International Journal on Advanced Science Engineering Information Technology

Vol.7 (2017) No. 4
ISSN: 2088-5334

Development of IoT Service Classification Algorithm for Integrated Service Platform

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***Abstract*— Recently, with the appearance of the IoT paradigm, the existing Internet environment has changed with various things that connect with the Internet. The IoT paradigm is applied to various service such as smart homes, building management, surveillance services, smart farm, and so on. The environment of IoT services concerned on communication and interaction processes between different devices. To solve these complex problems, many researchers and service providers are focused on the integrated service platform. However, previous studies did not consider problems such as service similarity and module reusability. In this paper, we focused on the classification of services for providing reusability. And we propose classification algorithm that is based on detail operation steps of IoT services. To proof proposed classification algorithm, surveyed over 100 commercial IoT services are classified into 19 groups. The experimental results present each group is grouped together by their purpose.**

***Keywords*— internet of things (IoT); integrated service platform; service classification; module reusability; service similarity;**

I. INTRODUCTION

The development of wireless networks and data processing, such as wireless communications, wireless sensor networks, and cloud computing enhanced the Internet into intelligent devices. This paradigm is called Internet of Things (IoT) that the existing Internet environment has been changed with various things that connect with the Internet. It is provided the services for the user by communication between which are close to life. Unlike the existing Internet service, the IoT service aims to provide a suitable service to users rather than simply communication between devices [1], [2]. Currently, simple services are provided, but services combining various services will be developed for the future.

Most of the services are provided based on independent servers for each service, so sharing and integration management among the respective services are not performed at present. Considering the development of explosively increasing IoT devices, the integration of services and exchange data of heterogeneous services will be present [3], [4], [5], [6], [7].

From a technical point of view, to integrate and manage various services, there are several problems to solve that as follows: various sensor devices, various data types of transmission, inter-device data exchange of services and other services, integration among different types of services and so on. From a market perspective, the main problem is that most of IoT services have their own server and own operation modules. There are many similar IoT services, they couldn't share their data, module, analysis reports and so on. Depending on the single server, it causes less accessibility and various data type of each service [8], [9], [10].

To solve various problems caused by collaboration between various sensor devices and various services, a combination of various services is required to manage uniformly and an integrated service platform has been needed. If several services are performed on a single platform, there are many advantages. The most of them are reusability of modules that causes easy to develop new IoT services and approach on IoT market. However, without similarity between services, reuse of module couldn't be provided. If the platform is provided without similarity, it can't be guaranteed the module reusability.

To provide reusability, we focused on the classification of services. Our proposed classification algorithm is based on detail operation steps of IoT services. Proposed classification consists of 4 steps. The first step is sensing step that classifies sensor devices. The second step is data management. In data management step, we classify the preprocessing of data and maintenance of data. Then, the processing step divides and combine operation modules. Finally, in the output step, we classify IoT services into their own actions.

To proof proposed classification algorithm, we sort 37 IoT services that perform its own processing from surveyed over 100 commercial IoT services. They are classified into 19 groups. The 10 groups of them that have more than one service. By experimental analysis, each group is grouped together by their purpose.

The remainder of this paper is organized as follows. Section II presents related works of classification of IoT services and the system environment that our research based on. Section II also presents the proposed classification algorithm that based on 4 operation steps. Section III details our experimental methodology and the results alongside a detailed analysis. Finally, Section IV concludes this paper.

II. MATERIAL AND METHOD

A. Related Works

Recently, the environment of IoT services concerned on communication and interaction processes between different devices. The architecture of the IoT basically consists of three layers: sensing layer, network layer, and application layer.

- Sensing layer: sensing devices such as RFID tags, smart
- Network layer: collected data are transmitted, communicated, and processed
- Application layer: various functionalities of IoT such as process components, execution components, etc.

