UDC 004.75

DOI: 10.18372/2073-4751.75.18012

[1]**Gasimov V.A.**, Doctor of Technical Sciences,
orcid.org/0000-0003-3192-4225,
[1]**Aliyeva Sh.Kh.**,
orcid.org/0000-0002-6481-1801,
[2]**Assanova Zh.S.**,
orcid.org/0000-0003-4456-9891

IMPLEMENTATION OF INDUSTRIAL INTERNET OF THINGS TECHNOLOGIES USING EDGE, FOG AND CLOUD COMPUTING

[1]**Azerbaijan Technical University**
[2]**Korkyt Ata Kyzylorda University**

vaqif.qasimov@aztu.edu.az,
shahla.aliyeva@aztu.edu.az

Introduction

The spread of the Industrial Internet of Things in various areas providing service to users around the world has changed the way businesses operate, and there has been a major shift in the industry from local applications to cloud computing. Companies are expanding their services from smart voice assistants to smart homes and are constantly testing new ideas to attract more customers.

The use of cloud technology without the need to increase computing power in computers, laptops and IIoT devices, without additional investment in their memory capacity has freed users from the problem of data storage and computation.

But today there is a serious need to reduce latency in certain applications, such as smart home appliances or self-driving cars.

Ever-growing demands for better and faster technologies make organizations to constantly increase their capabilities to meet the user needs. However, as organizations develop, they face the problem of the cloud alone not meeting the needs of their growing data exchange. This forces them to think about finding a way to store their data in the cloud, depending on the choice.

Today, the development of technology in many ways has transformed the internet from an information source to a data transfer mechanism with high computing power. The transition from a centralized architecture to a distributed architecture provides many advanced features for users.

In view of the above, the article examines technologies such as cloud computing, fog computing, edge computing, comparing them and analyzing the possibilities of their practical application.

Cloud computing, fog computing, edge computing and the correlation between them.

Smart applications that use artificial intelligence and machine learning often process large amounts data that is expensive to send or store to a central cloud service. Moreover, not every piece of data collected may be useful to users. If some portion of the computing can be done at the edge of the network, only important data can be transferred to the cloud server, which helps to significantly reduce costs. At the same time, bringing the computing power closer to the edge of the network also enhances security [1].

While the cloud provides computing, storage, and even communication which we can easily and efficiently access, such centralized sources can cause latency and performance problems for remote devices and data from a central public cloud or data center [2].

The ability to compute and analyze on a smart device is called "edge computing." IoT and edge computing are interrelated because edge computing solves IoT problems such as network traffic and latency. It opens up new possibilities in IoT applications, especially for those relying on machine learning in matters such as object detection, face recognition and obstacle avoidance [3].

IIoT technology is mainly used in the following areas and is expected to affect everything around us in the coming decades:

- in the oil and gas industry: management of oil exploration, production, refining, transportation and sales;
- in cities: traffic management, lighting, parking, smart office buildings, waste management;
- in cars: predictive maintenance, collision avoidance, self-driving vehicles;
- in power generation and distribution: smart grid, microgrid, power plant control systems;
- in agriculture: efficient production, situational irrigation and fertilization;
- in the environment: early detection of forest fires, tracking of endangered animals;
- in medicine: remote diagnosis, monitoring of the elderly and sick;
- etc.

Edge computing process brings the data closer to the source, and for it to work, data does not need to be sent to the remote cloud or other central systems. Edge computing can increase the speed and performance of data transfer, edge devices and applications, taking out of the equation the distance and time required to send data to central sources.

Fog computing is a standard that determines how edge computing works. It is a term created by Cisco. For computing is used on intermediate-level devices between the cloud and IoT edge devices called a fog layer. The fog layer consists mainly of fog nodes, which are industrial managers, gateway computers, switches and input/output devices providing computing, storage and communication services [4]. The fog computing model brings the cloud closer to the edge of the network where the devices are located and facilitates the operation of computing, storage and network services between the end devices and the cloud computing data centers (fig. 1).

The terms "edge computing" and "fog computing" are somewhat similar and are used interchangeably. Both edge and fog computing systems bring data processing closer to the source that produces data. The main goal in doing this is to reduce access to the data sent to the cloud. This helps to reduce latency and thus eliminate system sensitivity, especially in long-distance critical applications.

