Smart Parking/Leaving buses management system:

Hajj journey case study

Abdellatif I. M. SEMEIA[a], Ibrahim F. TARRAD[b] and Khalid M. KHAYYAT[a]

(a) Computer Engineering Department
College of Computers and Information Systems
Umm AL-Qura University
DrSemeia@gmail.com aisemeia@uqu.edu.sa

(b) Electrical Engineering Dept. (Communications Sec.)
Faculty of Engineering
AL-Azhar University

Abstract: - Because of over 70% of the pilgrims in the Hajj journey are using buses as the way of transportation. The most common problem is managing the buses trips to accommodate all riders whom are intended to use this facility in a specific time, moving from one place to the other according to the Hajj time plan. Parking/leaving buses management procedure that is used relies on manual method which the efficiency is very low. Exiting from parking lots without management plan makes bottleneck at parking gates and blockage at road intersections due to human behavior.

The journey time is increased as consequences of aforementioned which lead to uncontrollable situations. This article is introducing a smart Parking/Leaving buses management system that optimize the parking arrangement and helps to decrease Hajj journey moving times. The system is using the state of the art technology based on wireless sensor networks.

نظام الإدارة الذكي للمواقف / ومغادرة الحافلات: حالة دراسية على رحلة الحج

د/عبد اللطيف ابراهيم سيمه د/ابراهيم فتحي طراد د/خالد محمد خياط

الملخص: تشهد المملكة العربية السعودية في كل عام موسم هام لدى كافة المسلمين في شتى بقاع الأرض ألا وهو موسم الحج حيث يجتمع في هذا الموسم أعداد تقدر بالملايين لأداء هذا الركن الإسلامي وفيه يتم التنقل بين المشاعر المقدسة طبقا لجدول زمنى محدد مستخدمين طرق عدة مثل القطارات و الحفلات وأيضا سيراً على الأقدام. إن أكثر من ٧٠٪ من الحجاج في رحلة الحج يستخدمون الحافلات كوسيلة تنقل. نجد أن المشكلة الأكثر شيوعا التي تواجه القائمين على ادارة الحج هو الآلية التي تدار من خلالها رحلات الحافلات لاستيعاب جميع الحجيج المستخدمين لهذا المرفق في مدة زمنية وأماكن محددة وفقا لخطة الحج الزمنية. إن الطريقة اليدوية لإدارة المواقف لاستيعاب الحافلات وأيضا تحديد وقت المغادرة للحافلات قد يؤدي الي كفاءة استخدام منخفضة جدا، فالخروج من مواقف الحافلات دون استخدام إدارة جيدة يجعل عنق الزجاجة عند بوابات المواقف ويحدث انسدادات في تقاطعات الطرق بسبب السلوك البشري الأمر الذى يزيد وقت الرحلة وما لها من عواقب قد تؤدي إلى حالات لا يمكن السيطرة عليها.

تقدم هذه الورقة العلمية نظام إدارة الذكية يمكن استخدامه لإدارة مواقف الحافلات يمكننا من استيعاب اكبر عدد ممكن وترتيب الحافلات في المواقف وأيضا تحديد أوقات المغادرة لكل

حافلة من خلال خطة زمنية منضبطة طيلة وأوقات رحلة الحج. هذا النظام مبنى على طرق علمية وتحاليل رياضية مستخدما تقنيات حديثة من المستشعرات اللاسلكية الغير مكلفة وسهلة التطبيق. تم تقديم النتائج باستخدام نظم محاكاة مبنى على أساس التدفقات العشوائية المتغيرة مع الزمن لمحاكاة الواقع الفعلي وتم الحصول على نتائج عظيمة في ادارة الحافلات مما له الأثر البالغ في استيعاب عدد حافلات أكثر دون الاحتياج لتخصيص مواقف جديدة وأيضا تقليل زمن الرحلة لكل حافلة إذ أنه يزيد من معدل التدفق المرورى بين المشاعر المقدسة.

