International Journal of Distributed and Cloud Computing
12 (1) 2024, 01-07
http://www.publishingindia.com/ijdcc

Performance Analysis of Cloud and Fog Computing at Emporium

Aadhi Mahishi J.[1], Deepthi B. V.[1], Dharini B. N.[1], Varsha B. R.[1] and Samara Mubeen[2*]
[1]Student, Department of IS&E, JNNCE, Shimoga, Karnataka, India.
[2]Assistant Professor, Department of IS&E, JNNCE, Shimoga, Karnataka, India.
Email: samaramubeen@jnnce.ac.in
*Corresponding Author

Abstract: Cloud computing refers to manipulating, configuring, and accessing the hardware and software resources remotely. It offers online data storage, infrastructure, and application. Cloud computing offers platform independency, as the software is not required to be installed locally on the PC. Hence, the Cloud computing is making business applications mobile and collaborative. Fog computing facilitates the operation of compute, storage and networking services between end devices and cloud computing data centers. Fog computing, also known as fog networking, is a decentralized computing infrastructure in which computing resources and application services are distributed in the most logical, efficient place at any point along the continuum from the data source to the cloud. In a fog environment, the processing takes place in a data hub on a smart device, or in a smart router or gateway, thus reducing the amount of data sent to the cloud. It is important to note that fog networking complements not replaces cloud computing; fogging allows for short-term analytics at the edge, and the cloud performs resource-intensive, longer-term analytics. Emporiums generate a large amount of data from thousands of sensors that it can be useful for monitoring and analyzing, transferring data from sensors to cloud and then giving a feedback to end user so, this could be a problem at emporium because of high delay. Fog computing consider to be temporally near to the sensor; thus will decrease delay. The performance analysis of both architecture is done using iFog simulator in order to know which is the best.

Keywords: Cloud, Fog, iFog simulator.

I. Introduction

The popular trend in today's technology driven world is 'Cloud Computing'. Cloud computing can be referred to as the storing and accessing of data over the internet rather than the computer's hard drive. This means that one person does not need to access the data from either computer's hard drive or over a dedicated computer network (home or office network). Cloud computing means data is stored at a remote place and is synchronized with other web information.

Fog computing is a term created by Cisco that refers to extending cloud computing i.e., fog nodes at different locations are connected to single cloud. Fog computing facilitates the operation of compute, storage and networking services between end devices and cloud computing data centres. Fog computing, also known as fog networking, is a decentralized computing infrastructure in which computing resources and application services are distributed in the most logical, efficient place at any point along the continuum from the data source to the cloud.

Emporiums generate a large amount of data from thousands of sensors that it can be useful for monitoring and analysing. An unprecedented volume of data can crash storage system. Cloud computing could provide storage on demand and processing of system, but cloud could be anywhere far from system, as well as transferring data from sensors to cloud and then giving a feedback to end user so, this could be a problem at emporium because of high delay. Fog computing consider to be temporally near to the sensor thus will decrease delay. The performance analysis of both architecture is done in order to know which architecture provides best network usage, energy consumption and cost of execution.

Paper is organized as follows: Section I introduction, literature review in Section II, performance metrics considered for studies in Section III, system design in Section IV, implementation in Section V followed by conclusion in Section VI.

