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Design and Implementation of Intelligent Parking Guidance System based on Internet of Things(IoT)

[Hac-Hee Choi, Dong-Ju Min and Dong-Seong Kim*]

***Abstract*—This paper proposes an optimal dynamic resource allocation method in Internet of Things (IoT) Parking Guidance Systems (PSG). In the proposed method, a resource allocation using a forecasting model based on Q-learning is employed. To demonstrate efficiency of this method, it is verified by Matlab 7. Through simulation results, this paper proves that the proposed method can enhance total throughput, decrease penalty fee issued by Service Level Agreement (SLA) and reduce response time with the dynamic number of users.**

***Keywords*— Internet of Things, Q-learning, Virtual Machine provisioning (VM provisioning), Cloud computing**

I. Introduction

A Parking Guidance System (PGS) based on Internet of Things (IoT) is a service providing parking information to PGS users in real-time. By serving parking status information and minimum driving paths toward parking lot to PGS users, the system can minimize users' parking time, reduce traffic congestion and maximize the efficiency of the parking lot management system[1-6].

This paper proposes a PGS which employs a predictive resource allocation method using Q-learning model in IoT. The system is suitable for maximizing profits of the service provider and satisfying users' Quality of Service (QoS). The rest of this paper is organized as follows: In Section 2, we analyze the problems of a existing PGS. Section 3 explains the proposed system and also simulation works for the proposed system are compared with those of other systems in Section 4. Finally, Section 5 presents conclusions and future works.

II. Problems Analysis

PGS is the system that informs available parking space for preventing a parking problem. A shown picture 1 is block diagram of the existing PGS.

In the existing PGS, provider allocates physical components such as server, control modules and kiosk to provide stable service without considering the number of users and environment parameters. To assign physical components optimally, a study about PGS being linked with cloud system is progressed in brisk.

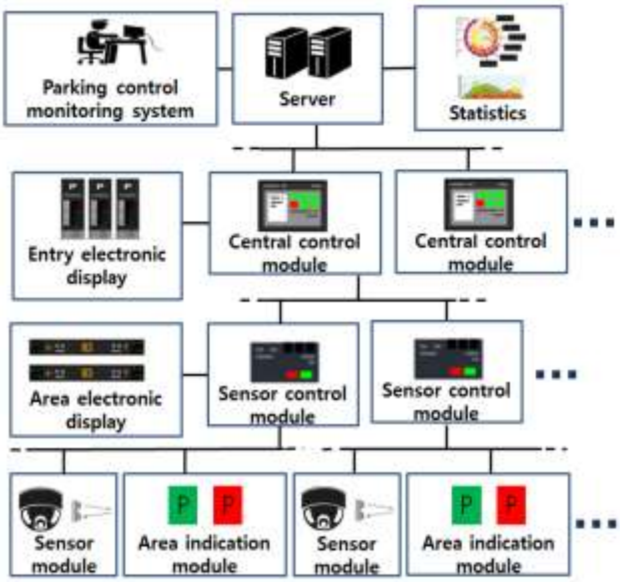

Figure 1. Block diagram of the existing PGS

This paper proves that using PGS based on IoT using Q-learning model is more effective than previous one by providing simulation about the PGS constructing cost and utility.

III. PGS based on IoT using Q-learning Model

This paper proposes an PGS based on IoT that offers a reasonable hardware allocation method for PGS providers and convenient parking facilities for users. The proposed system makes use of the Q-learning method which belongs to reinforcement learning to allocate memory, storage and CPU of Virtual Machine (VM) efficiently in cloud computing environment. In a particular state, the Q-learning algorithm learns Q-value by using compensation for each of the actions that can be taken from previous value and current value. The Q-value is represented by Q[S,A]. Pseudo code of the Q-learning method is depicted in Algorithm 1 in which the actions are defined by $a \in A$ and the current states are defined by $s \in S$ at time t.

Algorithm 1 Q-learning algorithm used in proposed scheme

1: **Inputs**
2: S is a set of states
3: A is a set of actions
4: ɣ the discount

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            α is the step size
Local
            real array Q[S,A]
            previous state s
            previous action a
initialize Q[S,A] arbitrarily
observe current state s
Repeat
            select and carry out an
            action a
            observe reward r and state s'
```

$$Q[s,a] \leftarrow Q[s,a] + \alpha(r + \gamma \max_{a'} Q[s',a'] - Q[s,a])$$

```
Until       s ← s'
            termination
End
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In the PGS based on IoT, the Q-learning algorithm aims to minimize the total cost of building the system for service providers and satisfies QoS for users. The following Figure 3 is a flow diagram of the Q-learning algorithm[7-9]. In order to understand the evaluation method of the existing cloud service performance measurements, this paper refers a cloud service performance measurement system platform provided by telecommunications technology association.