Fig. 1 shows a three-layer architecture of the IoT environment. Providing lots of IoT services, a service-oriented platform is proposed, that a large number of service operations are involved, such as service classification, discovery

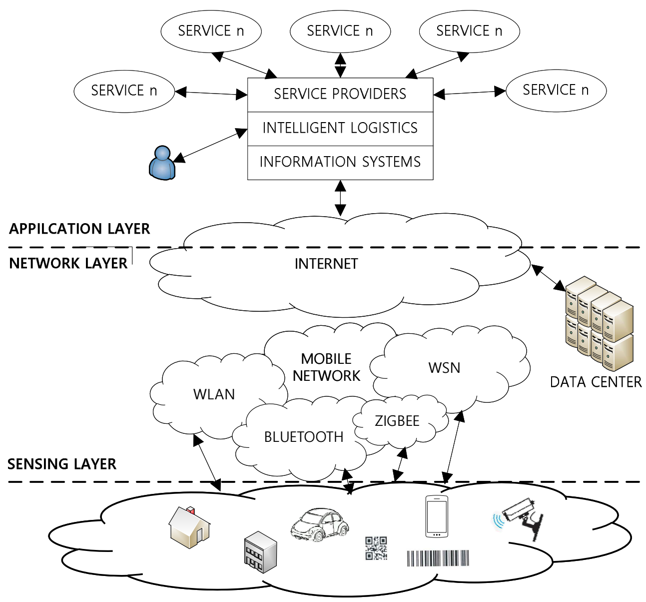

Fig. 1 Basic IoT architecture

In the previous classification criteria such as components, services, the power of devices, and sensor information have been suggested to classify Internet services.

[11] classify IoT device into 3 levels.

- Level 1: Identification and sensing devices
- Level 2: Ad-hoc device between sensor and wireless device
- Level 3: Connection device between wireless device and Ethernet

Level 1 is focused on storage and power availability. For example, simplest sensors, passive and semi-passive tags. Level 2 is focused on connection methods. For example, active tags, Zigbee full function devices. Level 3 is focused on communication method. For example, IP based, no IP based and so on. And, Fig. 2 shows the hierarchal classification of IoT service by service type into 3 levels [8].

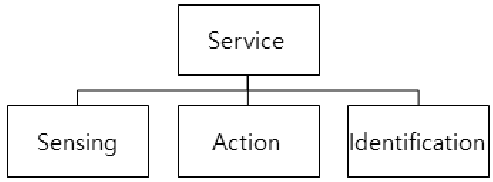

Fig. 2 Hierarchal classification of IoT service

The service is to allow or block user access and manage the following three (Sensing, Action, Identification). Sensing refers to simple sensors. For example, temperature, humidity measurement sensor and so on. The action is divided into a simple action such as on/off or a complex action. Finally, identification is a combination of version, service ID, description, and so on.

[8] classify IoT service that as follows:

- Low-level service: A set of sensors that can be consists of access devices or resources
- Resource service: A set of devices that manage sensors
- Entity service: A single service consisting of sensors and management devices
- Integrated service: An integrated service consisting of single services

The entity service is the core of IoT system that consists group of low-level services. For example, Amazon Echo, SKT Nugu, and so on. The integrated service is an IoT environment that can be organized by a group of entity services. For example, smart home, smart building, and so on.

Categorized the Internet service based on the power processing of the device. Since continuous communication of all wireless devices has a direct effect on the power of the device, a low-power, non-IP sensor connection using IoT gateway is proposed to solve this problem [13].

Zhu et al suggested the needs of open IoT platform for reusing collected and analysis data between various services. And, the common cloud based unified platform is proposed to combine several single services that depend on each single platform [7].

B. System Environment

To support various IoT services, we aim to provide an integrated platform on the public cloud. The system environment based on this study is shown in Fig. 3.

The system environment consists of four states: sensor, environment, service group, and platform.