Keywords: WSN and RFID Technologies, Stochastic Process, Traffic flow control, Hajj journey, and Parking/Leaving Time Management

I. INTRODUCTION

The estimation of the level of service of all parking areas within Arafat areas is one of the interior ministry tasks of traffic management in order to either maintain a stable traffic flow or to identify and cure bottlenecks. With respect to nowadays strictly limited resources and limitation of journey time, the authorities in charge will most probably favor conducting a estimation method which extracts the required data from available data sources or with an efficient data collection technique, rather than gathering the required data for each and every traffic light consecutively. During the recent years, various traffic data service providers and innovative data collection techniques (e.g. Automatic Number Plate Recognition (ANPR), Bluetooth, Radio-Frequency Identification (RFID), Wireless Sensor Networks (WSN), and GPS-Tracking) emerged, enabling practitioners and scientists access to data with both a quantity and a quality, they could not imagine in 20 years ago. The objective of this paper is therefore to establish a concept for a feasible, efficient and practical level of service estimation of parking/leaving buses within Arafat area, based on these data. On the other hand, wireless communications revelations in the recent years also allowed the developers to design small computational devices with merits such as, low cost production and low power consumption. One can imagine in a near future that, a connected environment expectedly will be disappeared while constant monitoring and information exchange is running. WSN and RFID are examples of which plays an important role. WSN has a great applicability on wide out-door environments such as object tracking and territory monitoring, while the RFID is commonly useful to in-door areas such as industrial production processes. However, integration of both technologies can improve the functionality of each one. In this article, the integration of RFID and WSN associated with the GPS will be used for exploiting a new parking/leaving management system which will gave a great effect on solving many of the Hajj journey traffic problems. Combining RFID (identifying and positioning) and WSNs (sensing, identifying, and multi-hop communication) properties can define several different application scenarios [1]. There are four types of integration mentioned in [2]

The remainder of this paper is organized as follows. Section 2 some review of a previous review of works that is related to our system. Section 3, gives a brief summary of the problem description. Section 4, provide a description of a smart parking/leaving management Scheme. Section 5 providing numerical results that is carried out using the new scheme. Finally, the paper closes with drawn conclusions and identified need for further research.

II. Related Works

Automatic Parking/Leaving buses scenario can be studied based on detecting the object (bus) at the entrance of the controlled area using integration of WSN and RFID. Due to human natures and different cultures, the usage of these facilities may face many obstacles and cease the better usability to take place. Real time monitoring and management of individuals is needed to increase the resources utilization and befits as much as we can from the information that can be collected every season to enhance the performance and help the decision makers to find solutions for any obstacles that might happen. Pereira, et al. [1], proposed of two heterogeneous architectures for integration between WSN and RFID technologies in tracking and monitoring animals. A nondeterministic pushdown automata model was presented. An implementation of WSNs and geo-reference databases management system (DBMS) is mentioned to monitor some kind of animals. Long range tags are studied for data validations to preservation and maintenance the natural resources. B. Torres, et al [4] presented a design with real-time access control application to validate the entry of a person entering a protected area to be monitored using integration of RFID and WSN. A person must carry an RFID tag, and when passing through the RFID field he/she will be identified, and will be granted or denied access to the area after validating the read tag ID with the entries in a database. They mentioned some complexity of integrating the RFID with WSN, and with some setup of new hardware they were able to lunch experiments and collect some results such as, running time, number of tags detected, starting time and ending time.

A transport protocol that can reduce the energy consumption and maintain the real time and high reliability of the actor is proposed by T. Wada et al. [5], by reducing transmissions of redundant packets in WSN. Using the one hop delay obtained from the past transmissions and the number of the hops, the packet arrival delay to the actor can be estimated. The consequence of that is increasing the sensors life time with reducing the power consumption. A review of the most important restoring connectivity of portioned problem is mentioned in [6], while suitable for solving such problems is chosen and adopted as a case study. Due to the behavior of pilgrims, some roles in placement and/or WSN elements is given based on the special topography of the case study' locations. A performance enhancement of the overall network; quantitatively and qualitatively, are given.

III. Problem Description

Studying the traffic behavior in the Hajj journey where the parking spots demand is exceeding the available capacity is very crucial especially when millions of pilgrims are moving from one place to another in very restricted time schedule. Avoiding bottleneck at the entrances and exits of specific areas such as Mena, Muzdalefah, and Arafat mountain areas has a great impact to facilitate the journey and ease the administration works. Hunting for a vacant parking spot in such areas is a source of anxiety for most bus drivers and it is time-consuming and traffic jamming as well. It generally results more traffic congestion and air pollution by constantly cruising in certain area only for an available parking spot if there is no parking management procedures were applied. Some survey on big cities during the rush hours shows that the traffic is increased by more than one third of regular traffic due to searching for parking spots. If we imagine this increasing during the Hajj journey, it would be

extremely difficult for interior ministry to apply a plan for transporting pilgrims from one place to another in the intended time and also led to a whole system traffic failure. The bad impact if there is no traffic management is that, during the rush hours in most Hajj areas, the traffic generated by buses searching for parking spot takes up to 40% of the total traffic and corresponding high proportion of CO2 emissions. Looking at one of the Hajj Journey area map, Arafat area is illustrated in Fig. 1. It shows some of parking areas closet to the pilgrims' tents which is not sufficient to accommodate the whole number of buses that assigned to carry the tents residences.

