Digitalization and Management Innovation
A.J. Tallón-Ballesteros and P. Santana-Morales (Eds.)

doi:10.3233/FAIA230052

Application of Edge Computing in Smart Water

Lijuan YE[1], Jiaming ZHONG[1] and Xuan CHEN[2]
Xiangnan University, Chenzhou City, Hunan Province, 423000, China

Abstract. With the further development of the internet of everything, as well as the increasing number of smart phones, smart glasses, and other end devices, the data growth rate has far exceeded the growth rate of network bandwidth. Meanwhile, the appearance of numerous novel applications, such as augmented reality (AR) and driverless technology, has higher demand for network latency. Therefore, edge computing integrates computing, network, and storage resources into a unified platform, which offers services to users, so that the data can be effectively processed at the beginning. This model is different from cloud computing that transmits all the data to a data center. It bypasses the bottleneck of network bandwidth and delaying and has aroused widespread concern. At the beginning, this article introduces the concept of edge computing and presents the definition of edge computing; then, it introduces the basic concept, characteristics and demands of smart water; at last, it constructs a smart water system framework on the basis of edge computing, and conducts functional analysis on each layer of the framework.

Keywords. Edge computing, cloud computing, smart water, system framework.

1. Introduction

With the rapid development of smart technology, cloud computing, and big data in recent years, the internet industry has proposed new demands for computing pattern. In the era of big data, the data amount is increasing sharply every day, and the data on the internet of things is scattered in geology, which asks for higher demand for the response time and security. However, cloud computing has offered efficient computing platform for big data processing, the growth rate of current network bandwidth is far behind the growth rate of data. As a result, the decreasing rate of network bandwidth cost is much slower than the decreasing cost rate of CPU, internal memory and other hardware resources [1]. At the same time, complicated network environment makes it hard for network latency to achieve breakthrough improvement, so it requires traditional cloud computing to solve the bottlenecks of bandwidth and latency [2]. Under this circumstance, edge computing has come into appearance and has obtained widespread concern of researchers in recent years.

---

[1]The first two authors contributed equally to this paper and should be considered co-first authors;
[2]Corresponding author, Xuan CHEN, Xiangnan University, China; Email: wgyxycx@xnu.edu.cn
It is the research result of The Key Cultivation Base for "The 14th Five-Year Plan" of Educational and Scientific Research (Lifelong Education Research Base(Fundamental Theory Area)) in Hunan Province (XJK22ZDJD58).

2. Concept of Edge Computing

2.1 Definition of Edge Computing

At present, there isn't any unified and strict definition about edge computing, which is understood and illustrated by many scholars from different perspectives. Professor Satyanarayanan [3] from Carnegie Mellon University describes edge computing as follows: "Edge computing is a new computing model, which arranges computing and resources storage (such as Cloudlet, micro data center or fog computing) on the network edges near mobile devices or sensors." Shi W.S. et. el. [4-5] From US Wayne State University defines Edge computing as: "a new computing model carried out on the network edges. Its downlink data represents cloud service, uplink data shows the internet of everything, while the edge of edge computing refers to any computing or network resource in the routing center from data source to cloud computing." These definitions emphasize that edge computing is a new computing model, whose key concept is that "computing should be much closer to the source or the data and closer to users." Here, "close" includes several kinds of meaning. Above all, it can represent the short network distance, so some instable factors, like reducing bandwidth of network scale, latency, and vibrating, can be easily controlled and improved. It can also represent the short distance, which means edge computing resources and users stay at the same scene (shown in the position). Therefore, it can offer individualized services (such as the services based on location information) to users. Sometimes, the space distance and network distance may not be connected, but the application can select appropriate compute nodes in accordance with its needs.

Network edge resources mainly consist of the user terminals like mobile phones and personal computers; infrastructures such as WiFi access point, cellular network base station, and routers; embedded devices like cameras and set-top boxes; micro computing centers like Cloudlet, MicroDataCenter. These resources are large in number, and are scattered around users independently, which are then called edge nodes. On the other hand, edge computing can unify these independent and scattering resources, to provide services for users.