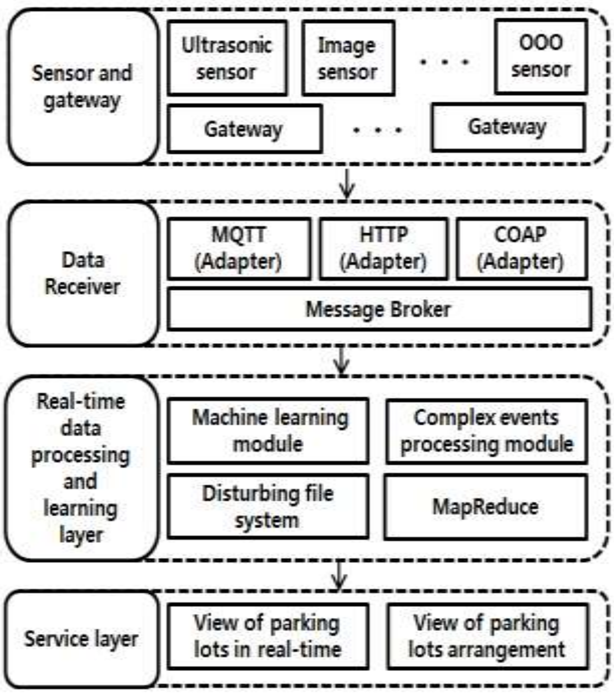


Figure 2. Architecture of PGS based on IoT

Figure 4 depicts the platform.

The PGS based on IoT collects data through gateway via range of wireless communications such as ZigBee, Z-Wave, Bluetooth, WiFi, NFC, RFID[10-14]. In a sink, the role of message broker is to minimize data loss and it constitutes message queue based clustering. Real-time processing layer offers a real-time Distributed Control System (DCS) technique considering the scalability. Batch processing layer uses the Hadoop distributed processing model, the search engine Nutch. Finally, after being stored at the service layer, the processed data provides information in various aspects for application program. Figure 6 is a flowchart of the PGS based on IoT. If status information is received as input from parking sensors, the PGS based on IoT users will receive the processed parking information.

Figure 3 shows performance measuring procedures of the PGS based on IoT.

Figure 3. Input and output flow diagram of the PGS based on IoT

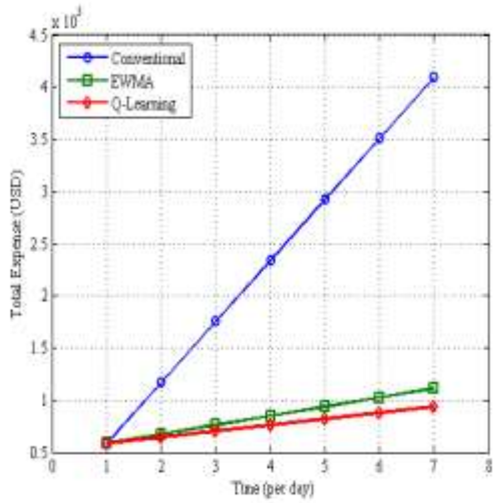
IV. Simulation Results

In order to evaluate effectiveness of the proposed method, we use Matlab to perform simulations on total construction cost of parking area in terms of process response delay time, dynamic number of users and cumulative number of users. For objective performance measurements, in this paper the proposed PGS based on IoT using Q-learning method is compared with the existing PGS and the PGS using EWMA method.

TABLE I. SIMULATION PARAMETER

Parameter	*value*
Maximum number of users	15,000
Minimum number of users	300
Over provisioning cost	20 USD
Under provisioning cost	4 USD

As shown in table 1, a scenario that each day the maximum and minimum number of users are 15000 and 300 people is assumed. Figure 4a and 4b shows the comparison of the total cost PGS for the maximum, the minimum number of each method.



