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RESEARCH ARTICLE

IoT and Cloud Based Application for Smart Cities

Akıllı Şehirler için Nesnelerin İnterneti ve Bulut Tabanlı bir Uygulama

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ABSTRACT: The world population, which has increased exponentially in recent years, brings with it the increase in energy consumption and the existing causes rapid depletion of resources. As a result of increasing population numbers, the city jobs, housing, infrastructure, health, transportation, security, etc. meeting their needs difficulties are encountered. Parallel to the rapidly depleting resources, the cities offered to the population opportunities are decreasing and it is considered that it may become inadequate over time. Urbanism implemented with traditional administrations in terms of not experiencing difficulties in terms of resources and opportunities. approach has begun to leave its place to smart urban applications that can be described as smart. In this context, taking measurements from all physical sizes in our environment with the understanding of smart urbanism, resources are stored in place and interpreted both in real time and asynchronously. There are improvements in important criteria such as consumption of energy, raising the living standard of the population, and the use of efficient energy will be the subject. In this study, Industry, a concept that has entered our lives with smart urbanism and developing technology. Within the scope of 4.0, cloud computing and internet of things, which are among the Industry 4.0 application layers. An application on urbanism was carried out. Physical measurements taken from the environment, as a central microcontroller It was measured electrically via the Arduino board used and then simultaneously or via the internet o the Thinkspeak internet platform, a free platform for asynchronous use, for later interpretation was sent and stored here, and then the evaluation stages were carried out.
Keywords: Smart cities, internet of things, cloud information, environmental measurements, digitalization

ÖZ: Son yıllarda katlanarak artan Dünya nüfusu beraberinde enerji tüketiminin artırılmasını ve mevcut bulunan kaynakların hızla tüketilmeye başlanmasına neden olmaktadır. Artan nüfus sayısının bir sonucu olarak şehir kapasitelerinin çok üzerinde bir nüfusun iş, barınma, altyapı, sağlık, ulaşım, güvenlik vb. ihtiyaçlarının karşılanması konusunda zorluklar yaşanmaktadır. Hızla tükenen kaynaklara paralel olarak şehirlerin nüfusa sunmuş olduğu imkanlarda azalmakta ve bununla birlikte zaman içerisinde yetersiz duruma gelebileceği değerlendirilmektedir. Kaynaklar ve imkanlar noktasında zorluk yaşanmaması açısından geleneksel yönetimler ile uygulanan şehircilik yaklaşımı artık yerini akıllı olarak nitelendirilebilecek akıllı şehircilik uygulamalarını bırakmaya başlamıştır. Bu bağlamda akıllı şehircilik anlayışı ile çevremizde bulunan tüm fiziksel büyüklüklerden ölçümlerin alınması, depolanması ve hem gerçek zamanlı hem de eş zamansız olarak yorumlanması sonucunda kaynakların yerinde tüketimi, nüfusun hayat standardının yükseltilmesi, verimli enerjinin kullanımı gibi önemli kriterlerde iyileştirmeler söz konusu olacaktır. Bu çalışmada akıllı şehircilik ve gelişen teknoloji ile hayatımıza girmiş olan bir kavram olan Endüstri 4.0 kapsamında, Endüstri 4.0 uygulama katmanlarından olan bulut bilişim ve nesnelerin interneti tabanlı olarak akıllı şehircilik üzerine bir uygulama gerçekleştirilmiştir. Çevreden alınan fiziksel ölçümler, merkezi mikrokontrolör olarak kullanılan Arduino kart aracılığı ile elektriksel olarak ölçümlenmiş ve ardından internet aracılığı ile eş zamanlı ya da daha sonra yorumlanmak üzere eşzamanız kullanım için ücretsiz bir platform olan Thinkspeak internet platformuna gönderilerek burada depolanmış ve daha sonrasında değerlendirme aşamaları gerçekleştirilmiştir.
Anahtar Kelimeler: Akıllı şehirler, nesnelerin interneti, bulut bilişim, çevresel ölçümler, dijitalizasyon

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1. INTRODUCTION

In the last thirty years, population growth and migration from rural areas to urban areas have increased significantly. According to the data of Turkey Statistical Institute (TSI), while 76% of the population lived in rural areas and 24% in 2010, 92.5% of our population reached 81 million people in 2017 and only 7.5% of them live in villages and towns. At this point, our country is rapidly urbanizing well above the world rates [1].