II. Literature Review

In order to support the maximum number of user and elastic service with the minimum resource, the Internet service provider invented the cloud computing within a few years, emerging cloud computing has become the hottest technology [1]. Cloud computing has evolved to emerge the most topical IT paradigm in recent times. Cloud computing is rapidly transforming the IT landscape. On a pay-as-you-use basis, cloud consumers can access resources, applications and infrastructure provided by cloud providers. Such access could be in form of applications already deployed by cloud providers for use by the cloud users. It could be in form of the capability to develop and deploy user applications using services of a cloud provider [2]. Cloud computing systems have proven to be effective in meeting the varying demands for computing distributed sharing resources and services. Cloud computing is based on the fundamentals of distributed computing networks, service orientation, virtualization and grid computing system. Further, the usage of grid technologies has also been introduced as a method for accessing cloud computing resources, enabling the monitoring and management of cloud resources [3]. VCC is a new hybrid technology that has a remarkable impact on traffic management and road safety by instantly using vehicular resources, such as computing, storage and internet for decision making. Compare the mechanism with normal cloud computing (CC) and discuss open research issues and future directions [4]. Fog computing provides the data and computation close to end users which reduces the amount of data sent to cloud. Design goals of fog computing platform are to provide low latency to end users and efficient utilization of resources and energy. Some of the challenges in fog computing platform are choice of virtualization technology, fight with latency, security and privacy, network management. Comparison of fog and cloud in terms of latency and bandwidth reveal that fog computing is advantageous for clients in terms of low latency and high bandwidth [5]. The main idea of fog computing is to utilize the processing and storage resources at the edge of network by deploying IoT services on available edge devices to reduce latency and processing cost. The framework facilitates the communication between the devices, fog device orchestration, IoT service deployment, and dynamic resource provisioning in the fog landscape. In addition to these main functionalities, the framework is able to react on various system events, e.g., device accidence, device failure, and device overload [6]. Fog computing is an emerging technology to address computing and networking bottlenecks in large scale deployment of IoT applications. It is a promising complementary computing paradigm to cloud computing where computational, networking, storage are deployed at the edge and network layers in a multi-tier, distributed and possibly cooperative manner. These elements may be virtualized computing functions placed at edge devices or network elements on demand, realizing the “computing everywhere” concept [7]. The primary motivation to employ fog computing in the proposed approach is to minimize the latency as well as network usage in the overall smart car parking system. For demonstrating the effectiveness of the proposed approach for reducing the lag and network usage, simulations have been performed in iFogSim and the results have been compared with that of the cloud-based deployment of the smart car parking system. Experimental results exhibit that the proposed fog-based implementation of the efficient parking system minimizes latency significantly. It is also observed that the proposed fog-based implementation reduces the overall network usage in contrast to the cloud-based deployment of the smart car parking. Deployment models of both cloud and fog architecture is constructed and by using iFogSim simulations have been performed to compare which is efficient [8].

III. Performance Metrices Considered for Studies

A. Energy Consumption

It is defined as the energy consumed while transmitting the data from end devices to cloud.

B. Network Usage

It is defined as the amount of network used while transmitting the data from end devices to cloud.

C. Cost of Execution

Cost spent to complete the process for both cloud and fog architecture.

IV. System Design

Fig. 1 depicts the use case diagram of cloud computing. In this case, there are outlets like Max, Zara and Peach and Lily. Raw data is captured from the cameras in outlets and stored in server. This data is completely sent to cloud for long-term storage.

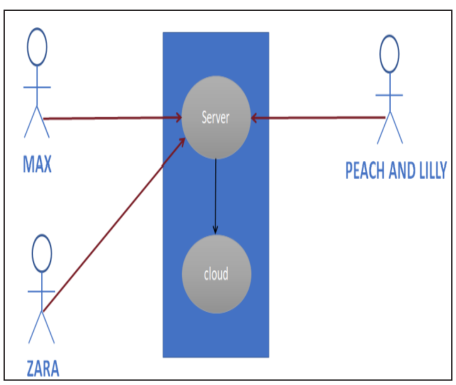

Fig. 1: Use Case Model for Cloud Computing

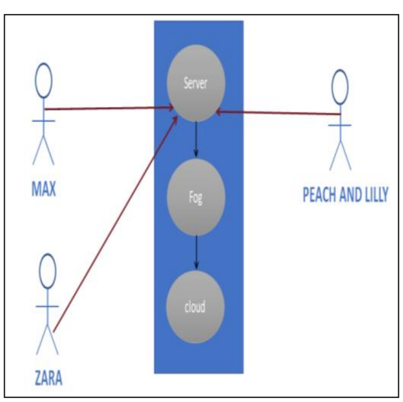

Fig. 2: Use Case Model for Fog Computing

Fig. 2 depicts the use case diagram of fog computing. In this case, there are outlets like Max, Zara and Peach and Lily. Raw data is captured by cameras in outlets and stored in servers. This data is sent to fog node which is close to source and the data is analyzed locally, filtered and then sent to the cloud for long-term storage.

Fig. 3 shows the proposed three-tier architecture of cloud computing. The first tier consist of various stores, the second tier consist of server used for moving the information which is going to be saved on the cloud which is present in the third tier.