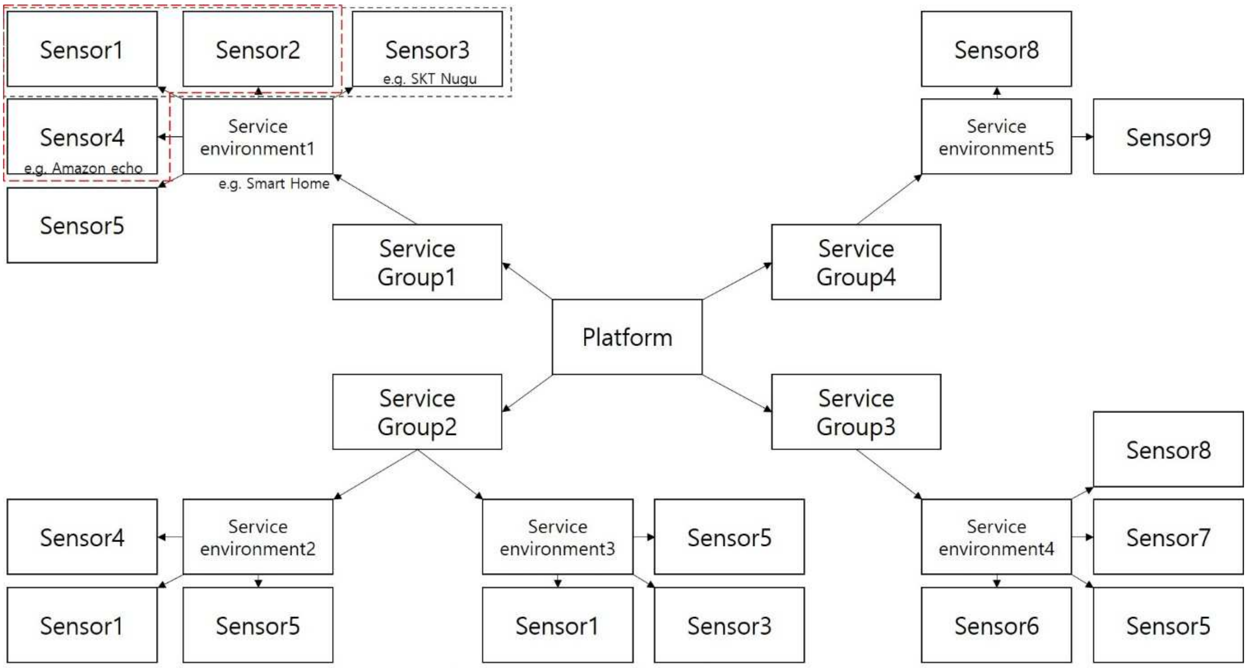

Fig. 3 System environment

- Sensor: Consists of data acquisition devices.
- Service environment: the environment in which a single service is provided, consisting of sensors and operating devices.
- Service group: Consists of various services that can be provided in the same service environment.
- Platform: Integrated management of various service groups.

In sensor state, there are lots of sensors to collect data such as heat, light, temperature, pressure, sound and so on. Each sensor could be a single low-level service such as an alert. However, low-level service couldn't satisfy the user needs. To provide adaptive service, the analysis is needed. Simple analysis can be performed on the sensor device, but complex analysis needs high performance of cloud. The service environment is a space that the complex service is provided. For example, Amazon echo returns the appropriate response or action to the user's request using the sensor inside the space. A service group is a set of services that perform a similar role. For example, Smart Home Service Group could consist of Amazon Echo, SKT Nugu, KT Jini, etc. We are willing to present an integrated platform that serves lots of services (smart home service group, smart building service group, smart farm service group, etc). By proposed integrated platform, efficiently integrated management is presented and reusability of configuration modules of each service is increased.

C. Classification Algorithm of IoT Service

In this section, to present efficiently integrated management and increasing reusability of configuration modules of each service, we describe classification algorithm of IoT service. The proposed service classification algorithm consists of four steps as follows. Sensing, Data management, Processing, and Output. The classification criteria for each step are as follows.

- Sensing: presence of own power/IP
- Data management: presence of data preprocessing/ maintenance
- Processing: operation modules
- Output: output actions

1) Sensing Step

There are various sensor devices gathering input data for IoT service. They perform very simple actions to complex actions. Depending on actions, they perform sensing, identification, communication with their groups, communication with the server and so on. In this step, we are focused on communication type, computation power, and battery capability. Table 1 shows classification of sensing devices and each classification criteria.

TABLE I
CLASSIFICATION OF SENSING DEVICES AND CRITERIA

Level	Criteria	Explanation
1	Self-power	Activate battery power
2	Connect to AC/DC	Using an external AC / DC power adapter
3	IP	Presence or absence of IP

The level 1 sensor devices are classified by their battery capability that can be rechargeable or one-time usage. The level 2 sensor devices are classified by fixed power. They are more powerful than level 1 sensor devices, but they are fixed at certain space as a fixed sensor. The level 3 sensor devices are classified by communication method. There are several communication methods such as RFID, NFC, WiFi, Bluetooth, ZigBee, GSM, 3G, LTE and so on. But, in this level, we classify them into IP and non-IP by the amount of data transmission.