This rapid population growth in the cities, making housing, transportation, education, health, infrastructure, green areas and etc. more difficult for local government services to reach people in a more comfortable, faster and cheaper way [2].

Nowadays, the way of providing these services to people quickly and inexpensively has brought about the concept of 'Smart City' with the use of information and communication technologies. "According to the European Commission, smart city is defined and shaped by factors of sustainability, economic development and quality of life. It is emphasized that smart city targets can be achieved through physical infrastructure, human and social capital, information and communication technologies infrastructures." Smart cities are created as safe, environmentally sensitive, effective and efficient living centers created with superior technologies such as sensor systems, electronic devices and communication infrastructure [3].

At this point, the 'Smart Cities' approach has come to the forefront in the policies of countries and international organizations as it has the potential to produce rational solutions to urban problems. This approach, which is based on the logic that urban infrastructures and networks, especially transport and energy, can manage itself without human intervention, aims to improve the living standards of people living in cities. Smart cities have many stakeholders from different sectors. Citizens, municipal administrations and communication companies are the primary stakeholders in anthropocentric smart cities. Human beings stand out as the mass and user in the target of the smart city, and municipalities are in an important place to provide public resources to citizens as a service.

On the other hand, communication firms have the function of gathering all the stakeholders in smart cities on a single roof and creating the bridge between them in terms of infrastructure [4].

1.1 The Examples of Smart Cities from our Country and the World

With the emergence of the concept of smart city, many countries in the world began to form the technological infrastructure in this direction.

It is predicted that cities which determines the needs and characteristics of cities in the direction of smart urbanisation and creating the ecosystem accordingly, will be one step ahead in the smart urbanisation. Amsterdam is a pioneer in the smart city approach, and its success is based on an approach that complies with the principles of strategic urban planning. Amsterdam's smart city strategy is called the "Amsterdam Smart City Program". The idea for this initiative was introduced in 2007. The smart city initiative was realized in cooperation with Amsterdam Innovation Motor, Liander energy network operator and Amsterdam Municipality. Through this portal, it is aimed to ensure the development and strengthening of Amsterdam's information society [5].

Barcelona, another example of a smart city, was implemented in 2012 under the name of 'Smart City Barcelona Program, along with 200 projects in 22 different sectors with a smart city road map by providing a holistic approach. Between 2011 and 2014, it has been identified that these smart project implementations of Barcelona contributed 85.000.000 euros to the economy, 12 supported projects created 1870 jobs, 53 million euros in investment and 0.53 euros in investment for each euro spent from the municipal budget. When the economic benefit analysis of these applications is made; There are 9700 tons of CO2 emissions thanks to smart traffic applications, 600.000 tons of water saving from park irrigation systems, and an economic benefit expectation of 832 million euros by 2025 [6], [7].

Copenhagen, which was chosen as the green capital in 2014, aims to increase the quality of life, economic growth and create a sustainable city by following the concept of smart city and enabling the participation of its citizens. When the economic impact of smart applications in Copenhagen is examined, 1% increase in the number of tourists visiting, new business opportunities of 104 million euros have been created, a saving of 5.5 million m3 in water consumption, a saving of 1.7 million liters of fuel at the end of 30 million km journey, and in addition, thanks to the intelligent traffic systems implemented, the traffic flow was improved by 11% and 32% [4].

Songdo, another smart city among the examples, is 65 km from Seoul, the capital of South Korea. The city of Songdo was established as a smart city by domestic and foreign large-scale companies, and the infrastructure of GIS systems was established in Songdo and smart home systems were delivered to all citizens through digital communication. For example, citizens can have meetings with their children's teachers through remote video communication, remote health care, public transactions, tax payments and information can be done. Garbage thrown from smart houses to garbage cans on the street is separated by underground separation units and conveyed to final waste collection sites [8].

In Turkey, the transition to smart cities and smart applications implementation, which started in the 2000s in development programs and plans, has been involved in policy and strategy documents. Policies, Vision 2023, Information Society Strategy and Action Plan [6].

