Occupational Health Service Platform Architecture based on IoT and Edge Computing

Kyoungjae Sun
ICT Convergence Standards Research Section
ETRI
Daejeon, Korea (Rep. of)
kjsun@etri.re.kr

Sung Hei Kim
ICT Convergence Standards Research Section
ETRI
Daejeon, Korea (Rep. of)
shkim@etri.re.kr

Hyungho Do
CEO
HealthAll
Daegu, Korea (Rep. of)
hhdo@healthall.co.kr

***Abstract*—This paper proposes an occupational health service platform architecture based on Internet of Things (IoT) and edge computing. In the proposed architecture, various types of IoT devices are used to collect workers' health status and occupational environment status. The functionalities defined in the platform running in a distributed way between the edge and core clouds are tailored to the characteristics of the workers' physical and mental healthcare system, as well as features for the improvement of the occupation environment. With the proposed idea, it enables to provide comprehensive capabilities for industrial health services, including worker health management, occupational environment enhancement, and human resource management.**

Keywords—Occupational Health, IoT, Edge Computing, Healthcare

I. INTRODUCTION

The convergence of physical devices with the internet has made the Internet of Things (IoT) and Edge computing technologies indispensable for advancing service innovation. IoT technology facilitates real-time data collection, analysis, and processing by interconnecting various sensors and devices. Also, edge computing optimizes network efficiency by minimizing data transmission to central processing systems, thereby reducing latency and conserving bandwidth. As a result of these advantages, the adoption of IoT and edge computing technologies spans various fields.

One of the emerging domains embracing these technologies is healthcare area, where IoT communication is extensively employed through health devices such as smartwatches, blood pressure monitors, and medication dispensers. These devices periodically monitor individual health status, leveraging data to offer personalized disease management and health improvements. The accumulated data finds application in diverse healthcare contexts, including medical care in hospitals, health insurance services, personalized health interventions, and therapies. Furthermore, the incorporation of Edge computing technology facilitates convenient data collection and remote individual management, enabling swift responses to emergencies and critical scenarios. Especially, edge computing significantly benefits enterprise environments with headquarters and multiple branches across diverse regions, allowing for the rapid and efficient collection of workers' health status and the delivery of appropriate occupational healthcare programs. However, some challenges are still remained in the context of occupational health services, which requires a broader perspective encompassing not only the scope of data collection but also diverse applications and the recipients of shared data.

This paper proposes an architecture considering the application of IoT and edge computing technologies for occupational health service platform and defines the functionalities within that platform. The main contributions of this paper are as follows:

- Analysis of existing works for digital health using IoT and edge computing, and occupational health service
- Architecture framework for occupational health service platform with IoT and edge computing
- Functionalities for providing occupational health service in proposed architecture

In Chapter 2, relevant studies related to occupational health services are analyzed, and Chapter 3 presents the proposed structure and functionalities. The paper concludes in Chapter 4.

II. RELATED WORKS

A. Occupational health service

In the modern occupation area, workers are exposed to various factors that have the potential to negatively impact their health depending on their specific occupations. These factors depend on the type of work, the physical and mental exertion involved, the materials and products utilized, and the working environment. For instance, workers in a logistics company who drive long distances may experience physical symptoms like herniated discs, respiratory diseases, or circulatory disorders, as well as mental health issues. Another example is a worker using polyurethane foam products, who developed respiratory symptoms and was diagnosed with new-onset asthma at the on-site clinic for employee health. Beyond the scope of workplace-related injuries and health risks, a noticeable surge in obesity and sedentary behavior among employees is evident, often aggravated by prolonged periods of sitting and compounded by age-related diseases and disabilities linked to an aging workforce. These concerns not only extend to physical maladies but also encompass significant psychosocial difficulties rooted in work-related stress [1]. Such risks bear substantial consequences, affecting not only individuals and local communities but also employers, leading to augmented costs including absenteeism, productivity reduction, and treatment-related expenses for companies underwriting workers' health insurance [2].

