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# The Design of Dynamic Fog Cloud System using mDBaaS

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***Abstract***

*Cloud computing has evolved into a core computing infrastructure for the internet that encompasses content, as well as communications, applications and commerce. By providing powerful computing and communications capabilities in the palm of the hand everywhere with a variety of smart devices, mobile applications such as virtual reality, sensing and navigation have emerged and radically changed the patterns people live. The data that is generated is getting bigger. Cloud computing, on the other hand, has problems with system load and speed due to the collection, processing and control of remote data. To solve this problem, fog computing has been proposed in which data is collected and processed at an edge. In this paper, we propose a system that dynamically selects a fog server that acts as a cloud in the edge. It serves as a mediator in the cloud, and provides information on the services and systems belonging to the cloud to the mobile device so that the mobile device can act as a fog. When the role of the fog system is complete, we provide it to the cloud to virtualize the fog. The heterogeneous problem of data of mobile nodes can be solved by using mDBaaS (Mobile DataBase as a Service) and we propose a system design method for this.*

**Keywords:** *Fog Computing, Cloud Computing, Dynamic Fog computing, mDBaaS(Mobile DataBase as a Service)*

## 1. Introduction

Cloud computing and fog computing techniques have been proposed to deal with the large amount of data generated by the development of Internet of Things (IoT). It has evolved into a core computing infrastructure for the internet as a full-fledged service that encompasses content, as well as communications, applications and commerce. The evolution of smart devices has increased the amount of data that must be handled in cloud computing [1].

Because data from mobile devices is too large to be sent to the cloud for analysis, a new computing model is needed to effectively analyze and process the data. For this purpose, a fog computing model is proposed by Cisco [2, 9], which can distribute and process data according to the flexibility, size and speed of data.

Fog Computing extends the services of cloud computing to the edge of the network and acts like a local cloud. The concept of providing data, computing, storage, and application services to the end-user is very similar to the cloud. However, fog computing differs greatly from existing cloud computing in terms of

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geographical distribution, number of nodes, and mobility support.

In fog computing, the end user's service is hosted near the user, thereby reducing the service latency and improving the service quality according to the user's needs or circumstances, thereby providing the best user experience

Fog computing techniques are called techniques such as Local Cloud (LC), Cloudlet, Mobile Cloud Computing (MCC), Mobile Edge Computing (MEC), and Fog Computing. MCC refers to a framework in which storage and computing are performed in a place other than a mobile terminal. MEC means "a data in a box" to operate a cloud server on a mobile network edge [3]. This type of fog system is a technique of distributing the function of cloud to the region and processing the data which occurs in the region. A dynamic cloud method that provides cloud services dynamically by migrating services and applications of the cloud system has been proposed [4].

In this paper, we propose a dynamic fog computing in which a mobile device acts as a fog by grouping surrounding mobile devices into one area without fixing the fog system. We apply MDBaaS to solve the problems between mobile devices. This paper describes related research, proposed system, system operation, and conclusion.

## 2. Related research

### 2.1 Fog computing paradigm

Wearable devices are very similar to the distributed computing model. The wearable device is one kind of edge computer, and the data information generated is mainly simple sensor data. A limited battery-operated wearable device transmits data to peripherals such as nearby fog computers (routers, set-top boxes, and smart phones) using low-power local communication technologies such as Bluetooth, without connecting the cloud. If additional analysis is required, it is transferred to the central data server and storage in the cloud. As a result, both the application and the interface can be distributed in an efficient manner.

Augmented reality and real-time video analysis can also be applications of fog computing. Smartphones, tablets, and smart glasses that utilize augmented reality do not affect the user experience by receiving real-time image information from other input information and processing it in real time. Systems that require this high level of processing can provide the best user experience by minimizing latency if fog computing helps. It is also expected that it will be easy to provide necessary information in real time by storing and analyzing images of camera sensors installed on the road in the fog. Fog computing is expected to be available not only in the aforementioned scenarios, but also in various areas such as connected cars, smart buildings, smart grids, smart cities and healthcare.

In addition to Cisco, many companies, including IBM, VMware, Intel EMC and Extreme Networks, are making products that comply with the fog computing distributed computing model. For example, Extreme Networks has released a switch (X460-G2) and an AP (IdentiFi Access Point 3805) that enable data processing at the edge. Freescale also demonstrated energy-efficient, high-performance SoCs. These products may become the servers of fog computing in the future[3].