Fig. 1, Arafat area Map

The parking areas in the Arafat area photo can be shown in Fig. 2, as a small gray shapes and zooming one can see more details about these shapes as yellow dashed areas.

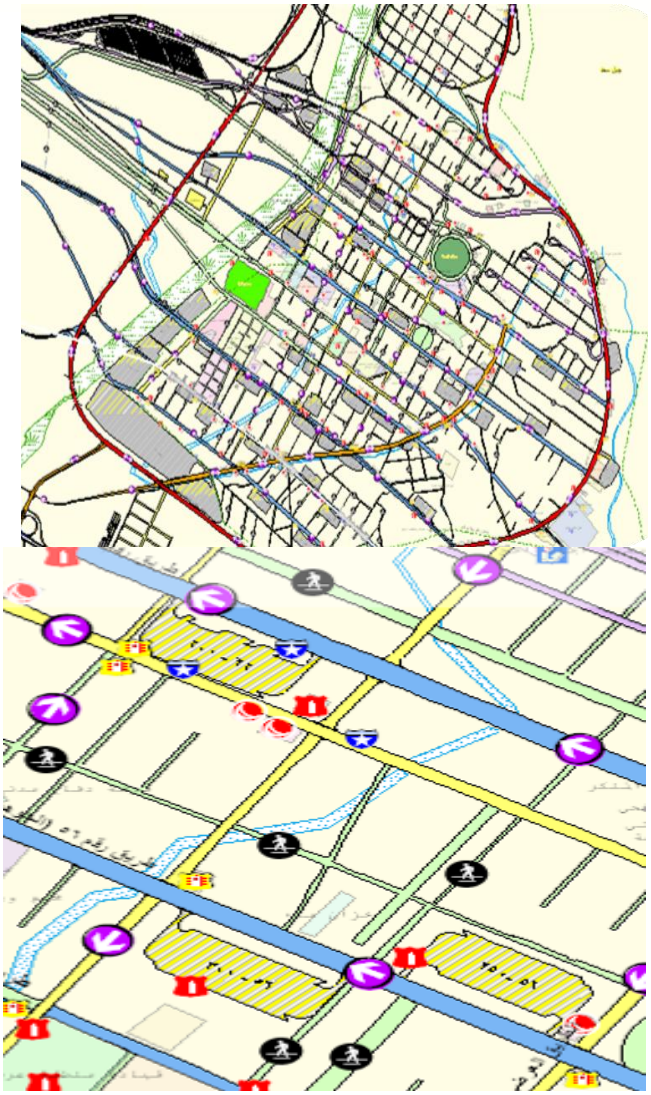


Fig. 2, Parking areas in Arafat Mountain Area.

From the site real inspections of the Arafat topology, any parking area is categorized into two topologies: either one-gate parking area or two gates parking area. In the parking area which has two gates, we can be assign one gate for entrance and the others for leaving. This parking area can follow what so called First-In First-Out discipline (FIFO). On the other hand if the parking area has a single gate it should follow what so called Last-In First-Out (LIFO), or Last-Come First-Serve (LCFS) discipline. In the latter one, the selection of bus to leave the parking area is done in the reverse order which they arrive, and the bus entering last is the first to be selected for leaving. Arranging using this way will use the whole parking area without leaving any vacant parking spot.

The LIFO queueing discipline can be considered as M/G/1 queueing system case in which leave permission is given to the most recent bus arrival on a non-preemptive basis. In other words, no bus will leave in the one front of it is still park. Here we have the probability of access the exit equals one; P=1 (no externally assigned priorities). This order of service like any push-down stack operates in this fashion. Because of the decision rule in independent of the leaving time, one can see immediately that the average parking size and the average waiting time to leave must be the same as the

stack strategy. On the other hand, the FIFO which is the two gates parking areas case, the leaving permission is given to the first bus which parked in that area. Amazingly the mathematical treatment of such case is the same as the previous one (Both results have established for the M/G/1 queueing system model). With unconditional behavior, we find that with probability 1-ρ, the bus has to a waiting time of zero and with probability ρ it has a waiting time [7][7] whose moment transform is to be:

$$\ddot{W}(s) = E[\exp-(sw)] = 1- \rho +\lambda\{(1-G(s)\}/\{s+\lambda-\lambda G(s)\}$$

Where, $\ddot{W}(s)$ is the bus waiting time to leave parking area, and λ is the bus coming/leaving rate.