To solve these challenges, a growing number of companies have considered deploying occupational health services. These services are designed to uphold the health, safety, working capacity, and overall well-being of the working population [3]. Comprising an array of disciplines spanning beyond medicine, including occupational medicine,

nursing, ergonomics, psychology, hygiene, and safety, this comprehensive approach contributes to refining working conditions and establishing secure and healthful work environments.

However, the comprehensive approach also brings challenges in efficiently coordinating and sharing healthcare services among diverse stakeholders. To address these challenges and effectively provide occupational care across diverse domains, the platform for occupational health service is required for sharing workers' health status data among multiple health-related stakeholders inside of the enterprise and also external healthcare systems. By leveraging digital and IT technology, the occupational service platform enables rich connectivity, efficiency, and flexibility on individual, organizational, and societal levels. Consequently, it enhances user experiences, and decision-making processes, and supports entrepreneurial activities [4].

B. IoT and edge computing for healthcare

IT-based healthcare systems are referred to as smart health or e-health and more recently, they are being termed as digital health. In research related to healthcare systems, applying IoT and Edge computing technologies have been studied in around utilizing Edge computing resources to monitor symptoms based on health-related data measured from IoT devices [5]. For example, monitoring technologies have been proposed, such as dynamic detection of abnormalities in Electro Cardio Graphy (ECG) using wearable devices to track Parkinson's disease symptoms [6], and voice pathology detection using smartphones [7]. Besides of medical detection, a research in general health management has also been proposed, such as identifying different foods for diet analysis [8]. Most of studies focus on the rapid analysis of data collected from IoT sensors using artificial intelligence and predictive algorithms in Edge computing, for purposes ranging from pathological diagnosis to general health monitoring. However, these approaches do not, focus on healthcare application deploying within edge computing.

Existing studies related to industrial health have been focused to the monitoring of worker health and safety in challenging work environments through IoT devices, with providing swift assistance following workplace accidents [9,10]. In [9], a proposal was put forth for panel space operators to perform initial assistance by detecting gas leaks and fires at the worksite through IoT devices. In [10], they proposed using sensors attached to Personal Protective Equipment (PPE) worn by miners to assess compliance with safety regulations and monitor external risk factors. Recently, there has been an expansion of the scope of worker applications, including IoT-based sensor-driven employee health monitoring systems [11] to safeguard employees from infectious diseases like COVID-19. However, there are still lack of research on industrial health-related systems that manage various worker symptoms and illnesses.

III. OCCUPATIONAL HEALTH SERVICE PLATFORM

A. Occupational health service platform architecture

Figure 1 illustrates the proposed architecture of an occupational health service platform, which hinges on the synergy of IoT and Edge computing technologies. In the figure, there are diverse types of IoT sensors connected to the platform. These IoT sensors encompass not only health monitoring devices like smartwatches which affix to workers to gauge health metrics and IoT-enabled medical devices, but also sensors capable of measuring environmental data (e.g., temperature, humidity, and air quality) within the workplace, as well as industrial sensors. These IoT devices serve the purpose of quantifying variables germane to worker health, bolstering industrial health policies, and informing health-centric occupational resolutions. To facilitate the connection of IoT devices, the platform must provide IoT interfaces and protocols such as OCF [12] and LoRA [13].