To sum up, we define edge computing as "a new computing mode, which unifies nearby resources in geological distance or network distance, to offer computing, storage, and network services". [6]

2.2 Edge Computing Platform

Edge computing platform consists of edge computing nodes and intermediate computing nodes. By using computing, storage, and network resources of the data transmission route, edge computing platform distributes many decentralized and irrelevant light tasks to each node, so as to achieve unified control and management. In this way, tasks can be carried out, and developers can rapidly develop and deploy the application, so that it can offer services to users, and thus becoming the infrastructure of edge computing. Meanwhile, the original data may be refined on the edge computing platform after being processed, while the number of data being transmitted on the core network will be reduced greatly. Therefore, edge computing technology has ensured the efficiency of analysis framework and reduced the data amount to be uploaded to the cloud, which is the key to the efficiency of the whole framework. [7]

2.3 Basic Concept and Features of Smart Water

By making use of some high-tech information technology, such as the internet, internet of things, 3s technology, big data analysis, cloud computing, virtual reality, numerical simulation, and AI, smart water refers to a corresponding intelligent technology system of monitor, control, management, and integrated utilization during the process of natural circulation and social circulation of water. Smart water devotes itself to promoting integrated, refined, coordinated, and scientific management of hydrology, meteorology, ocean, water conservancy, and water affairs, and pushing forward to the smart development of public services. In this way, it can provide intelligent services to integrated utilization and management of water resources, flood control and drought relief, disaster prevention and reduction, along with protection of water ecological environment, to realize intelligent water control, intelligent water utilization, and intelligent water management in the whole world and society.[8]

3. Big Data System Framework of Smart Water Based on Edge Computing

Edge computing offers services near the data source, so that it can give full play to its advantages on many mobile applications and internet of things applications. Aiming at the characteristics and demands of smart water, this paper integrates the application of edge computing into smart water system, and constructs a smart water big data system framework based on edge computing [9-11], which is shown in Figure 1. According to this system framework, cloud computing technology and edge computing technology complement each other, to help edge devices acquire and process related data and information of water activities, and to hep cloud computing centers summarize and further process computing analysis results. The system is made up of data collection layer, data processing layer, and data application layer. In data collection layer, various sensors and network terminals can collect the data of enterprise operation; in data processing layer, edge computing can process a large amount of edge equipment data and protect the privacy, while cloud computing provides powerful computing and storage support; in data application layer, it offers various forms of water application services to users.

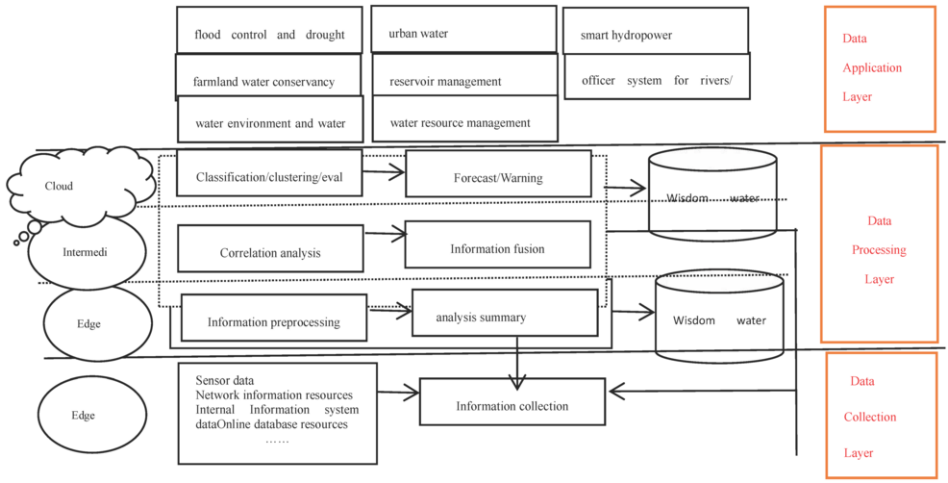

Figure 1. Smart Water System Framework Based on Edge Computing

(1) Data Collection Layer
Data collection layer is made up of various types of sensing equipment and smart devices based on the internet of things, which takes charge of the data collection relating to water affairs. At the data collection layer, edge computing nodes can collect sensor data, data from internal information system, network data, and data from online database. This layer is the foundation for water system to analyze, process, and utilize related data and information of enterprises. Data collection layer consists of the following functions: first, relying on all kinds of sensors, it can collect some real time data of nearby intelligent terminal devices, such as regional user group, user behavior, feedback, water consumption, water quality, and leakage rate of pipe network, to monitor and control water environment, water ecology, and water resources in an all-around way. Second, through wireless communication link, it can exchange data between edge devices and between the devices and the upper layer.[12]

Because the data collection layer in smart water system framework based on edge computing is near the network edge of data source, the efficiency of obtaining data is higher; its scope is wider, and data recognition is more accurate when compared with traditional data collection layer.

(2) Data Processing Layer
This layer consists of edge computing nodes, intermediate nodes, and cloud computing center. According to different computing capability and task demands, these three data processing subjects can process data at different degrees, which can then generate related information and knowledge of smart water. [13-15]

(3) Data Application Layer
Data application layer is made up of cloud servers, which would further calculate all kinds of data after ECN treatment, to optimize smart services. In order to adapt to the characteristics of smart services, data application layer should coordinate with edge node layer. Edge node layer takes charge of real time data processing from intelligent equipment and sensors, so as to reduce the delayed response time of terminal application. On the other hand, data application layer takes charge of centralized treatment of scattering data from edge node layer to improve the functions of intelligent terminal devices. As edge node can collect and pretreat users' various types of behavioral data, while cloud center only needs to comprehensively calculate the treatment results from edge layer, and effectively reduce the calculation pressure of cloud center. Therefore, smart water activities based on edge computing framework are more effective and accurate.