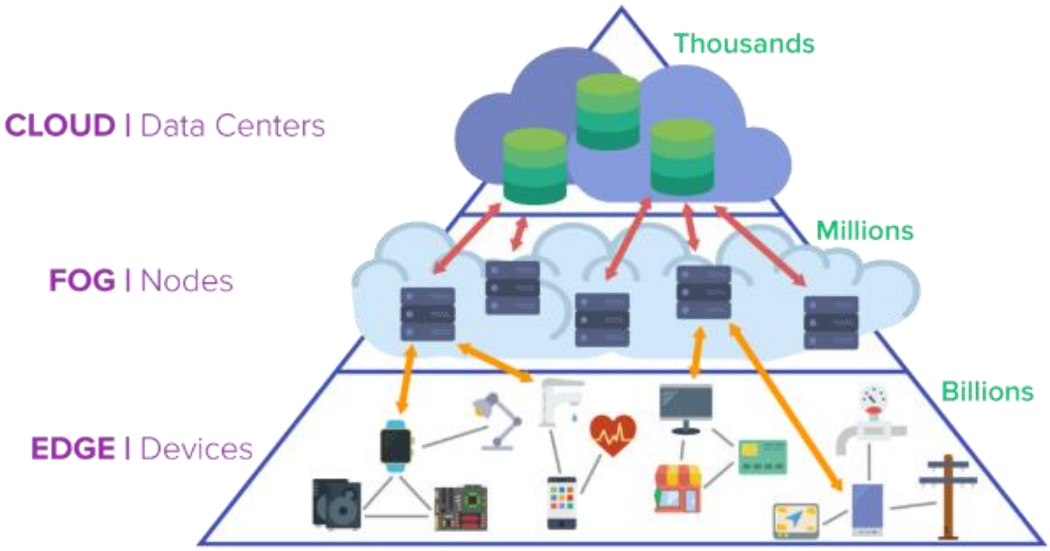

Fig. 1. Fog junctions connect external devices to the cloud

By bringing data processing closer to the source, companies also increase security because they do not need to send all the data over the public Internet.

Both edge and fog computing paradigms are similar, both intellectually and in terms of sending data to the data source or to nearby analytical platforms (cars, engines, speakers, screen sensors). Both technologies use the power of local area network computing capacity to perform computational tasks that can be easily performed in the cloud. It helps organizations reduce their reliance on cloud technology for computing and storing data, which eliminates common latency problems and speeds up data-based decisions. In other words, edge and fog computing models can minimize latency on smart devices and make faster decisions compared to the cloud computing model.

Edge computing processes certain applications based on a fixed logic and provides a direct transfer service without data analysis. Fog computing works with edge computing to run applications in a multi-level architecture that separates and connects devices and software and allows reconfiguration for a variety of applications, while continuously implementing smart transfer with computing, storage, communication capacity in the cloud (fig. 2) [5].

The main difference between cloud computing, fog computing and edge computing is where the data is processed. In cloud computing, data is generally processed on a central cloud server located outside the data source. Edge computing usually occurs in the devices to which sensors are connected or in the gateway device located near the sensors. Fog computing forwards edge computing tasks to LAN equipment or processors directly connected to the local network so that they are physically away from the sensors.