2) Data Management Step

The standard of IoT service has not yet been clearly defined. To provide integrated management, the data format of IoT service should be unified. However, most of IoT services use their own data formats and file system. So, each data should be converted the same format to share among them. In this data management step, we are focused on the data format of transmission and maintainability of stored data. Table 2 shows classification of data management and each classification criteria.

TABLE II
CLASSIFICATION OF DATA MANAGEMENT AND CRITERIA

Level	Criteria	Expanation
1	Data preprocessing(client)	Preprocessing by client
2	Data preprocessing(server)	Preprocessing by server
3	Type of storage data	Volatile data/ non-volatile data

The level 1 data preprocessing is the conversion of a data format that performs at the client before data translation. The level 2 data preprocessing is the conversion of a data format that performs at client server after data translation. In other words, the preprocessing at level 1, 2 convert data into a unified format to prepare own main processing of each IoT service. At level 3, the data is classified by type of storage data. Some of IoT services keep their data to analysis, but also there are other IoT services use their data only once. In this data management step, data of IoT services are classified by preparation before their own main processing.

3) Processing Step

Most IoT services have their own analytical operations to provide services. However, these analytical operations are a combination of basic operations with their own analysis modules. Table III shows an example of basic operation.

TABLE III
CLASSIFICATION OF EXAMPLE OF OPERATION

Level	Operation	Explanation
0	Compare	Basic operation
0	Sum	Basic operation
0	Count	Basic operation
0	Average	Basic operation
0	-	-
1	Set	Combination of basic operation
2	ETC	Own operation of service

The level 0 consists of basic operations and they have no operator precedence between them. The level 1 is another operation that user defined with a combination of basic operations. It can be evolved to new operation or function. The level 3 is service dependent operation if the service needs their own analysis function.

4) Output Step

The IoT services have their own output actions that depend on their purposes. For example, the case of smart air conditioner it analysis the temperature of space by the sensor device and decide cooling down if the temperature is over threshold and request cooling down action to the air conditioner and the variation of temperature can be saved as a monthly report. Most of IoT services perform basically report their analysis, alert the situation, request action by their analysis result, and so on. Table 4 shows an example of basic action.

TABLE IV
CLASSIFICATION OF EXAMPLE OF ACTION

Level	Action	Explanation
0	Report	Basic action
0	Alert	Basic action
0	Action	Basic action
1	ETC	Own action of service

5) Proposed Classification Algorithm

In this subsection, we proposed classification algorithm. As follows above classification steps, proposed algorithm is focused detail action of each step. Table 5 shows proposed classification algorithm.

TABLE V
PROPOSED CLASSIFICATION ALGORITHM

```
Algorithm classification is
input:    Types of sensing S
          Types of data management D
          Types of Processing type P
          Types of Output O
Output:   Classification Code

Sensing_classification(S)
          Begin
          if S is Using battery
                    do S << self_power od fi
          else if S is AC/DC adapter
                    do S << AC/DC od fi
          else
                    do S << IP od
          End

Data_management_classification(D)
          Begin
          if D is Preprocess the client
                    do D << Data_preprocessing_client od fi
          else if D Preprocess the client
                    do D << Data_preprocessing_server od fi
          else
                    do D << Type_of_storage_data od
          End

Processing_type_classification(P)
          Begin
          if P is Compare operation
                    do P << Compare od fi
          else if P Sum operation
                    do P << Sum od fi
          else if P Count operation
                    do P << Count od fi
          else if P Average operation
                    do P << Average od fi
          else if P Set operation
                    do P << Set od fi
          else if P ETC1 operation
                    do P << ETC_1 od fi
          End
```