Data application layer includes many applications, such as flood control and drought relief; farmland water conservancy; water environment and water ecology; urban water; reservoir management; smart hydro-power; officer system for rivers, lakes or bays; and water resource management.

4. Conclusions

Taking basic framework of edge computing technology as reference, this paper discusses about the application of edge computing in smart water, and proposes a big data system framework for smart water based on edge computing. By means of unique system framework and reasonable rights and liability distribution, smart water system based on edge computing can provide diversified services with faster speed, higher quality, and better efficiency. Through collection, analysis, integration, and extraction

from data collection layer and data processing layer, the obtained information and knowledge are stored in water information database and water knowledge base, which would become the foundation of various services in this system. By turning the requests input by users into standard expression, and through rapid searching in water information database and water knowledge base, cloud computing center can provide the information knowledge or deliver the answers required by users, to achieve the interaction with users. Moreover, edge computing model also creates conditions for the system to perceive the enterprise development trend, because edge computing node and cloud computing center could comprehensively collect and analyze all the information concerning about enterprise competition in real time. At last, it shapes the understanding about the situation of enterprises, and presents complicated application scenes to users through visualization technology.

Acknowledgments

It is supported by the Lifelong Education Research Base(Fundamental Theory Area)) in Hunan Province (XJK22ZDJD58); Resarch Center of Water Resource Management Information and Big Data Mining Technology in Chenzhou (yfzx201901); Science and Technology Planning Project in Chenzhou, “Study on the Application of Big Data in Sustainable Use of Water Resources” (zdyf201915).

References

[1] Gray J., 2004. Distributed computing economics. Queue, 6(3), 63-68.
[2] Armbrust M.; Fox A.; Griffith R., etal, 2009. Above the clouds: A Berkeley view of cloud computing. UCB/EECS-2009-28. Berkeley: EECS Department.
[3] Satyanarayanan M., 2017. The emergence of edge computing. Computer,50(1), 30-39.
[4] Shi W.S.; Sun H.; Cao J. , etal, 2017. Edge computing-- An emerging computing model for the Internet of everything era. Journal of Computer Research and Development, 54(5), 907-924.
[5] Shi W.S.; Cao J.; Zhang Q., etal, 2016. Edge computing: Vision and challenges. IEEE Internet of Things Journal, 3(5), 637-646.
[6] Zhao Z.M.; Liu F.; CaiZhiping, and XiaoNong, 2018. Edge Computing: Platforms, Applications and Challenges. Journal of Computer Research and Development, 55(2), 327-337.
[7] Tang M.W.; Su X.N.; Zhang Y.Q., 2018. Collection of Emergency Information of Internet of Things in Big Data. Information science, 36(3), 46-50,69.
[8] The Institute of Smart Water, Wuhan University. Smart Water [EB/OL]. http://zhsy.whu.edu.cn/yjsgk/zhsy.
[9] Chu J.W.; Chen F.; Guo Ch.X., 2020. Exploration and Application of Edge Computing in Library Smart Services. Information Studies: Theory & Application (ITA), 43(3), 78-84.
[10] Li Y.T.; Shi J.; Hu Y.P., 2019. Research on Competitive Intelligence System Based on Edge Computing. Information science, 37(10), 34-39.
[11] Lin B.; Yang R.ZH.; Yang ZH.X.; Jin K., and Zhang Y.H., 2018. Intelligent Agriculture System Based on Block Chain and Edge Computing. Technology Intelligence Engineering, (3).
[12] Zhang B.F.; Zhang X.W., 2019. Design of Remote Video Supervisory System for Cultural Relics Security Based on Edge Computing. Journal of Beijing Union University, (3), 83-88.
[13] Qi B.; Xia Y.; Li B.; Shi K., and Xue M.F. 2018. Home Energy Management System Based on Edge Computing: Framework, Key Technology, and Implementation Methods. Electric Power Construction, 39 (3), 33-41.
[14] Wang SH.Q.; Wang Y., 2019. New Data Processing System Based on Edge Computing. Computer and Modernization, (7), 15-19+87.
[15] Zhang J.M.; Xie W.L.; Yang F.Y; Wu Zh.Y., and Xie L., 2016. Mobile Edge Computing Technology and Local Offloading Scheme. Telecommunications Science, 32(7), 132-139.