We can extend our study to the drivers' behavior under in four assumption ways. (*i*) Balking: Some drivers show reluctance for waiting in the line for getting parking spot. They do not join the line at their correct position and attempt to jump the line and reach for either exit gate when the time for leaving is came or entrance gate for parking spot. This is done by passing other ahead of them. (*ii*) Reneging: some bus drivers after waiting sometime in the line leaves the line without getting the parking spot due to impatience and trying to pull back which causes traffic jamming or blocking the sequence from getting the service (Parking or Exit). (*iii*) Collusion: Some of the bus drivers join the line together and only one bus instead of all, stay in the line, however, when their turn comes for service, the bus driver who were in collusion demand an access to either parking area or exit road. (*iv*) Jockeying: In case there is more than one waiting line for similar type of service, in our case study it is exist as looking for parking or accessing the exit road, some bus drivers keep on shifting from one waiting line to another waiting line to improve their position and get immediate service.

IV. Smart parking/leaving management Scheme Description

Automatic assignment of parking spot and leaving time for buses is very important especially for hajj season where millions of pilgrims are moving among Holy places "Masha'er" in specific days and restricted times to perform "Hajj Manasek". The Kingdom of Saudi Arabia (KSA) are trying to facilitate these trips and helps the pilgrims to perform the Hajj without suffering taking into their considerations that, most of them are elder people. The automation of these procedures can be done with using *Wireless Sensor Network*, WSN, and *Radio Frequency Identifier*, RFID[10][7]. Most but all of buses have RFID tags which can be founded in the plate number. These tags are passive tags which can only be detected in the reader areas. Readers can be implemented in the designated areas, parking areas, from which the data can be collected and with central computer the assignment can be done automatically based on the parking spaces and situations. Now, we come to the point of an important question; how can we direct the bus driver to a specified area? To answer such question, it must be a means that can be used to tell the driver in which area can he parks his bus, WSN can achieve this mission. Each bus must carry a device such as Personal Digital Assistant PDA, or even smart mobile phone. This smart mobile phone can receive the routing data and the explicit parking area for the bus driver. The spot will be closed as much as it can to the group tents and hence, the parking area will be well organized. Once the bus has entered the assigned spot, the sensor will send the required information to the data collector (Actuator) which will pass it to the

common operational center (COC) and then removed from the vacant spot's database section.

Buses will be equipped with long rang wireless sensors while actors (WSN reader) will take places at the parking areas. These readers are also forwarding continuous data to a common operational center [9][10] which will update the stored data in a distributed database (DDB) for management purposes. There are software packages running on the main server on the COC to determine the actions to be taken. Ready information will be sent to individual ones; bus driver, in the group(s) that are intended to be ready at the entrance of Arafat Mountain area platforms before the bus is reached by. Once the bus reached the coverage area the bus driver will receive directions for get into the correct parking spot and the bus driver will move accordingly, the WSN reader on the entrances collects these events, bus came and directed, and send it back to the COC for information updating. The bus which didn't catch the direction information can be detected from the readers on the entrance since a sort of acknowledgments will be used to send back to the entrance reader to confirm that the direction has been sent correctly. In such case, the sender will try to retransmit the information again to the prospective bus driver. In case the retransmissions are failed after a specific period of time, the COC will send non-acknowledged action to the entrance gate coordinator to either poll him out of the queue or direct him manually. These ones are to be accumulated with their situations and will be fixed during the parking waiting time based on the COC DDB system.