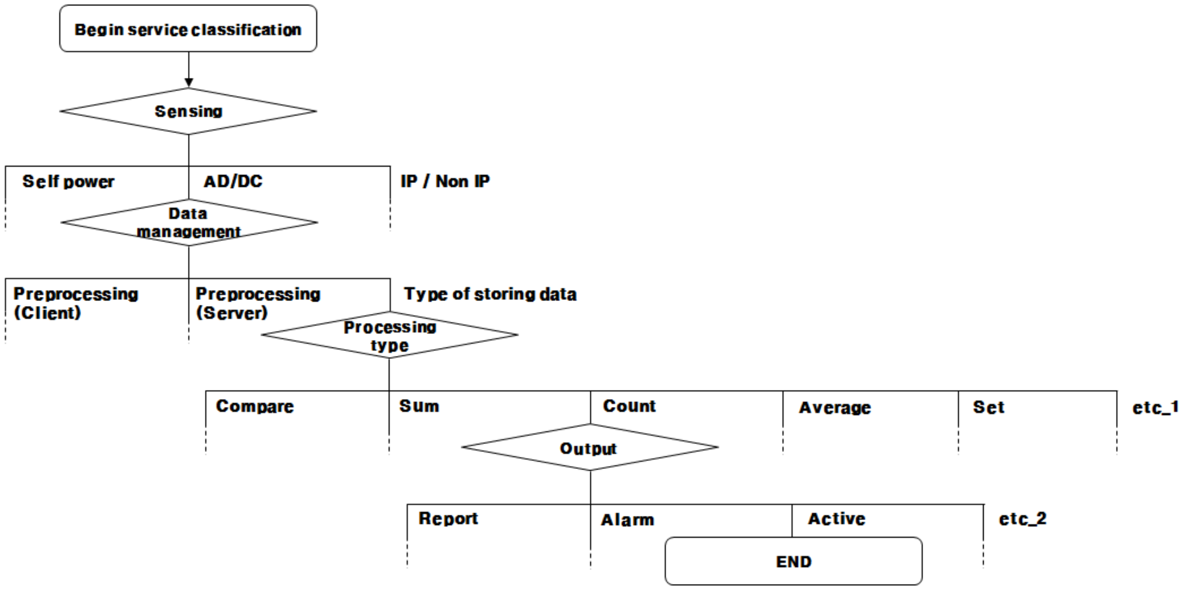

Fig. 4 Example flow of proposed classification algorithm

```
Output_classification(O)
        Begin
        if O is Report operation
                do O << Report od fi
        else if O Alert operation
                do O << Alert od fi
        else if O Action operation
                do O << Action od fi
        else if O ETC2 operation
                do O << ETC_2 od fi
        End
```

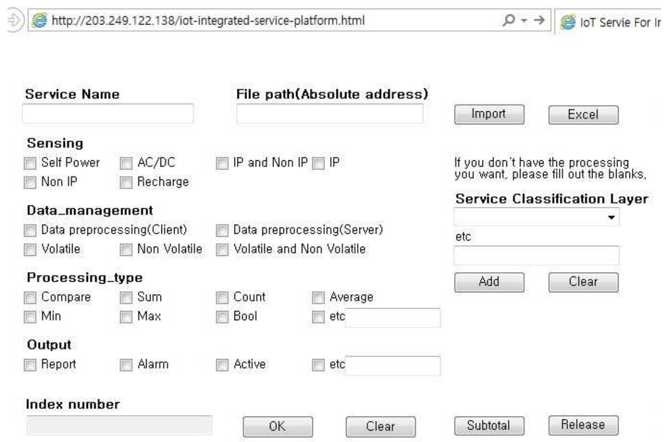

Fig. 5 Proposed classification system

III. Result and Discussion

The experiment environment of our research is progressed on a single cluster with 4 desktops. Each one consists of Intel i7 8 cores (4 hyperthreaded cores included) 3.4GHz processor, 16GB memory, 256GB SSD. And we used Ubuntu 14.04 as OS, C# 7.0 for our experiment. In this experiment, we are focused on grouping commercial IoT services by proposed classification algorithm.

We survey over 100 commercial IoT services. But there are too many low-level IoT services that perform only sensing and alert. We select 37 commercial services as an experimental set that performs its own processing. Fig. 5 shows proposed classification part on our platform.

We put the experimental set into proposed classification system. It classified into 19 groups. 10 groups of them that have more than one service. It proofs that each group is grouped together by their purpose. Remaining 9 groups contain single service. We think the reason is the absence of similar services. Table 6 to 10 shows the representative group by proposed classification algorithm.