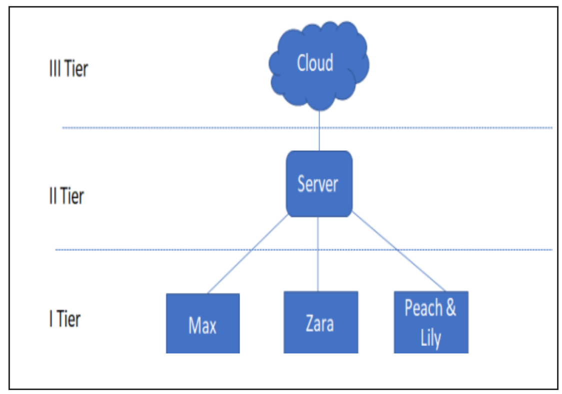

Fig. 3: Three-Tier Architecture of Cloud Computing

Fig. 4 shows the proposed fog architecture of emporium. In addition to above explained cloud architecture it consists of fog node in first tier. Information of every store is stored in single fog node.

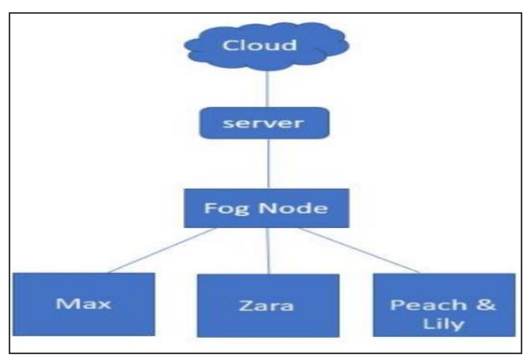

Fig. 4: Fog Architecture of Emporium

Fig. 5 shows the proposed fog architecture of various stores. In addition to above explained fog architecture of emporium, here each store is connected to separate fog nodes. Information of each store is collected and stored at their respective fog nodes.

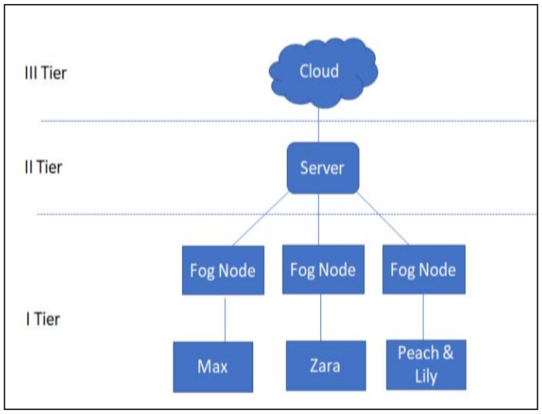

Fig. 5: Fog Architecture of Various Stores

V. Implementation and Result Analysis

Fig. 6 shows the work flow diagram of cloud and fog computing. In cloud computing data captured by camera at every store is collected and sent to the server, from server 100% of the collected data is uploaded to the cloud. Whereas in fog computing collected data of each store is uploaded to the fog node, frequently accessed data is remained in the fog node. Through the server the data which is not stored in fog node is uploaded to the cloud.

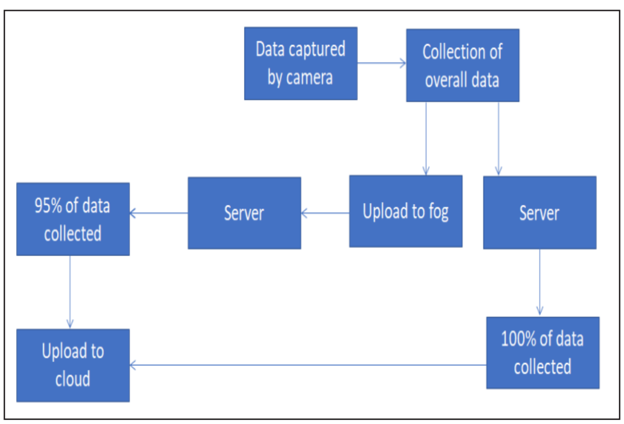

Fig. 6: Work Flow Diagram of Cloud Computing and Fog Computing

Case 1: Performance analysis of an emporium In this case performance analysis of cloud and fog in an emporium is done for the parameters such as energy consumption, network usage and cost of execution. Values of these parameters are compared in order to know which architecture gives better performance Table I shows the energy consumed by cloud and fog nodes for different number of cameras.