Paradorp, which proposed a fog computing model, presented a Wi-Fi AP or set-top box as a fog computing gateway in a smarthome environment. Paradrop has attempted to reduce the latency caused by reducing communication between the end user and the cloud and to protect personal information. However, QoS, billing, security, computation offloading, and interface selection must be considered before fog computing is applied to real life and industrial areas. In the future, fog computing is expected to grow rapidly with IoT through joint efforts with various commercial technologies.

### 2.2 Mobile cloud computing

This is a combination of network environment service using mobile device and cloud computing technology [5]. This technology provides a service for the purpose of reusing the resources of the mobile device while providing the mobile device to the cloud service [6]. In this paper, we propose a system that collects and processes data from a mobile device of a moving user using the proposed system.

### 2.3 mDBaaS

When a system is developed in a collaborative environment, it is necessary to predict the planned load of the system and predict the future growth rate of the system. At this point, you decide which database to use and how to configure it. This process is carried out through various predictions and several uncertain variables are created in the process, so it is also difficult to respond effectively. DBaaS has the advantage of solving this problem. DBaaS provides agility so you can quickly plan your application and use the database effectively depending on the state of the application [7].

There are two forms of DBaaS in the cloud. The first type is the integration at the schema level and the second is the integration at the database level into the Real Application Clusters (RAC). Integration at the schema level is difficult to implement due to problems in standardization of the schema, but it can be used most effectively when it is implemented [8].

In addition, DBaaS can be provided with traditional DB functions, and SQL can be provided as an interface function. In the cloud environment, multi-database environment can not maintain the ACID attribute. Therefore, the basic local database should be maintained [8]. The DBaaS hub system in this paper can process large data based on data warehouse. The system can provide a NO SQL interface for file processing to allow partitioning, replication, and large-scale distributed processing of data in an accessible and flexible model.

## 3. Proposed system

### 3.1 System overview

The proposed system stores subscriber information, data schema, and fog system services in the server of the cloud system and has the status information of subscribers. When the subscriber requests the fog service to the cloud server, it sends the service information, surrounding smart node information through the user GPS information requesting the fog service, and schema information through mDBaaS to the node to be a dynamic fog cloud.

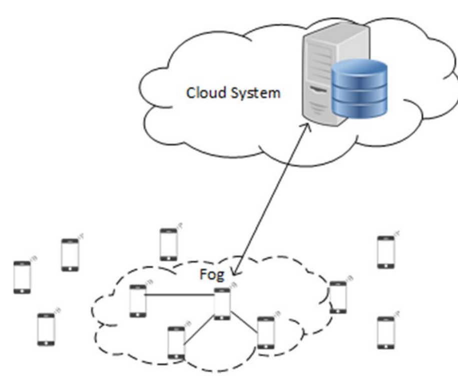


**Figure 1. Overview of the proposed system**

Based on this information, the fog cloud server constructs a dynamic fog cloud through the surrounding nodes. It runs the cloud service and shares the results, which are then sent to the cloud server and used for aggregate statistics. An overview of this is shown in Figure 1.

At this time, the mobile device that becomes the fog becomes the edge cloud fog system using the virtually bundled mobile devices, and transmits the collected / processed data to the cloud system when its role is terminated.

### 3.2 System configuration

The proposed system consists of a cloud server and a dynamic fog server. The cloud server acts like a control center. The dynamic fog server manages configuration for providing services dynamically, participant management, data conversion to be used in the configured service, and mDBaaS for the generated information. The system configuration is shown in Fig. 2.

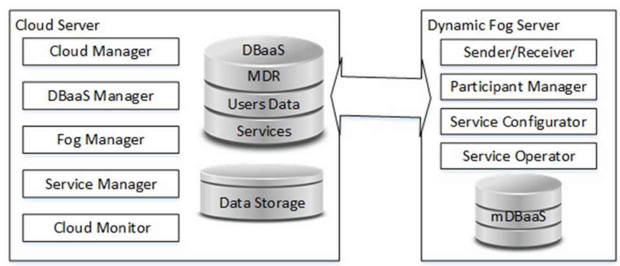


**Figure 2. System configuration**

The cloud server has the configuration shown in Figure 2, and each component performs the following functions.

