Edge Computing in Building Automation system - Pros and Cons

https://doi.org/10.31713/MCIT.2019.31

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Abstract— **This article examines the use of Building automation system to give comfortable conditions for users to provide improving energy efficiency. We found out the impact of the Internet of Things concept on BAS development, and how the use of modern wireless technologies, edge and cloud computing is determining the way of the following progress. Also, their advantages and disadvantages were considered. A separate section focuses on the state of BAS in Ukraine and the key factors that influence it.**

Keywords— BAS; Building Automation System; edge computing; IoT; cloud computing; fog computing.

I. Introduction

The main function of the Building Automation System (BAS) is to provide comfort to users. Today the interest in such systems increases. This is motivated by many factors: the rising cost of energy and the desire to increase our comfort, reducing the negative impact on the environment, and, not least, the global trend to rational consumption. That is, the automation system allows to increase the energy efficiency of the building, reducing the primary energy consumption for its maintenance, which is of great importance for both owners and end-users of the premises (residents, office tenants), as well as globally for the state, affecting the structure of energy consumption, since the maintenance of buildings is a significant part of the total use of primary energy - at least 30%, of which 85% goes to the heating and cooling of rooms [1]. As a result of the development of society, science and technology, the share of buildings energy consumption tends to increase [2]. Therefore, energy savings in this sector is considered very effective, promising and requires a lot of attention from scientists and engineers. Modern buildings have the potential to act as intelligent systems that promote the transition to smarter energy use [2]. Now we have got necessary control technologies to increase buildings efficiency but need to choose an optimal approach and technological set for this purpose.

II. Building automation systems

A. General overview

Automation systems represent a wide range of concepts, from the automatic work of certain structural parts of the building to the "intellectual" building, which integrates the tasks of maintaining climate parameters, security, maintenance, optimization and monitoring. They can help accelerate the use of renewable technologies and reduce energy consumption, carbon emissions and operating costs while increasing the thermal comfort, satisfaction, health and productivity of occupants [3]. The modern building is greatly influenced by the innovations in technology and information that are directly sought by BAS.

Initially, BAS included only heating, ventilation and air conditioning equipment (HVAC), gradually adding functionality such as lighting control, access control, and more. During the development, BAS made the transition from closed systems to the use of the Internet of Things and cloud computing.

Technology development has certainly been influenced by the increase in the cost of energy. So, more and more attention has been paid to the energy efficiency of buildings, which is the driving force of the industry. For a modern building, the automation system should be an integration centre that will include, in addition to HVAC management, a unified decision-making system for system management, maintenance management, monitoring and deep analysis of the data obtained.

B. Wireless technology

Hardware miniaturization, ubiquitous devices and connectivity are the three main technological factors in the new IoT paradigm [4]. Therefore, there is a real opportunity for the implementation of automation in older buildings, without the need for major reorganization, using the ability to create wireless networks of smart devices. In such cases, flexible wireless sensor networks are needed to realize the concept of a “smart” building, providing indoor and outdoor control and localized intellectual functions. They also need adaptive control systems that offer high usability and progressive programs that provide energy savings, improved safety, a more comfortable living and working environment [5]. Advances in electronics and wireless connectivity bring smaller components with reduced power consumption and reduced costs, allowing the development of low-power, low-cost wireless sensing and control devices to reduce human intervention [6].

In homes, wireless sensors provide low costs and ease of installation, as well as being easily upgraded to new and existing buildings, providing flexibility and controllability of the building management system throughout its life cycle (for example, changing floor plans). These wireless sensors can be used in the construction of lighting management, temperature monitoring, heating, ventilation and air conditioning, fire detection, surveillance and access control, etc.

However, wireless in-building environments is a difficult area. There are problems associated with the strong and difficult to predict loss of radio wave propagation path, as well as the need for simple, low-power sensor nodes. In addition to the technical benefits, wireless systems can cost less than wired systems. The wireless approach can reduce the cost of installing a single sensor by about 90% compared to a leading solution [5]. Popular wireless IoT solutions are built on Z-Wave, ZigBee, Wi-Fi, Bluetooth and EnOcean technologies [7].

C. *IoT usage: cloud, fog and edge computing*

According to Cisco forecast, the total amount of data created by any device will reach 847 ZB per year by 2021, up from 218 ZB per year in 2016 [8]. Also, it is predicted that by 2020 the Internet will be about 50 billion connected IoT devices [9].

These devices collect a lot of data. To obtain useful information, the data must be processed and analyzed. The amount of computing requires costly hardware or the use of cloud computing. However, in this case, the network must have a very high bandwidth. Edge Computing is a potential solution to this problem - a technology that optimizes computing. Edge Computing pre-processes data collected by Edge IoT devices before sending them to remote centralized or distributed servers deployed in the cloud [9]. Unlike cloud-based systems, Edge Computing offers a decentralized scheme of work with the distribution of computation at different levels (Figure 1) [9]. This allows you to retain the benefits of IoT solutions and eliminate several disadvantages of cloud computing (Table 1).