Table I: Performance Analysis of Overall Energy Consumed

	Iterations	No. of cameras	Cloud	Fog
Energy Consumed	1	2	2706542.91	2713616.65
	2	4	2714027.03	2727338.67
	3	6	2717184.49	2727338.67
	4	8	2728592.09	2741060.69
	5	10	2739999.69	2754782.70

Fig. 7 shows the graphical representation of cloud and fog for the parameter energy consumption. This graph portrays energy consumed by fog is greater than cloud for different number of cameras.

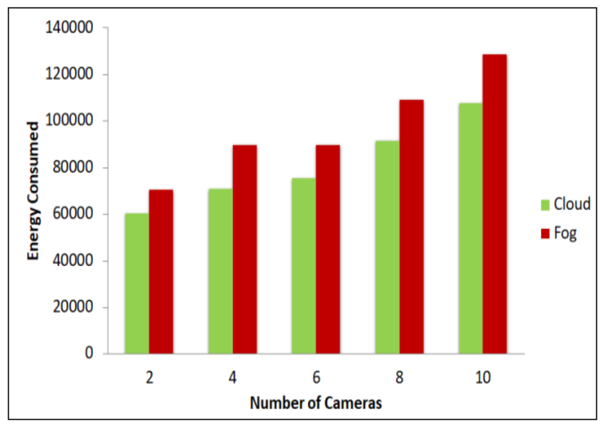

Fig. 7: Graphical Representation of Energy Consumption of Cloud and Fog

Table II shows the network usage by cloud and fog nodes for different number of cameras.

Table II: Performance Analysis of Overall Network Usage

	Iterations	No. of cameras	Cloud	Fog
Network usage	1	2	23722.3	19813
	2	4	47624.9	39626
	3	6	71799.5	59439
	4	8	96246.1	79252
	5	10	120964.7	99065

Fig. 8 shows the graphical representation of cloud and fog for the parameter network usage. This graph portrays network usage by fog is lesser than cloud for different number of cameras.

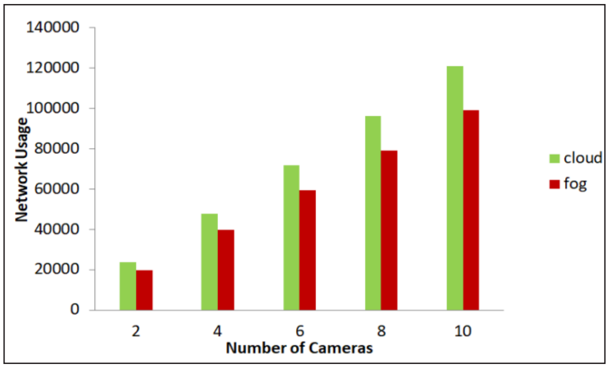

Fig. 8: Graphical Representation of Network Usage of Cloud and Fog

Table III shows the cost of execution by cloud and fog nodes for different number of cameras.

TABLE III: PERFORMANCE ANALYSIS OF OVERALL COST OF EXECUTION

	Iterations	No. of cameras	Cloud	Fog
Cost of Execution	1	2	60314.0	70342.6
	2	4	70924.4	89796.6
	3	6	75400.7	89796.6
	4	8	91573.5	109250.6
	5	10	107746.3	128704.6

Fig. 9 shows the graphical representation of cloud and fog for the parameter cost of execution. This graph portrays cost of execution by fog is greater than cloud for different number of cameras.