Smart city elements are determined by sub-areas such as transportation, technology, energy, building, health services, infrastructure and management. Research firm Frost-Sullivan's report predicts that in 2025, there will be more than 26 smart cities in our country. Cities that make investments in some but not all of the areas identified as smart cities are called sustainable cities. In our country; In 2000, the process started with the establishment of an ecological and technological settlement named as the Informatics Valley Project in the province of Yalova, and the information-centered smart city projects continued later in Bursa, Ankara, Kocaeli, Eskişehir. Istanbul Fatih, Kadikoy, Beyoglu, smart city projects are carried out. Examples include smart meters, smart buildings, Fatih Sports Complex, ISKI (Istanbul Water and Sewage Administration), drinking water distribution management, IMM, Ispark traffic control center, smart parking pricing and automatic parks, Istanbulcart, Isbak, smart container, mobese and digital library. Istanbul Fatih Municipality has started to use augmented reality technology for the first time among local governments in its mobile application called FatihAR. According to this application, when the image of any building in Fatih Municipality is photographed and sent to the relevant service center with 3G-4G communication technology, the existing information about the building can be transferred to the user instantly. In Ankara, ASKI carries out applications such as administrative control and data acquisition system, EGO Cepte, smart stop, in-vehicle passenger information and camera systems, smart structures, industrial park, automatic fire brigade command center [9], [10].

Figure 1: Smart city policies.

"Turkey's First Smart City" program, in Karaman, offers to the public many smart applications such as traffic, education, transportation and environmental cleaning. Finally, smart bicycles, smart bus tracking systems, in-bus information

systems, smart city planning elements starting in Konya, smart stop, smart parking, smart junction, priority crossing, traffic control system, smart lighting, smart irrigation, remote meter reading, smart waste collection, disability navigation, smart measurement, patient monitoring, panic buttons, smart security, love chain, wireless internet, interactive kiosks, such as applications, the city provides central and local administrations [11].

In cooperation with Antalya Metropolitan Municipality and TURKSAT, the Smart City Application was passed with the protocol it signed in May 2015. Since 2015, free internet access is available in public areas such as municipal beaches, parks and Wi-Fi services. Blood pressure and blood measurement system, smart phone device and medical coaching services are provided to patients with chronic patient follow-up service, GSM panic button distribution is provided to a group of older citizens with panic button service, kiosk devices are installed in five places with city information screens. Following the implementation of the first protocol signed in 2015, in the second stage, projects such as supervision and smart junction systems, manageable wifi and internet service, smart irrigation, smart lighting, kiosks, city information screens and city management platform were included [12].

In Balıkesir, a total of 250 km of fiber optic lines were installed in Altıeylül, Karesi and Bandırma, the districts with the highest population, in cooperation with Turkcell Superonline. The smart junction system in the city receives its internet from this infrastructure. 17 intersections in the city were equipped with smart systems and improvements in traffic flow reaching 40%. With this intelligent junction system, data related to the transportation network can be obtained and recorded and reported, the signalized intersections can be managed from the control center, the duration of the adaptive managed signalized intersections can be automatically updated in line with the traffic data, and the images can be monitored live via traffic cameras. The sub-components of the traffic management system in Balıkesir have been established as signaling management system, data management system, video monitoring system, traffic control center and mobile application platform.Balıkesir Intelligent Public Transportation System (BALTUS) provides great convenience to citizens in public transportation. With the BALTUS software, citizens can learn bus schedules, bus arrivals and departures, stops, instant bus locations, filling points, balances on cards and fare schedules [13].

Since the electronic transformation processes started e-transformation in the management mentality, it has been observed that this transformation has been implemented both in the internal structure of the management system and in the public and local public services extending to the cities and offered to the public. KBS and GIS systems that we see in almost all cities today, traffic order, occupancy-space information used in parking lots, visualization of public spaces (parks, etc.) and applications etc. are the applications that facilitate the life of the city. The transition to smart administrations has become more than the return of the era and the preference of the governor, and has become the preference of the people living in the city [14].