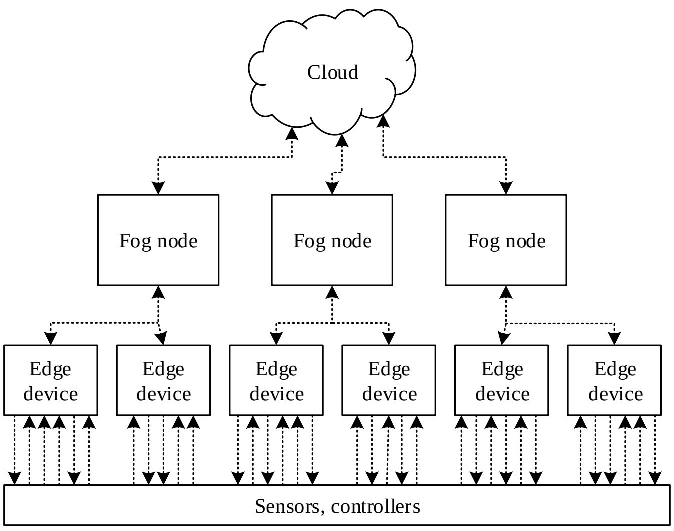

Figure 1. Hierarchical structure of the system using the cloud, fog and edge technologies

TABLE I. COMPARING THE ADVANTAGES AND DISADVANTAGES OF DIFFERENT TECHNOLOGIES

Parameter	Cloud computing	Fog computing	Edge computing
Benefits	Availability, scalability, high power, speed of calculation	Low latency, user defined security	Work in real-time, very low latency, system autonomy
Disadvantages	Lack of full control, high latency to transmit information, inability to access offline, low security	Limited scalability, limited memory, system complication	Service costs, limited resources (memory capacity), cost of equipment, computing speed

III. CHALLENGES AND ISSUES

The complexity of the management, structure and hardware of building automation systems logically led to a significant number of challenges and issues, which in turn gave rise to research in various directions. A large part of them relates to the use of modern concepts of the Internet of Things, cloud, fog and edge computing in BAS, optimization, adaptive control systems and exploring operating modes depending on building type, location, size, etc. mentioned below. The key development vectors, as noted earlier, are improving user comfort, reducing the cost of BAS implementation, reliability and optimizing energy consumption.

The first item may include the development and organization of access to visual interfaces for interaction with the system [11], or the implementation of interaction with a person by voting on their comfort level [12]. Such systems use feedback about the quality of climate parameter management, which allows us to focus not only on the set normative values of the parameters but also on the real feelings of staff or residents inside.

Trends in the use of edge, fog and cloud technologies in the right configuration reduce the price of the equipment as well as future maintenance costs [9]. However, with a three-tier structure, there is a risk of interruption in the connection between the parts, which affects reliability. An example of a solution is to duplicate levels-distributed functions in a simplified form so that, in the event of a break or failure of the structural part, BAS can function in a restricted mode until communication is restored [13]. Therefore, the distribution of functions is performed, on the one hand, with an emphasis on system reliability and performance. On the other hand, considering it as a compromise between the delay in data transmission and the time it takes to calculate

The field of energy optimization is inexhaustible because a complex BAS has many structural parts, each of which merits separate research. Includes the influence of human behaviour [14], the use of MPC, process modelling, etc.

IV. BAS STATE IN UKRAINE

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In Ukraine as in a whole Europe, the energy efficiency of buildings is key to sustainable development. However, despite the huge potential of energy efficiency, today Ukraine is one of the most energy-intensive countries in the world. This situation is related to several factors:

- low energy prices;
- over-regulation of the market through the provision of excessive subsidies and government regulation of prices;
- low public awareness;
- insufficient funding, etc.

Confirmation of the relevance of the issue is the adoption of the Law of Ukraine "On Energy Efficiency of Buildings", which entered into force on July 23, 2018 [15], which introduces a mandatory procedure for energy certification and definition of classes of buildings, compliance with the requirements for the minimum level of energy efficiency. It also focuses on the obligated automation of building systems to achieve high energy efficiency. A separate document regulating the scope of BAS is the European standard EN15232. This standard has been adapted in Ukraine and is used as a national standard DSTU B EN 15232: 2011 [16]. But despite government support, the importance of automation systems is being overlooked, so BAS will not gain popularity and widespread availability in the coming years, and complex smart homes and cities solutions will come from more economically advanced countries after testing and implementation.

V. CONCLUSIONS

The use of BAS is a strategic solution for the development of society and countries by improving energy efficiency, convenience and security. They can be key elements in building smart cities of the future.

The development of building automation is positively influenced by the concept of the Internet of Things. It broadens the audience, makes technology cheaper and, as a result, more affordable. IoT enables you to develop solutions that are appropriate for different market segments. Due to their flexibility and scalability, these design solutions can be upgraded to meet new trends. The use of wireless technology extends the capabilities of the system, increases the speed and reduces the cost of installing the system.

The rapid development of the industry is confirmed by various researches to improve the performance of BAS. They are about optimization, improving the energy efficiency of the building without reducing the comfort level of users, reducing the cost and increasing the reliability of the designed systems.

Ukraine already has legislation regulating energy efficiency and use of BAS. However, the importance of automation is overlooked, which negatively affects the development of the industry.

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