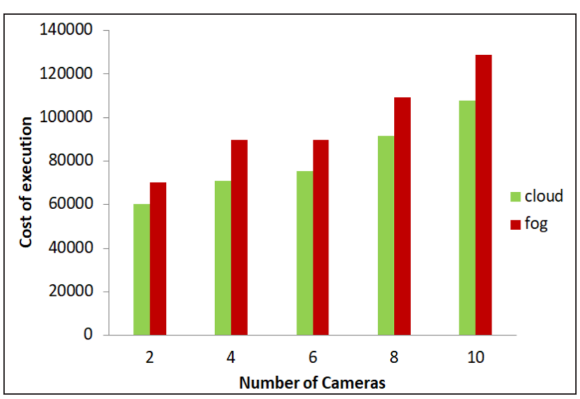

Fig. 9: Graphical Representation of Cost of Execution of Cloud and Fog

Case 2: Performance analysis of individual outlets In this case performance analysis of cloud and fog of various stores is done for the parameters such as energy consumption, network usage and cost of execution. Values of these parameters are compared in order to know which architecture gives better performance. Table IV shows the energy consumed by cloud and fog nodes for various stores like Zara, Max and Peach & Lily.

TABLE IV: PERFORMANCE ANALYSIS OF ENERGY CONSUMPTION OF VARIOUS STORES

Energy Consumed	Iterations	No. of cameras	Zara		Max		Peach & Lily	
			Cloud	Fog	Cloud	Fog	Cloud	Fog
	1	2	177974.59	185500	179410.66	185500	262863.47	292500
	2	4	278914.99	291500	277237.43	291500	360290.40	397500
	3	6	332628	344500	334034.1	344500	422391.73	450500
	4	8	585739.4	609500	492779.5	518500	477395.73	503500
	5	10	641475.74	662500	624543.17	655500	531407.62	556500

Fig. 10 shows the graphical representation of cloud and fog for the parameter energy consumption of Zara. This graph portrays energy consumed by fog is greater than cloud for different number of cameras.

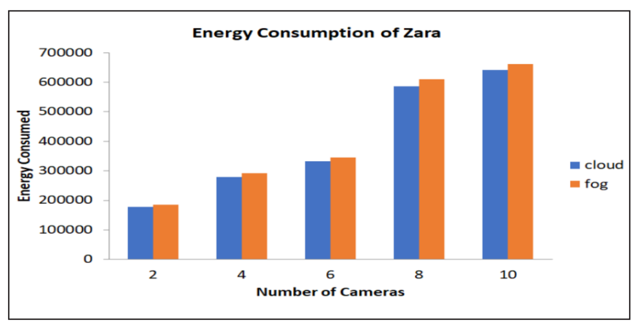

Fig. 10: Graphical Representation of Energy Consumption of Zara

Table V shows the network usage by cloud and fog nodes for various stores like Zara, Max and Peach & Lily.

TABLE V: PERFORMANCE ANALYSIS OF NETWORK USAGE OF VARIOUS STORES

Network Usage	Iterations	No. of cameras	Zara		Max		Peach & Lily	
			Cloud	Fog	Cloud	Fog	Cloud	Fog
	1	2	1631.2	1351	1631.3	1351.5	2426.4	2014.5
	2	4	2023.1	1733.5	2023.1	1733.5	3065.5	2600.5
	3	6	2414.9	2115.5	2414.9	2115.5	3463.5	2982.5
	4	8	2806.7	2497.5	3986.3	3466.5	4671.1	4027.5
	5	10	3198.5	2879.5	5913.8	5098	5913.8	5098

Fig. 11 shows the graphical representation of cloud and fog for the parameter network usage of Zara. This graph portrays network usage by fog is lesser than cloud for different number of cameras.

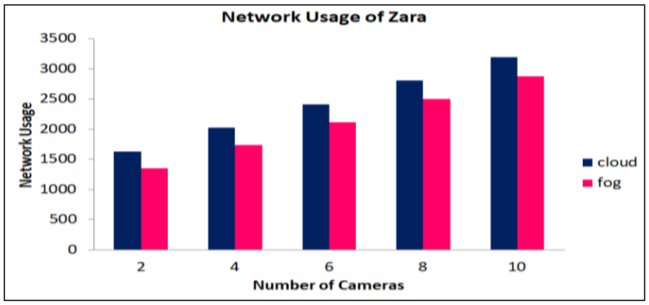

Fig. 11: Graphical Representation of Network Usage of Zara

Table VI shows the cost of execution by cloud and fog nodes for various stores like Zara, Max and Peach & Lily.