In this study, IoT based atmel AVR microcontroller card has been used within the scope of smart life and smart management which is one of the basic elements of smart urbanism applications and the environmental measurement parameters such as light level, air quality, temperature and humidity have been monitored by using an environmental sensors of an monitoring was performed with cloud-based, IoT support. It was measured by sensors and transferred to the cloud and then to the internet environment. These findings were evaluated and evaluated to provide the most suitable working environment in terms of energy efficiency.

2. METHOD

Within the scope of smart management and life application, Arduino UNO, Arduino Ethernet shield and public office building's office environment, temperature, humidity, light level, CO2 gas levels were measured and monitored throughout the day. Following and evaluating these data over the internet, they were transferred to the cloud platform, which is a cloud computing server, and then evaluated.

2.1 *Hardware Components*

Arduino Uno includes a microcontroller with all of the components, 14 digital input-output pins are available and 6 of them can be used as PWM outputs. In addition, 6 analog inputs, 1 16 MHz crystal oscillator, USB output can be used.
Arduino Ethernet Shield is an electronic board with Wiznet W5100 ethernet chip. By installing this card on top of an arduino and connecting to an internet network with RJ45, the Arduino card can be opened to the internet. Arduino ethernet shield is compatible with TCP and UDP [15].

Air Quality Measurement Sensor (MQ-135) A gas sensor that calculates the ambient air quality by measuring the amount of NH3, NOx, alcohol vapor, benzene, smoke and CO2 gases [16].

It accurately measures the concentration of sulfur, benzene, water vapor, smoke and other harmful gases (NH3, NOx, Alcohol, CO2, etc.). Temperature and Humidity Measurement Sensor The DHT-11 is a digital temperature and humidity sensor. It uses the capacitive humidity sensor and thermistor inside. It transmits the data of the sensors to the digital output pin. The sensor outputs every 2 seconds. The maximum operating current is 2.5 mA. It works with 5% sensitivity for 20-80% humidity. It can measure 0-50 °C [17].

LDR photo-resistance decreases non-linearly as the amount of light falling on it increases. Therefore, the increase in light intensity causes the resistance value to decrease, and the decrease in light intensity causes the resistance value to increase. LDR (Light Dependent Resistor), in Turkish, means light-dependent resistance. Another name is photo resistance. Although LDR was a type of resistance, it was also a passive sensor [18].

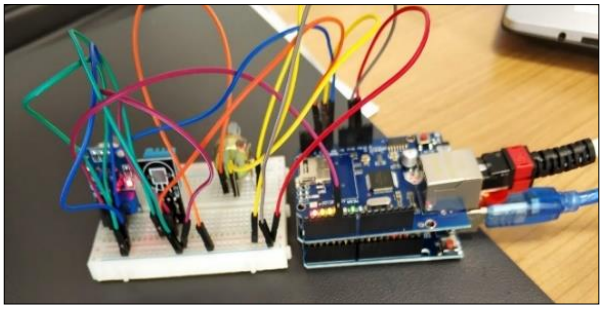

Figure 2: Electronic circuit.

2.2 *Cloud Software*

ThingSpeak is an IoT analytical platform service that enables the collection, visualization, and analysis of live data streams in the cloud. ThingSpeak provides instant visualization of data sent by devices to ThingSpeak. With the ability to run MATLAB code, it is often used for online analysis and data processing at the time the content is entered, and for prototyping IoT systems that require analytics. An IoT system includes all these elements. ThingSpeak is located in the cloud part of the diagram and provides a platform for collecting and analyzing data from sensors connected to the Internet [19].

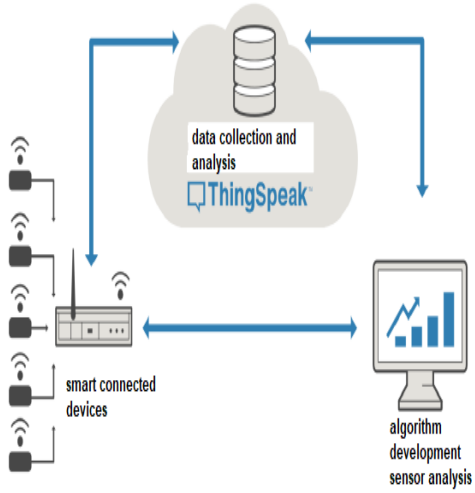

Figure 3: The general architecture of the system.