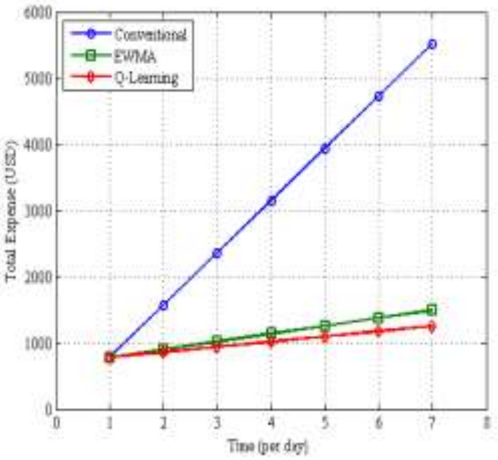


Figure 5. Comparative studies of IoT PGS's penalty fee a) costs on peak visitor scenario, b) costs on worst visitor scenario

Total saving costs for each parking algorithm of each scenario is shown in Table 5. The total saving costs of devices that use the proposed Q-learning method, conventional method and EWMA when the number of users is lowest are 4020 dollars, 22400 dollars and 4260 dollars, respectively.

TABLE II. TOTAL SAVING COSTS OF EACH SCENARIO

parameter	*Conventional*	*EWMA*	*Q-learning*
Maximum number of users	22,400USD	4,260USD	4,020USD
Minimum number of users	1,640,000USD	47,989USD	30,354USD

Similarly, when the number of users is highest the costs of Q-learning method, conventional method and EWMA are 30,354 dollars, 1,640,000 dollars and 47989 dollars respectively. As a result, the proposed Q-learning method is the best cost saving method.

Figure 5 Shows the cumulative number of users of each PGS within 1 week.

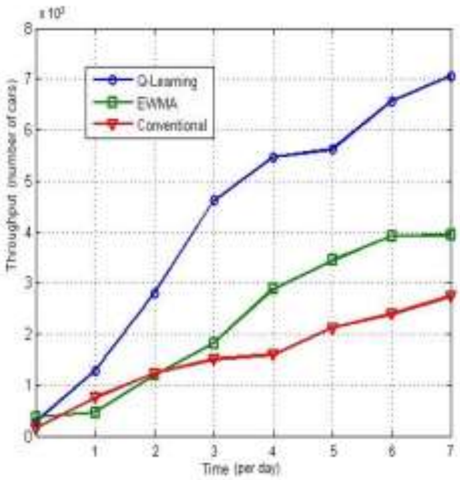


Figure 6. Number of parking lot cumulative cars per week

Figure 6 shows the measured response delay needed as the number of users changes. The simulation was conducted within a week during the busiest period of at least 8000

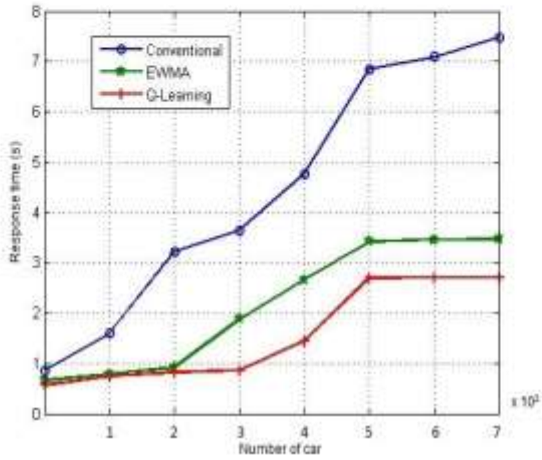


Figure 4. Response time from server to users with the dynamic number of users.

parking vehicles per day at Korean International Airport. As shown in Figure 7, the proposed Q-learning method can serve 7,000 cars within a week while the EWMA method and the conventional method can only serve 4000 cars and 2800 cars, respectively. This demonstrates that the performance of the proposed Q-learning method is 90% better the other two methods in terms of the number of users. In addition, while the response delay time of EWMA method and the conventional method increases as the number of cars increases, the response delay time of the proposed method maintains at 2.8(ms) even when the number of user is at its peak.

V. Conclusion

This paper proposes a Q-learning resource forecasting models and design techniques for the optimization of dynamic resource allocation in IoT PGS. The Q-learning resource forecasting technique is proposed in order to guarantee users' QoS and minimize service provider's cost. In addition, the paper analyzed hardware resource allocation of the existing PGS compares its economic feasibility with other PGS based on IoT. It is also proved that the proposed resource forecasting model shows excellent performance in PGS. In the future, the Q-learning resource prediction model technique will be applied and evaluated in various applications.

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