TABLE VI
HEALTHCARE GROUP FOR MEDICINE

Group ID	0x88481080
Sensing	Self-power, Non-IP
Data management	Data preprocessing(server), Non volatile
Processing_type	Average, Threshold

Service_ name	Explanation	Sensor specs	Operation Steps
Fitbit Charge HR	Activity Wristband	PurePulse, All Day Activity, SmartTrack, Auto Sleep, Bluetooth	sensing -> analysis -> report
Dexcom _Sevenp lus	Glucose monitoring	Glucose, 360 degrees of sensor	sensing -> analysis -> report
Lively	Medical Alert Watch	Lively passive activity Sensors	sensing -> analysis -> report

TABLE VII
HEALTHCARE GROUP FOR BODY

Group ID	0x88481480
Sensing	Self-power, Non-IP
Data_management	Data preprocessing(server), Non volatile
Processing_type	Average, Threshold(Max)

Service_ name	Explanation	Sensor specs	Operation Steps
Nuvant	Healthcare_wearable	Temperature, Heart rate, Respiratory rate, Motion Tracking	sensing -> analysis -> report
IT bra	Healthcare_wearable	Novel Sensor(Monitor changes in the temperature of a cell	sensing -> analysis -> report
Amp strip	Healthcare_wearable	ECG Sensor, MEM's accelerometer, Skin temperature, Bluetooth	sensing -> analysis -> report

TABLE VIII
BABYCARE GROUP

Group ID	0x88481CC0
Sensing	Self-power, Non-IP
Data_management	Data preprocessing(server), Non volatile
Processing_type	Average,Threshold(Max,Min)

Service_name	Explanation	Sensor specs	Operation Steps
Owlet _Sock	baby monitoring	Pulse Oximeterw, Bluetooth	sensing ->analysis ->report/
Sprouting	baby monitoring	Heartrate, Temperature, Accelerometer	sensing ->analysis ->report/ alarm
Mimo	baby monitoring	Heartrate, Temperature, Gyro, Bluetooth	sensing ->analysis ->report/ alarm

TABLE IX
HUMANLIFE GROUP

Group ID	0x88481EC0
Sensing	Self-power, Non-IP
Data_management	Data preprocessing(server), Non volatile
Processing_type	Average,Threshold(Max,Min),bool

Service_name	Explanation	Sensor specs	Operation Steps
Weatherflow_sky	weather monitoring	Outdoor temperature, Humidity, Barometric pressure, Wind speed, Wind direction, Average & Gusts, Lightning strikes, Rain intensity, UV index, Brightness, Solar	sensing ->analysis ->report/ alarm
Weatherflow_air	weather monitoring	Air temperature, Relative humidity, Atmospheric pressure Lightning: strikes & distance, Wireless	sensing ->analysis ->report/ alarm
8cups	weather habitude monitoring	Weight, Wireless, Bluetooth	sensing ->analysis ->report/ alarm

TABLE X
SMARTHOME GROUP

Group ID	0x90508220
Sensing	Self-power, Non-IP
Data_management	Data preprocessing(server), volatile
Processing_type	Compare,Bool

Service_ name	Explanation	Sensor specs	Operation Steps
Amazon Echodot	voice recognition home secretary	High-sensitivity microphone	sensing ->analysis ->active
Amazon Echo	voice recognition home secretary	High sensitivity microphone	sensing ->analysis ->active
KT Gienie	voice recognition home secretary	High sensitivity microphone	sensing ->analysis ->active
Google Home	voice recognition home secretary	High-sensitivity microphone	sensing ->analysis ->active

IV. CONCLUSIONS

While the IoT becomes a major issue of interest in both the academy and the industry, a solid foundation is still lacked for its rapid development. Various services are appeared such as smart homes, building management, surveillance services, smart farm, and so on. We focused on integrated IoT service platform that should be concerned with communication and interaction processes between different devices.

In this paper, to provide service similarity and module reusability, we propose classification algorithm that is based on detail operation 4 steps of IoT services. The first step is sensing step that classifies sensor devices. The second step is data management that classifies the preprocessing of data and maintenance of data. The third step is the processing step that divides and combine operation modules. The fourth step classifies IoT services into their own actions. To proof proposed classification algorithm, we sort 37 IoT services that perform its own processing from surveyed over 100 commercial IoT services. They are classified into 19 groups. The 10 groups of them that have more than one service. By experimental analysis, each group is grouped together by their purpose.

In this paper, our classification algorithm is based on service operation steps. In further works, we are going to study similarity based classification algorithm for sharing service modules and analysis data.

ACKNOWLEDGMENT

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT & Future Planning (NRF-2016R1C1B1008330) and partly supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2016R1D1A1B03931602).
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