- Cloud Manager(CM): CM accepts the fog generation request and acts as an arbiter to provide information for generation.
- Monitor: The monitor checks for changes in the state of the cloud system. The state is the state information for maintaining the operational state of the cloud and the generated fog system.
- Service Manager(SM): Provide service modules so that the fog can operate the service.
- DBaaS Manager(DBM): Provide database management services for integrated management of metadata and fog information for cloud and dynamic fog.
- FM manages the operation of fog and the users who participated in fog. FM collects the generated information and transmits it to DBM for integration and statistics. CM and SM are necessary components for preparation of service to generate dynamic fog. FM supports the service operation after the fog is created, collects the data generated by the users, and transmits the data to the DBM for processing.
- DBaaS: It is a cloud service that stores information about MDR (Meta Data Registry), user data, and service. MDR stores the relationship between metadata and data for the data to be used in this system. The schema data contained in the schema manages the schema and relationships among the sensors, GPS, users, user groups, services, and service modules.
- Data Storage(DS): FM collects user data from fog server and performs integration and processing in DBM. The processed user information is stored in DS.

The dynamic fog server manages participant management, service configuration, and configured service for fog service. The components are as follows.

- Participant Manager(PM): Manages identification, GPS, and fog group information of users participating in dynamic fog. The information collected from this element is location information via the GPS sensor of the user's equipment.

- Service Configurator(SC): The SC constructs the service by creating the fog. The fog generation configures the service based on the service module provided by the SM server of the cloud server. The configured service accepts participants through PM and provides dynamic fog services.
- Service Operator(SO): SO is a component that operates a fog system configured through SC. It collects and processes the information calculated by the users of the smart device of the users participating in the fog service. The processing results provide participants with their own information and other users' information. This allows the user to use the service and verify the relationship with other users.

### 3.3 mDBaaS(mobile DataBase as a Service) design

Information about the fog configuration and services for it is in schema format. The information extracted from the information in Table 1 is transmitted to the requested mobile device according to the fog configuration request. Based on this information, a mobile DBaaS is formed and is called mDBaaS.

Table 1 represents the configuration of mDBaaS for data management in mobile devices. a is the group information of the participants for the fog configuration. It consists of group ID, group name, and group description. b is the personal information of the users participating in the fog. The personal information includes an identifier, a group information, a name, a location, a sensor list for sensing, participant configuration information, and fog establisher information. c is a table for GPS information. It stores basically detected information through GPS sensor and is used for location information and user's movement information. This includes the sentence ID, UTC reference time, record state, latitude, north-south indicator, longitude, and east-west indicator information. The sensor information consists of the values measured in the smart device for analyzing and providing the participants' behavior patterns. These are sensor ID, sensor Name, sensor field, sensing data, and sensing units.

**Table 1. mDBaaS for fog configuration**

a)

| mGID | mGName | mGDesc |
|---|---|---|

b)

| mID | mGID | mName | mLoc | sensorList | partConf | ownerConf |
|---|---|---|---|---|---|---|

c)

| GPSID | Sentence ID | UTC Time | Rec State | Latitude | Longitude | NS Indicator | EW Indicator | mID |
|---|---|---|---|---|---|---|---|---|

d)

| sID | sName | sField | sData | sUnit | mID |
|---|---|---|---|---|---|

Table 2 shows service information for fog. Fog can receive the service module from the SM of the cloud server in order to execute the specific service. Therefore, it is necessary to manage meta information for service management. This meta information consists of service information and module information for configuring the service. The service consists of service ID, service name, service description, and service module list. A module consists of a service module ID, a service module, a service module location, and a service module URL, and can refer to them as needed.

**Table 2. Service information for fog**

a)

| svcID | svcName | svcDesc | moduleList |
|---|---|---|---|

b)

| svcMID | svcModule | svcModLocation | svcModUrl |
|---|---|---|---|

The mDBaaS consists of fog configuration information and service configuration information as described above. This is meta information for service configuration.

# 4. System operation

## 4.1 Cloud-to-Fog Interaction

The cloud system dynamically configures the fog by supporting fog configuration for smart devices that require configuration of the fog system. The operating procedure for this is shown in Figure 3, and operates in the following order.

① Join : Join the cloud system providing the service in the fog system.

② Fog system : Requirement for fog system configuration: The smart device that wants to configure the fog system requests service and participant information for fog configuration.

③ Participant information transmission: According to the request of ②, it provides the user information that can participate in the vicinity of the requested equipment on the GPS.

④ Providing service module for fog generation: The cloud server provides the service module to create the fog for providing the service and the metadata information necessary for the service operation through the interaction between DBM and SM. This information is the basis for constructing the fog system.

⑤ Identification of participants for dynamic fog configuration: In order to construct a dynamic fog based on the information provided through ④, the neighboring users perform work to confirm participation in fog.