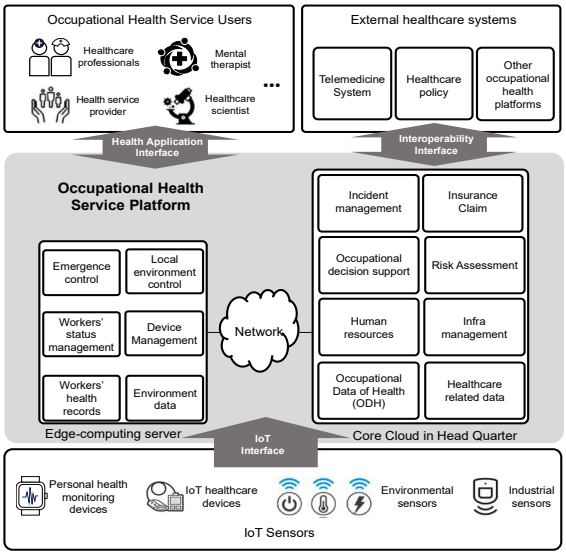

Fig. 1. Proposed plaform archichtecture fot occupational health services

The proposed occupational health service platform comprises a central cloud and distributed edge computing servers. Occupational health service functionalities are deployed at each server depending on its location and designated role. End users engaging with the occupational health services proffered by the platform encompass adept professionals who steer physical and mental health management based on the collated health records of workers—such as physicians, nurses, and mental therapists. Furthermore, occupational health service providers catering to employees' health management and healthcare scientists poised to harness the accrued data for health policy formulation can also be encompassed. To facilitate the exchange of health data to diverse stakeholders, the platform must provide user interfaces, necessitating the establishment of access and data access policies tailored to each user.

The proposed platform takes into account its cooperation with external healthcare systems, facilitating the exchange of healthcare data with telemedicine systems, healthcare policy organizations, and other occupational health service platforms. Telemedicine systems connected to external medical experts and hospitals require workers' health status to provide medical care. Healthcare policy organizations such as national industrial health bodies require data to determine the legal restriction and policies. Other occupational health service platforms can request to exchange of workers' historical healthcare records or occupational hazard data with previous employers or affiliated entities. To enable this interoperation with external systems, the proposed platform requires to provision interfaces to exchange healthcare data and occupational health-relevant information, necessitating

adherence to standardized interfaces like HL7 FHIR [14] and IHE [15] for healthcare data interchange.

B. Functionalities of occupational health service platform

The functionalities of the occupational health service platform, operational within the cloud, are located in distributed between the edge and the core cloud, aligning with their requirements and characteristics. Within this framework, edge computing servers are strategically stationed across diverse company branches or work sites, with their principal objective being the provision of customized occupational health services that are attuned to the nuances of local workers and the surrounding occupational environment. These servers are also adept at supporting services requiring rapid response times. In tandem with established functionalities like emergency response and worker health monitoring, which have been explored in prior studies, the proposed architecture introduces enhanced monitoring and environmental control capabilities, rooted in the environmental data within the edge computing server's coverage area. Therefore, edge servers facilitate the autonomous monitoring of hazardous environmental factors that could impact workers' health at each location, thereby enabling informed and rapid decision-making processes. The wealth of data collected from IoT devices can be subjected to thorough analysis and used by occupational health services, such as the management of local infrastructures and human resources within a specific area. The platform also provides interfaces that facilitate the seamless dissemination of the generated and analyzed data to a spectrum of stakeholders in formats that align with their distinct requirements. Conversely, the core cloud located at the enterprise headquarters takes the role of hosting occupational health service functions that require richer computational resources than their edge servers, less time-sensitive, or richer connectivity and interoperability. One example is a risk management function which is required to oversee the holistic views of workers' health and the comprehensive management of human resources, predicated on the data amassed through edge computing servers. Furthermore, to comprehensively deliver occupational health service provisions, functions such as insurance claims related to occupational incidents or diseases are also indispensable components within the architecture.

IV. Conclusion

In this paper, we have proposed an occupational health service platform architecture based on IoT and Edge computing, defining essential functionalities within the proposed architecture. Leveraging a distributed server architecture built upon Edge computing, enterprises can comprehensively manage workers' health and safety by utilizing distributed computing resources deployed at headquarters and branch offices. Using IoT devices, proposed occupational health service platform collect data not only of workers' health status but also of the occupation environment status. By defining functionalities that support improvements in workers' health and safety, as well as aiding in corporate occupation decisions based on that, this extended approach surpasses existing proposals, enabling a wide array of industrial health-related applications and facilitating interoperability with diverse stakeholders. To practically implement the proposed occupational health service platform, it is necessary to detailed design of IoT interfaces with stakeholders and additional features . It is also important to develop security and authentication functions to provide sensitive personal medical information and health records to stakeholders securely. These are remained as further researches to make real implementation of the proposed platform for occupational health services.