3. FINDINGS AND DISCUSSIONS

Illumiuance level is a very important factor for fast, safe and accurate vision of employees. It has been proved by scientific researches that it has an impact on employee performance, health and behavior. Flares due to insufficient or excessive lighting are examples of poor lighting. Poor lighting can jeopardize safety in the working environment, as well as blurred vision, pain and fatigue in the eyes, dry eye and headache. In a nutshell, economy is provided with a proper lighting system, work efficiency is increased, accidents that may be experienced are prevented, working environment comfort is provided and most importantly, human health is protected.

In the system, the data obtained from the illuminance level measurement sensor is converted

into a 'luxury' unit in the code block created by the Arduino IDE.

The level of illumination required in the general office areas is determined as 500 lux and the values of the data monitored during the day are determined over the internet, at what times of day and for how long.

In the light of the data obtained, it was determined in which periods the quality and clean air requirement in the office was needed during working hours. Carbon dioxide (CO2) is very important for determining indoor air quality. There is 0.03 vol% CO2 in the atmosphere. In outdoor environments, 330-500 ppm CO2 can be found according to environmental effects. Under normal conditions, CO2 is present indoors and although it is not a toxic gas, it can create oxygen deficiency and increase the risk of suffocation. When the CO2 concentration exceeds 35,000 ppm, breathing nerve receptors are triggered, leading to respiratory failure. Various disturbances may occur depending on the indoor air quality. These are defined as 'closed building syndrome, sick building syndrome and building related diseases.

The data obtained from the findings, depending on the temperature and humidity changes in the office, the heating and cooling systems during the day were examined to learn about when the circuit will be need to activated or deactivated.

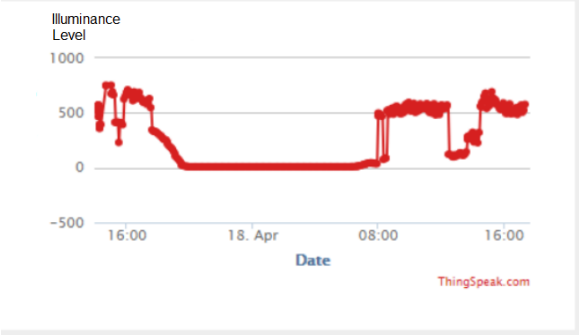

Figure 4: Illuminance level measurement data.

There is a central heating and cooling system in most of the management and living areas. However, it is known that in central systems, temperature differences occur between two neighboring offices. Even if they have the same internal temperature, the heat perception of the users may be different from each other. For example, one can say that an office with a temperature of 22 degrees is hot and the other can say that it is cold. As it can be understood from this situation, despite the thermostat, users' comfort understanding of temperature is different. As a result, it is seen that dry thermometers only adjust the temperature according to certain temperature values without considering comfort status. In room thermostats, the lack of temperature adjustment according to certain standards creates a disadvantage in terms of energy efficiency. The users are cooled by giving heat to the environment by sweating according to the activity they perform.

This affects the amount of humidity in the environment and creates differences in the sensed temperatures according to the relative humidity in the environment. In the findings found in the examination made in Figure 3; in the working environment, during the working hours, the level of illumination is mostly above 500 lux.

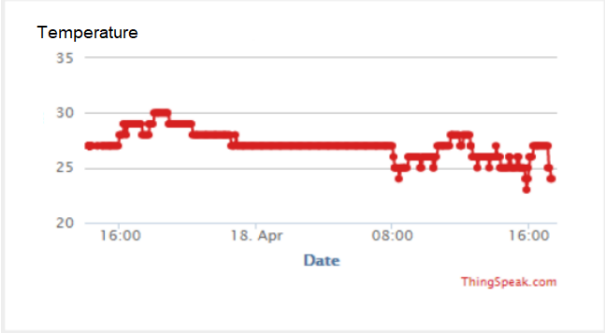

Figure 5: Temperature measurument data.

It is understood that it falls below this value during working hours and lunch time. As a result of the examination made in Figure 4; In the measured office environment, the temperature values are above 25 degrees Celsius over a large period of time. However, the fact that the office environment in which the data is received is sun-facing side has an effect. However, it was observed that the heating system was activated in the whole building with the effect of seasonal conditions.