TABLE VI: PERFORMANCE ANALYSIS OF COST OF EXECUTION OF VARIOUS STORES

Cost of execution	Iterations	No. of cameras	Zara		Max		Peach & Lily	
			Cloud	Fog	Cloud	Fog	Cloud	Fog
	1	2	91029.6	380900.4	231252.7	573709.39	79959.9	194366
	2	4	111101.5	387900.4	253108.8	623709.39	80947.8	170710
	3	6	155073.5	480900.4	311324.8	573709.39	95780.6	170710
	4	8	213117.6	551709.3	411829.6	687860.1	112100	136829
	5	10	255432.8	573709.3	413337.26	707873.84	113266	157874

Fig. 12 shows the graphical representation of cloud and fog for the parameter cost of execution of Max. This graph portrays cost of execution by fog is greater than cloud for different number of cameras.

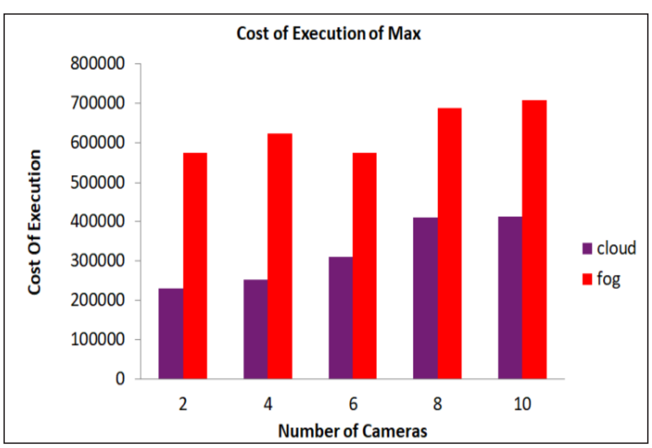

Fig. 12: Graphical Representation of Cost of Execution of Max

VI. Conclusion

Cloud Computing is on-demand availability of computer system resources, like computing power, without direct active management by the user. Fog Computing is an extension of cloud computing where fog nodes deployed between data source and cloud. Literature survey of papers on cloud and fog computing is carried on. A gap was identified to find the performance of both computing architecture, by considering the emporium details in iFog simulator. Result analysis concludes that cloud gives the better performance for parameters energy consumption, cost of execution and fog gives better performance in terms of network usage. In future this work can be implemented in different sections in single store and product monitoring can also be done which gives shop owner an alert message when product is going out of stock.

References

[1] L. Qian, Z. Luo, Y. Du, and L. Guo, "Cloud computing: An overview," In M. G. Jaatun, G. Zhao, and C. Rong (Ed.), Cloud Computing: CloudCom 2009, *Lecture Notes in Computer Science (LNCS),* vol. 5931, pp. 626-631, 2019.

[2] I. Odun-Ayo, M. Ananya, F. Agono, and R. Goddy-Worlu, "Cloud computing architecture: A critical analysis," *2018 18th International Conference on Computational Science and Applications (ICCSA),* Covenant University, Ota, Ogun, Nigeria, 2018, pp. 6256-6260.

[3] N. S. Aldahwan, and Muhd. S. Ramzan, "Descriptive literature review and classification of community cloud computing research," *Scientific Programming*, pp. 459-508, 2021.

[4] Md. Whaiduzzaman, M. Sookhak, A. Gani, and R. Buyya," A survey on vehicular cloud computing," *Journal of Network and Computer Applications*, pp. 135-142, 2016.

[5] S. Yi, Z. Hao, Z. Qin, and Q. Li, "Fog computing: Platform and applications," *2015 Third IEEE Workshop on Hot Topics in Web Systems and Technologies (HotWeb),* 2015, pp. 501-520.

[6] K. Bachmann, “Design and implementation of a fog computing framework,” *Software Engineering & Internet Computing*, pp. 612-630, 2017.

[7] P. Habibi, Mohd. Farhoudi, S. Kazemian, S. Khorsandi, and A. Leon-Garcia, “Fog computing: A comprehensive architectural survey,” *IEEE Access*, vol. 8, pp. 69105-69133, 2020.

[8] K. Sattar Awaisi, A. Abbas, M. Zareei, H. Ali Khattak, Muhd. U. Shahid Khan, M. Ali, I. Ud Din, and S. Shah, “Towards a fog enabled efficient car parking architecture,” *IEEE Access*, vol. 7, pp. 159100-159111, 2019.