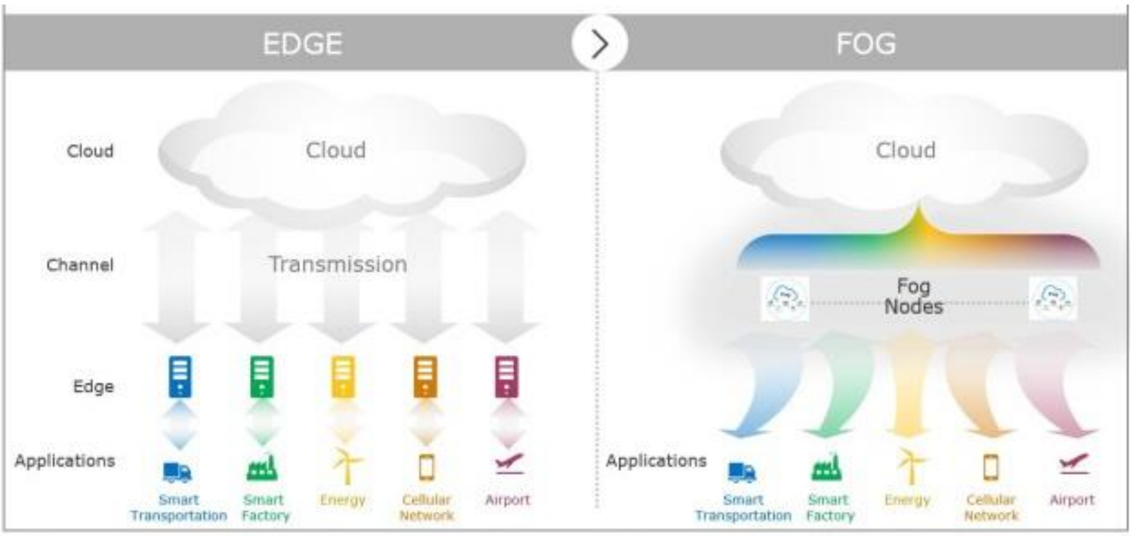

Fig. 2. View of edge and fog architectures

Therefore, data in edge computing is processed in the sensor or device without moving to another location. In contrast, in fog computing, data is processed within an IoT gateway or fog nodes located in the LAN.

Cloud computing has more data storage capacity than fog computing with its limited processing power, as well as superior and advanced computing technological capacity, and the computing power and storage capacity of Edge computing are lower than those of cloud computing, as both operations are performed in the devices (IIoT sensors) themselves.

Cloud computing is the most suitable solution for long-term in-depth analysis of data. On the other hand, fog and edge computing are more suitable for fast real-time analysis.

It should be noted that, unlike cloud computing that is dependent on the Internet, Internet access is not required for the use of edge and fog computing. Thus, they are more suitable for cases where IoT sensors may not have an uninterrupted Internet connection.

Fog computing is used to facilitate the connection between the cloud and IoT devices by providing computing, storage and data management at network nodes in the vicinity of IoT devices. The cloud-IoT connection is activated by edge computing, which is a P2P (peer-to-peer) network of decentralized users (fig. 3) [6].

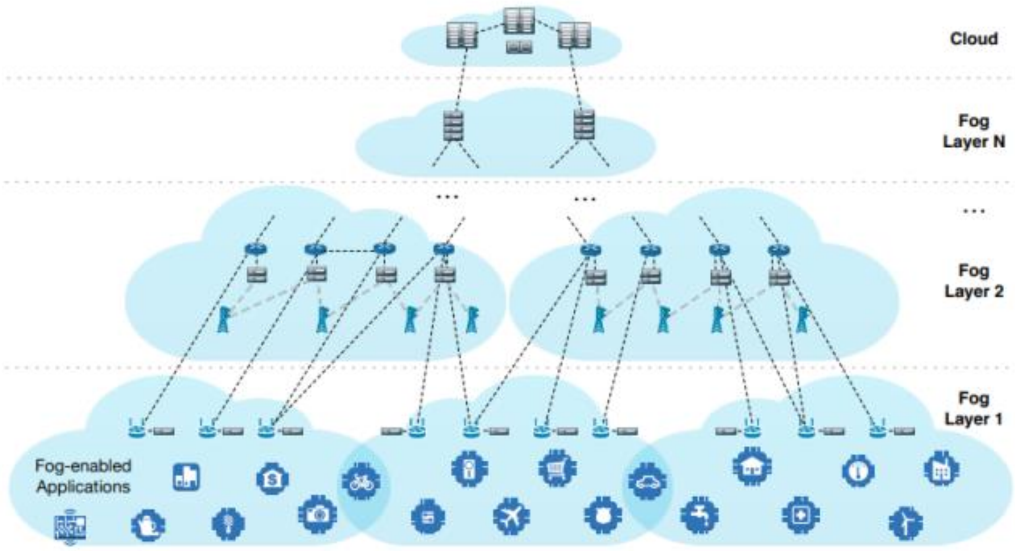

Fig. 3. Cloud use of network technology in IoT connection

From a security perspective, fog and edge computing technologies are very convenient. In fog computing, data is distributed between nodes. Therefore, it is more difficult to manage data than in the centralized structure of cloud computing. In edge computing, the data remains in the device itself, which makes it the most reliable of these three computing technologies. For this reason, when security is important, fog and edge computing are preferable.

Again, because data is distributed between nodes in fog computing, the latency is minimal compared to cloud computing, where everything is stored in a single center, and it does not disrupt the entire system if any errors occur. Even if one node is switched off in fog computing, keeping the other nodes in operation is the correct choice for use cases that require zero gap.

Conclusion

The main difference between an IoT device or an application that communicates with a cloud server is that a two-way transmission with a cloud server can take several minutes, whereas the interaction between the "nodes" takes several milliseconds.

