality of devices are written using the Android Software Development Kit (SDK), mainly using the Java programming language, which is taken as a basis [5]. The Android SDK for Java is widely used, which can be said with confidence that it can be used stably, and Android Studio was used as a development environment [6].

The main control window of the mobile application is quite convenient. The appearance of the mobile interface under different operating modes of the Android smartphone is shown in Fig. 2. This window displays a field that will be used to enter the IP address of the server to which the request will be sent, as well as the switch field.

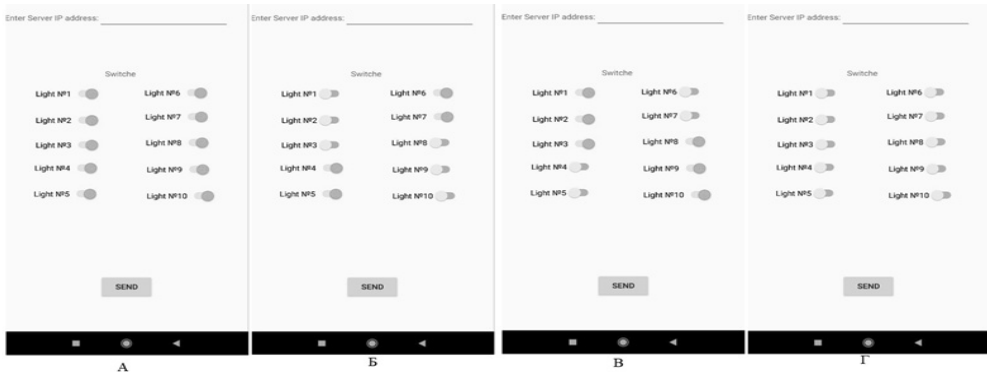

Fig. 2. Appearance of the mobile interface: a) full lighting, b) direct lighting, c) side lighting, d) shutdown mode

PLC and HMI simulation. Due to the value of the light variables, the light will be either intense or slightly light. This can be useful if the stadium is highly qualified, like FIFA qualified stadiums hosting world-class sporting events. In the case of a large sporting event, it is necessary that the spotlights shine as much as possible, for example, in case of conflict moments on the field during the game, all events could be clearly recorded. And during the example of training in the dark, it will be enough to see the field and objects on it.

Lighting control is implemented on the Siemens S7 1200 PLC, as it is the ideal solution for a stable connection to the internal network, which will have real-time access to the outside [6]. The controller is equipped with a built-in Ethernet interface, thanks to which a number of operations can be performed: SIMATIC programming, diagnostics. The solution of the tasks of operational control and monitoring at the stadium is entrusted to the human-machine interface (HMI), namely to the stationary operator panel Siemens KTP900 Basic PN, which will be connected at a high level, as well as floodlights (to the general network).

The system under test consists of an HMI operator panel and a PLC. Project settings, lighting modes and PLC input data processing algorithms are implemented in the Tia Portal integrated software development environment for process automation systems Fig. 3.

Figure. 3. PLC and HMI simulation in Tia Portal

Research results. In fig. 4 depicts the stadium lighting simulation modes, where orange means that the floodlights will shine as much as possible for a professional sports match. Yellow means lighting without using all the resources of the spotlight. The brightness of the spotlights depends on the value of the light variables. Zero means the spotlight is off, one means yellow, two means orange.

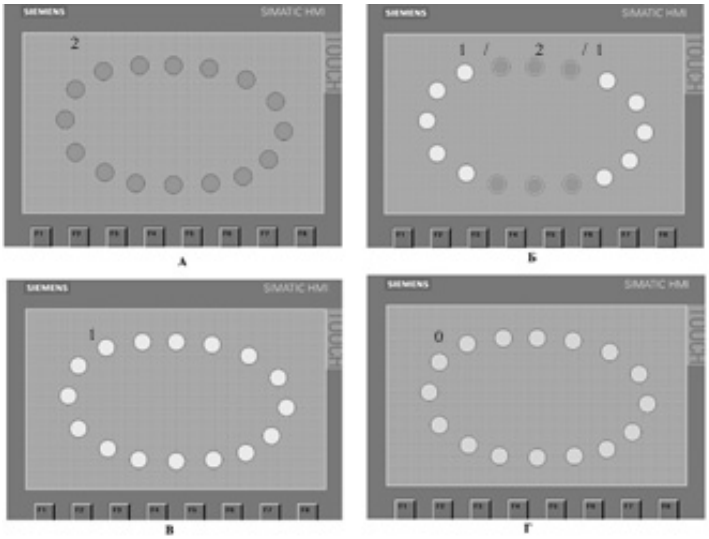

Fig. 4. Stadium lighting simulation modes a) powerful lighting mode b) normal lighting mode c) energy saving lighting mode d) lighting off

In fig. 4 a) shows the mode of maximum power lighting. This mode will be appropriate during international matches, when it is necessary to focus the attention of spectators on the field. Fig. 4 b) reflects the normal lighting mode when the orange spotlights are focused on the field and the fan zone lighting is not strong. In fig. 4 c) - energy-saving lighting mode, when all floodlights are not turned on at full power. In fig. 4 d) shows the lighting after performing the algorithm for automatic switching off of light, which is described in Lambda.

Conclusions. The introduction of the Internet of Things and the connection to lighting systems is creating another revolution, which in turn opens wide opportunities for the creation of advanced lighting systems for sports facilities. The proposed sports stadium lighting system provides seamless communication, contextual services and real-time data exchange between the PLC and the user interface via the AWS cloud platform. The infrastructure has been implemented as code using Terraform and setting up continuous automated lambda execution to ensure system economy. A study of effective lighting modes has been done for their implementation in the developed mobile application.

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СИСТЕМА ОСВІТЛЕННЯ СПОРТИВНИХ СПОРУД НА ОСНОВІ ТЕХНОЛОГІЙ ІНТЕРНЕТУ РЕЧЕЙ

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Досягнення смартфонів та наявність хмарних серверів дозволили розробити недорогі архітектури для систем управління освітленням спортивних споруд. У цій статті пропонується система освітлення на основі IoT, яка забезпечує дані в хмарі для мобільних додатків Android для прийняття рішень щодо управління сценаріями освітлення спортивного стадіону. Запропонована система освітлення використовує концепцію сервісної платформи з підтримкою IoT, яка використовує інфраструктуру, що складається з програмованого логічного контролера Siemens S7 1200, стаціонарної панелі оператора Siemens KTP900 Basic PN з підтримкою HMI, шлюзу IoT для реалізації каналу зв'язку між ПЛК та хмарними платформами, мобільного додатоку Android та серверної частини розгорнутої на хмарній платформі AWS. В AWS використовуються три основні послуги: Elastic Container Service, Amazon Lambda, Amazon Relational Database Service. Представлено підхід до розробки мобільного додатку, який поєднує в собі застосування хмарного сервера, пристроїв освітлення та бази даних для віддаленого контролю і управління системою освітлення спортивного стадіону. У цій роботі ми представляємо, як розробити та реалізувати розумну систему освітлення спортивного стадіону на основі інтернету речей, використовуючи різні режими освітлення.

Ключові слова: *система освітлення, PLC, IoT, AWS, Java, Python, мобільний додаток.*

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