⑥ Fog generation and operation: This step creates a fog system based on the service information and meta information provided by the cloud system through ④ and the participant information collected through ⑤. The generated system creates the data that is performed by interaction between participants. The generated data is shared among the participants in the fog system, and the results are collected and provided to the cloud to perform statistics and analysis.

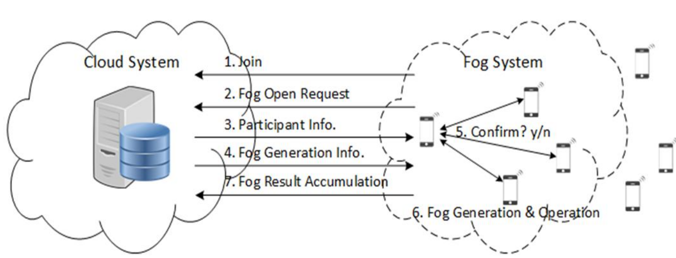


**Figure 3. Cloud-to-fog interaction**

This process can dynamically create a fog system through the cloud. Through service operation, information exchange within fog, information exchange between fog, and information exchange between cloud and fog can be performed. This can construct a fog system for dynamically grouping mobile devices and performing services within the group. The cloud can provide extended functionality beyond the traditional cloud approach by providing inter-fog intervention, service creation, and data analysis capabilities that originate from the fog.

### 4.2 Workflow for service operations

4.1 was a description of a generic approach to dynamically operating a fog system based on a cloud system. The following describes the workflow of the cloud, dynamic fog, and the movement of modules and data between participants.

The cloud accepts the fog generation request, provides the service module, collects and analyzes the results performed in the fog, and monitors the generated fogs. Dynamic fog creates a group of participants with the support of the cloud and actually runs the service. A participant is a user who subscribes to a dynamic fog and uses the service. The operation of the service is as follows.

Preparation steps (steps 1 to 9): The cloud server starts operating and calls FogGenApplu () for dynamic fog generation on the smart device. Accordingly, the cloud server performs Approve () for fog generation. Service module and candidate information of the participant are provided through the ProviceServiceModule. The dynamic fog configures the service through ServiceConfigure. This completes the configuration of the actual dynamic fog, and ServiceStarting() starts the service. Next, the participant is collected through participantGethering (), and the service module is provided to the participant with the ServiceModule (), and the process for configuring the service is completed.

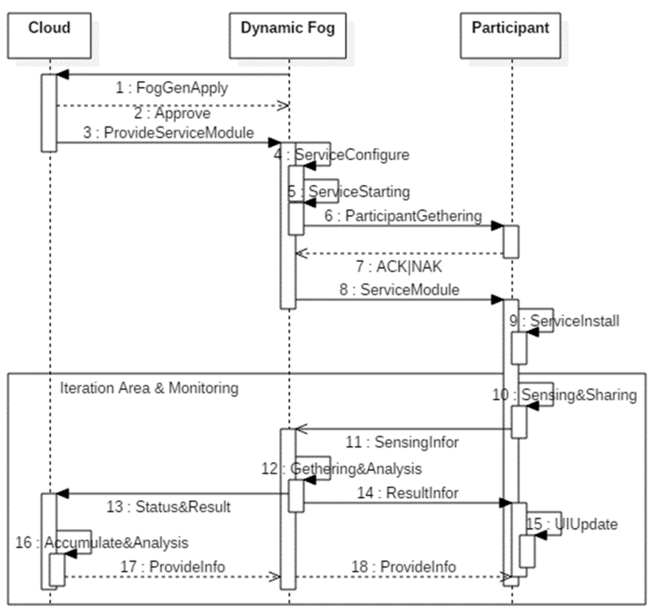


**Figure 4. Workflow for service operations**

Operational phase (steps 10-18): This step provides the participant with the result of processing the information sensed from the participant in the fog.

The cloud server collects this information and the status information of each fog, monitors the operation status of the fog, and transmits statistical information to the fog so that the participant can check the statistical information.

## 5. Conclusion

In this paper, we propose a method to construct a dynamic fog cloud that can solve the disadvantages through outline of cloud computing and fog computing. In order to use the cloud service, the mobile device of the subscribed users requests the cloud server to form the fog, and the cloud server provides the information for the system so that the requested mobile device can serve as the fog system. This allows flexibility of the fog system and provides flexible service. As an application example for this purpose, the contents collected from the mobile sensor are shared and aggregated through the generated fog.

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