While cloud computing remains the first choice for storing, analyzing and computing data, organizations are gradually moving to edge and fog computing to reduce costs. The main purpose of reconciling these two architectures is not to completely change the cloud, but to select only the important data from the general data flow.

Edge and fog computing architectures are also used to deal with performance optimization. Thus, although edge computing is widely used by medium-sized companies and telecoms working with backbone networks and radio networks, fog computing is more commonly used by data processing companies and service providers.

References

1. Bellavista P., Foschini L., Scotece D. Converging Mobile Edge Computing, Fog Computing, and IoT Quality Requirements. *2017 IEEE 5th International Conference on Future Internet of Things and Cloud (FiCloud)* / Prague, 2017. P. 313–320.

2. Bittencourt L.F., Diaz-Montes J., Buyya R., Rana O.F., Parashar M. Mobility-aware application scheduling in fog computing. *IEEE Cloud Computing*. 2017. Vol. 4. Iss. 2. P. 26–35.

3. Yi S., Hao Z., Qin Z., Li Q. Fog computing: Platform and applications. *2015 Third IEEE Workshop on Hot Topics in Web Systems and Technologies (HotWeb)* / Wasington, DC, 2015. P. 73–78.

4. Hu P., Dhelim S., Ning H., Qiu T. Survey on fog computing: architecture, key

technologies, applications and open issues. *Journal of Network and Computer Applications*. 2017. V. 98. P. 27–42.

5. Vilalta R., Lopez V., Giorgetti A., et al. Telcofog: A unified flexible fog and cloud computing architecture for 5g networks. *IEEE Communications Magazine*. 2017. V. 55. Iss. 8. P. 36–43.

6. Pinedo M.L. Scheduling: theory, algorithms, and systems. Springer, 2016. 690 p.

Gasimov V.A., Aliyeva Sh.Kh., Assanova Zh.S.

IMPLEMENTATION OF INDUSTRIAL INTERNET OF THINGS TECHNOLOGIES USİNG EDGE, FOG, AND CLOUD COMPUTING

Having superior features of productivity of the Industrial Internet technology of things used in the establishment of clever cities and clever villages, optimity, etc. increases the need to use it. The low-capacity of the physical resources of Iot-based sensors allows it to integrate into cloud technology. Cloud-based infrastructures are not sufficient for the existing requirements of the products of the products. The two main issues, in terms of reconciliation and network expansion limits arise. Also, the breaks of the Internet connection, the low conductivity, etc., as such problems, allow IIOT to integrate the "Fog Computing" and "Edge Computing" technologies. Taking into account the coverage and development of IIOT technology, it is believed that in many cases taking advantage of its full potential will be possible to combine clouds, fog and edge calculations. In this article, Industrial Internet technology of things, its integrated "Cloud", Fog ", Edge technologies are being investigated and differences between them, distribution-based approaches between levels are discussed.

Keywords: *Industrial Internet of Things, IIoT, Edge computing, Fog computing, Cloud computing.*

Касумов В.А., Алієва Ш.К., Асанова Ж.С.

ВПРОВАДЖЕННЯ ТЕХНОЛОГІЙ ПРОМИСЛОВОГО ІНТЕРНЕТУ РЕЧЕЙ ЗА ДОПОМОГОЮ EDGE, FOG ТА ХМАРНИХ ОБЧИСЛЕНЬ

Володіння чудовими характеристиками продуктивності промислової Інтернет-технології речей, використовуваної при створенні "розумних міст" і "розумних сіл", optimity і т.д. збільшує потребу в її використанні. Низька ємність фізичних ресурсів датчиків на базі Інтернету речей дозволяє їм інтегруватися в хмарні технології. Хмарних інфраструктур недостатньо для задоволення існуючих вимог, що пред'являються до продуктів групи продуктів. Виникають дві основні проблеми, пов'язані з узгодженням і обмеженнями на розширення мережі. Крім того, обриви інтернет-з'єднання, низька провідність і т. д. такі проблеми дозволяють ІІОТ інтегрувати технології "туманних обчислень"і" прикордонних обчислень". Беручи до уваги охоплення і розвиток технології ІІОТ, вважається, що в багатьох випадках використання всього її потенціалу дозволить комбінувати обчислення хмар, туману і кордонів. У цій статті досліджується технологія промислового Інтернету речей, її інтегровані "хмарні", "туманні", прикордонні технології та обговорюються відмінності між ними, підходи, засновані на розподілі між рівнями.

Ключові слова*:* *промисловий Інтернет речей, IoT, прикордонні обчислення, туманні обчислення, Хмарні обчислення.*