Acknowledgment

This work was supported by Institute of Information & communications Technology Planning & Evaluation (IITP) grant funded by the Korea government(MSIT) (RS-2023-00230017, Development of service model standard for IoT-based healthcare PaaS)

References

[1] M. Yassaee, T. Mettler, and R. Winter, “Principles for the design of digital occupational health systems,” Information and Organization, vol. 29, no. 2, pp. 77-90, June 2019.

[2] K. Sparks, B. Faragher, and C. L. Cooper, “Well-being and occupational health in the 21st century workplace,” Journal of Occupational and Organizational Psychology, vol. 74, no. 4, pp. 489-509, November 2001.

[3] World Health Organization, Global strategy on occupational health for all: the way to health at work, recommendation of the Second Meeting of the WHO Collaborating Centres in Occupational Health, no. WHO/OCH/95.1. Unpublished, World Health Organization, 1995.

[4] M. Balta, R. Valsecchi, T. Papadopoulos, and D. J. Bourne, “Digitalization and co-creation of healthcare value: A case study in Occupational Health,” Journal of Technological Forecasting & Social Change, vol. 168, 120785, pp.1-12, July 2021.

[5] S. U. Amin and M. S. Hossain, “Edge Intelligence and Internet of Things in Healthcare: A Survey,” IEEE Access, vol. 9, pp. 45-59, January 2021.

[6] A. A. Abdellatif, A. Mohamed, C. F. Chiasserini, M. Tlili, and A. Erbad, ‘‘Edge computing for smart health: Context-aware approaches, opportunities, and challenges,’’ IEEE Netw., vol. 33, no. 3, pp. 196–203, May 2019.

[7] G. Muhammad, S. M. M. Rahman, A. Alelaiwi, and A. Alamri, ‘‘Smart health solution integrating IoT and cloud: A case study of voice pathology monitoring,’’ IEEE Commun. Mag., vol. 55, no. 1, pp. 69–73, January 2017.

[8] C. Liu, Y. Cao, Y. Luo, G. Chen, V. Vokkarane, M. Yunsheng, S. Chen, and P. Hou, ‘‘A new deep learning-based food recognition system for dietary assessment on an edge computing service infrastructure,’’ IEEE Trans. Services Comput., vol. 11, no. 2, pp. 249–261, March 2018.

[9] Q. Sholihah, D. Hardiningtyas, S. A. Hulukati and W. Kuncoro, “Automation of occupational safety and health (K3) electricity based on internet of things (IoT),” IOP Conf. Series: Materials Science and Engineering, vol. 1034, no. 1, pp.012125, IOP Publishing, 2021.

[10] S. A. Ngubo, C. P. Kruger, G. P. Hancke, and B. J. Silva, “An occupational health and safety monitoring system,” Proc. of IEEE 14th International Conference on Industrial Informatics (INDIN), pp. 966-971, 2016.

[11] A. Nandakumaravarma, A. Gopalakrishnan, K. Ganesh, and S. Peter, “Employee Health Monitoring System with Attendance Tracking,” Proc. of the International Conference on IoT based Control Networks & Intelligence systems (ICINIS), 2021.

[12] Open Connectivity Foundation. *OCF Specifications*. Accessed: Oct. 22, 2022. [Online]. Available: https://openconnectivity.org/developer/specifications

[13] D. Shilpa, and A. Karthikeyan. "LoRa technology-an overview," Proc. Of 2018 second international conference on electronics, communication and aerospace technology (ICECA), pp.283-290, 2018.

[14] D. Bender and K. Sartipi (2013, June). “HL7 FHIR: An Agile and RESTful approach to healthcare information exchange,” Proc. of the 26th IEEE international symposium on computer-based medical systems, pp. 326-331, June 2013.

[15] R. Noumeir and B. Renaud, “IHE cross-enterprise document sharing for imaging: interoperability testing software,” Source code for biology and medicine, vol. 5, no. 9, pp.1-15, September 2010.