V. Numerical Results:

Stochastic process simulation [11] is used with some parameters; the frequency of the buses distribution is following uniform distribution. The dwelling time (time the bus is parked at the parking area) is the time the predefined in the Hajj journey schedule and deterministic time to leave the parking lot. On the other hand for comparison, the time to leave the parking lot for the buses which our management is not applied is following Poisson distribution which is reflected the real bus driver behaviors. The simulation results concerning the maximum number of leaving buses from the parking area for parking system with/without using the proposed scheme are shown in Fig 3 and 4 respectively. The results in Fig. 3, are pretty much in line with the analytical analysis mentioned previously. The maximum utilization using the management system is obtained, the new scheme make the flow to reaches about 70% with the first hour, while without using the scheme did not exceed 39%. This can be interpreted as, the more buses contending to access the roads without arrangement, the flow degradation is occurred. On the other hand, this is a great chance for increasing the percentage of leaving rates with this tied plane. Fig. 4, shows many scenarios and it is worth to mention here that, without using management plan, the traffic when the beginning of leaving time is reached, better performance results is happen while after 10 minutes the whole traffic system is suffering from crowded roads followed by the whole traffic system is almost blocked. In contrast, using the proposed scheme, the situations are completely different. The traffic flow is quite good with easiness trips progress traffic flow. The DDB can help in these scenarios on behalf of gaining more enhancements based on real-time observations. One can see, using the new scheme is doubling, or even more, the parking areas utilization.

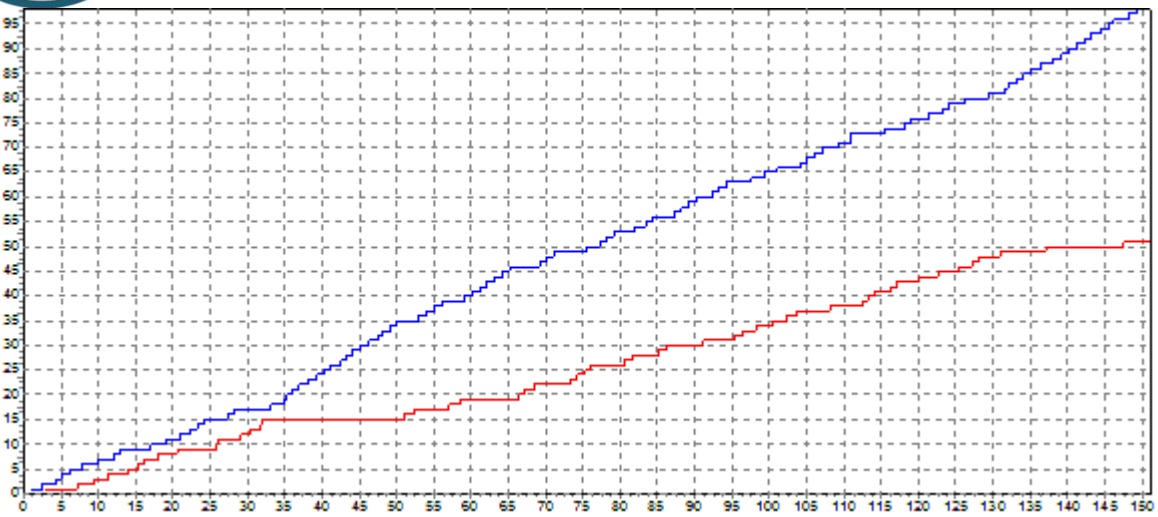
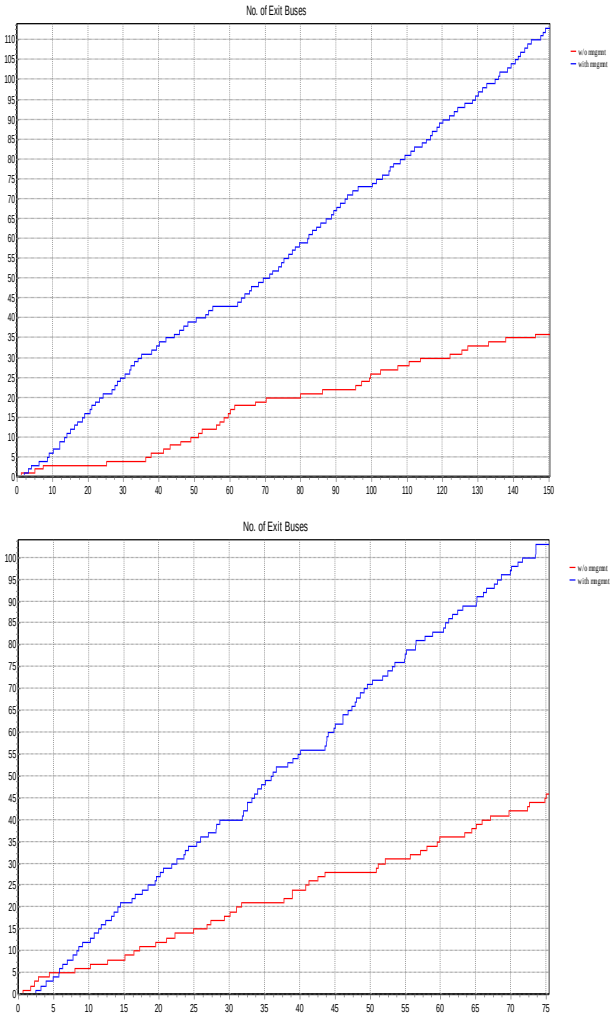