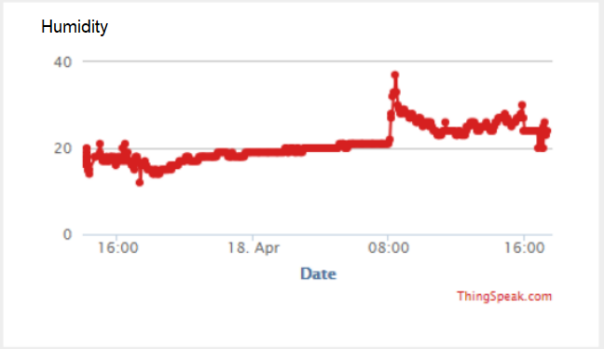

Figure 6: Humidity measurement data.

Figure 5 showed that the moisture content of the sample was observed in the 25-30% band. Figure 6 shows the data sent from the air quality measurement sensor to the cloud system. In the analysis made on the image, it is seen that the amount of harmful gas in the air is slightly below 200 ppm during the day.

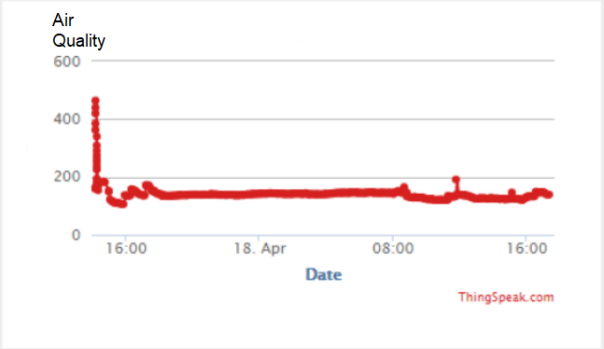

Figure 7: Air quality measurement data.

4. RESULTS AND RECOMMENDATIONS

In this study, "smart city" is defined. The necessity of smart urbanism services has been mentioned and the social and economic benefits of smart city have been revealed. The systems and services created by cities such as Amsterdam, Copenhagen and Barcelona, which are examples of smart cities in the world, are mentioned. The steps towards the smart cities in Turkey were researched. In the study carried out within the scope of smart living and smart management, which is one of the basic elements of smart urbanism applications, light level, air quality, temperature and humidity measurements were made by following an existing public administration building by using IoT-based Arduino and its components. These findings, which are measured by sensors and transferred to the cloud and then to the internet environment, are evaluated and discussed which steps can be taken in order to provide energy efficiency, optimal working and living environment.

As a result of the data obtained from the LDR of the light level measurement sensor in the created system, it was observed that a luminous level exceeds this value for a large part of the day in a living and management building with a light level requirement of 500 lux. The environment that is followed is a section where the illumination is high during the day. It is understood that a lighting control system can be established to open, close or reduce the lighting elements according to the changes in luminance levels and thus to achieve a large degree of energy efficiency.

In another analysis system, data from temperature and humidity sensors were examined. Humidity and temperature changes observed in the system established in the administration building were observed. Temperatures are above 25 degrees for most of the day. However, the fact that the environment in which the data is received is sun-facing side has an effect. However, it was observed that the heating system was activated in the whole building with the effect of seasonal conditions. The moisture content is 30% moist. It is ideal for the ambient humidity to be in the range of 50-55% to ensure optimum temperature sensation. In addition, it is observed that the consumption is unnecessarily increased due to the fact that the heating systems are activated especially during the mid seasons.

It is understood that if an intelligent management system is adapted to the changes in temperature and humidity during the day by means of remote monitoring and control systems, an effective way can be established in energy efficiency.

In the method made with the air quality measurement sensor, the air quality in the office environment was also monitored during the day and the periods during which the air had to be cleaned were examined. When the results were analyzed, it was observed that the ambient air values were 200 ppm. 400 ppm value was determined as critical value for ambient air and it was found that these values were not reached in the light of data. With the increase in this rate,

syndromes such as sleepiness, fatigue and boredom may begin to be seen in the people in the environment.

As ventilation devices cause high levels of energy consumption, it is concluded that energy efficient smart building solutions can be created by determining the times when ventilation systems will be commissioned and deactivated in the light of these data.

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