Fig. 3, the percentage of the buses leaving



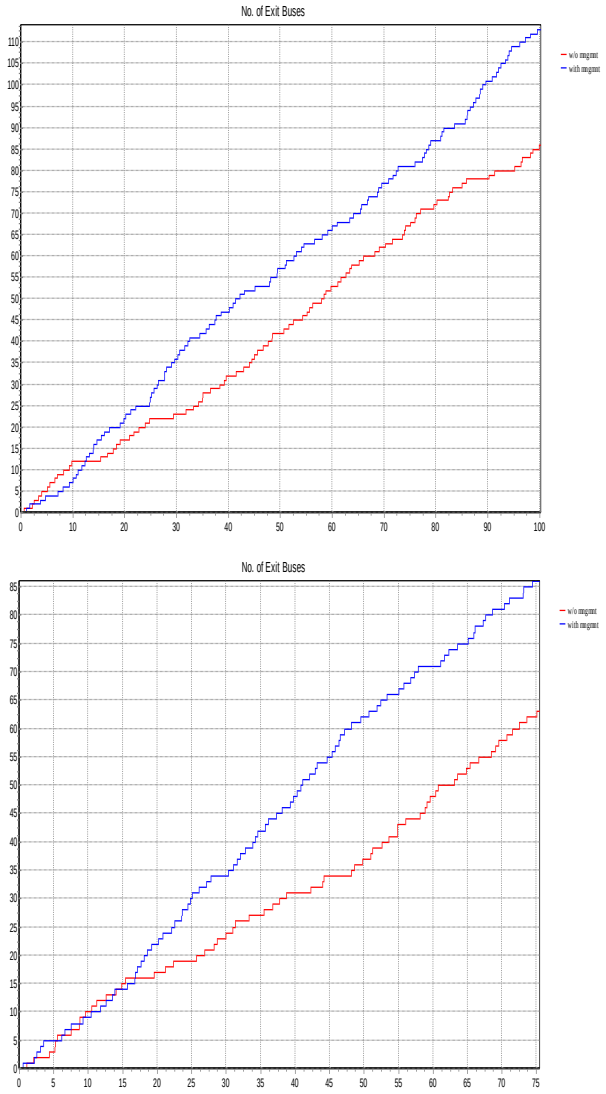


Fig. 4, Scenario shows the number of buses leaving the parking areas using the new system

VI. Conclusion and future work

In this research paper, integration types of RFID and WSN are reviewed with the some of the related work as well. Analytical model using stochastic processes is given for bus waiting time to leave the Arafat Mountain area. Smart Parking/Leaving buses management system is proposed. The organization of parking spots, and specific time assignment can be made for each bus when the time reaches for leaving the parking area which will be based on accurate information. This information is being received by the bus driver through WSN. Central Control site is automatically monitoring the situation of buses in a real time access and DDB will be updated automatically. Invoking information at any time can be done and the higher authorities are be provided with accurate information of any occasions in real time which could be remotely.

The maximum utilization of the management system obtained with using the new scheme reaches 70% after the first hour, while without using the scheme did not exceed 39%. This is a great chance for increasing the percentage of leaving rates with the Hajj tied plane. The result also shows many scenarios at the beginning of leaving time. Better performance is carried out with using our management scheme to avoid traffic jamming in many areas. The scheme is working fine with easy traffic flow. The DDB can help in these scenarios on behalf of gaining more enhancements based on real-time observations. One can see, using the new scheme is doubling, or even more, the traffic system flow percentages. The results show superiority of the carried load and parking system utilization in the way that it can easily established very fast.

The extensions of the current work include:

1. In the analytical discussion concerning the trips and pilgrims' distribution, more information is needed from the hajj minster with what ways they are using. It would be interesting to be investigated, however, whether the same optimal values under other distributions can be achieved.

2. So far, we have studied the management of parking areas and leaving time plan for buses, while the number of trips that a bus can made in the specific days is a very crucial piece of information. If this information is provided from the authorities, we could run the simulation and obtain better insight of each scenario.

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