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# A DEVELOPMENT OF A GATED COMMUNITY ACCESS DATA COLLECTING AND MONITORING SYSTEM

Chompunic Teawcharoenporn[1], Thanathorn Phoka[1,2,*]
Winai Wongthai[1,2] and Thanakrit Kraising[1]

[1]Department of Computer Science and Information Technology
[2]Research Center for Academic Excellence in Nonlinear Analysis and Optimization
Faculty of Science
Naresuan University
Phitsanulok 65000, Thailand
{ chompunict64; thanakritk63; winaiw }@nu.ac.th
*Corresponding author: thanathornp@nu.ac.th

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Abstract. *This paper proposes the development of a gated community access data collecting and monitoring system. Food delivery services are increased by the demand of residents in gated communities. To avoid the bottleneck at the main gate of a gated community, no digital data collection, additional payment from phone calls, and to enhance the community residents' personal safety, security, and privacy, there is a need to have digital information for the authorization processes among a community's resident, resident's visitor, and security guard at the main gate. There exist systems collecting digital data for the authorization processes of incoming and outgoing trips of a resident's visitor at a community's main gate. Based on these systems, we developed a system that can be suited to our environment in Thailand. The development leads to the main contribution of this work. This is to develop a system that can collect and monitor digital information for these authorization processes. Moreover, this work performed experiments to measure the time consumed by the authorization processes before compared to after using our system. One of the system's functions can help a resident to generate information to allow his/her visitor to be checked-in and checked-out automatically and digitally. This information is then sent to the security guard to authorizedly and digitally allow the visitor to be checked-in and checked-out. This allowing process with the other system's six functions can assist in enhancing the personal safety, security, and privacy of a resident. Then, the functions can reduce face-to-face conversations among a visitor, security guard, and resident. Avoiding these conversations can decrease crimes such as indecency, raping problem, or robbery. This may also decrease the risks of COVID-19 spreading. To achieve these functions, this paper proposes not only the system but also a system supporting the requirements. The architecture of the system, the use cases, and a prototype and experimental result and a discussion of the system are presented. From the experiment in our testing environment, on average, the time consumed by the authorization processes of the proposed system is lower than the old-manual system by about six times.*

**Keywords:** Gated community, Data collecting and monitoring system, Food delivery service, Personal safety, Digital information

1. **Introduction.** In Thailand, Kasikorn Bank's Research Center [1] estimates that in 2019 the race with food delivery applications continues to drive the food delivery industry to 33-35 billion Thai Baht (about 924-980 million United States Dollars); this is about 14% increased from 2018. One of the reasons for this driving force may be that people in urban society prefer dinners with online restaurants instead of onsite ones. This is avoiding traffic jams and the convenience of online manners. The popularity of online food

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delivery services among residents of housing estate juristic person (HEJP) [2] registered outside Bangkok is related to the increasing of HEJP projects/villages number [3]. Thai Department of Lands [4] reports in [3] that the registration of HEJP villages in 2018-2020 in Bangkok is more than 70 projects. The registration outside Bangkok is more than 170 villages. And both numbers are tended to be continuously increased.

However, emerging of this business generates negative impacts on the social society of an individual resident who lives in an HEJP village (for short, HEJP) in terms of the resident's personal safety, security, and privacy. In general, the security procedures of an HEJP village are highly intense, but these procedures can decrease the efficiency of the management of this business. The decreased efficiency may be because of the security procedures of an HEJP village in the processes of checking-in and checking-out and exchanging the identification card between a visitor and HEJP village's security guard at the village's main gate. These processes can be time-consuming. Then, this can slow down the delivery services because a visitor (such as a rider of a food delivery service) needs to call a resident whom he/she is visiting or delivering.

There are three main problems with the negative impacts of this business. In terms of economics, a visitor/rider must call a resident to prove himself to a security guard (SG) at the main gate. This may cause this visitor to pay the bill for unnecessary phone calls, and this bill can be expensive. Thai Office of The National Broadcasting and Telecommunications Commission reports that in the first quarter of 2020, the average price of voice services of five Thai main cell service providers is 0.51 Baht per minute [5]. In terms of society, for an incoming trip at the village's main gate, the authorization among a visitor, SG, and resident is composed of many processes and is time-consumed, as also agreed by [6]. This may cause a bottleneck at the main gate. Failure to obey the appropriate authorization can impact the reputation of the village [6].

Finally, in terms of public health, there are face-to-face conversations among a visitor, SG, and resident, which may increase the risks of COVID-19 spreading. Moreover, these conversations may cause crimes such as indecency, raping problem, or robbery. To sum up, the security procedures of a traditional HEJP village lead to three main problems: additional payment from phone calls, the bottleneck at the gate, and no digital data collection (digitization is better than the paperwork [6]). These problems can reduce the security of a resident who lives in this village.

The solution for the problems above can be to develop a data collecting and monitoring system. This can increase the safety of the village by taking records of checking-in and checking-out data. It also can increase the convenience of delivering food or meeting people in the village and reduce the problem of bottlenecks in front of the village. This also can decrease the payment of unnecessary visitors' phone calls. We will call this system a gated community access data collecting and monitoring system or GCMS. We believe it can be one of the components of a village to reduce authorization processing time at the gate. Thus, the main two objectives of this paper are i) to develop GCMS and ii) to measure how it can reduce time consumption at the main gate.

We believe GCMS can decrease the main problems above, especially for food delivery services in an HEJP village. This is because there is no proper research on the negative impacts of this kind of service yet. Thus, GCMS can be a preventive approach to the impacts. When checking-in and checking-out, digital data were intensively collected; this may stop a person who is thinking of committing a crime. Because if he committed it, this digital-collected data could be used for efficient investigation of the crime by the appropriate authority, such as polices or the village owner.

The organization of this paper is as the following. The background is described in Section 2, including gated community and digital timestamps, existing systems and feature comparisons, and the overview of the proposed system. The system design and implementation of the proposed system are discussed in Section 3, including the associated data to the proposed system, the main adopted technologies, and the system architecture and implementation of the system with three scenarios of usage. The results and discussions of the proposed system are presented in Section 4. Section 5 gives the conclusion and improvements of this paper.

## 2. Background.

**2.1. Gated community security and digital timestamps.** From [7], gated community or walled community emerged in the 19th century. Nowaday, this community is changed to be called a housing estate juristic person (HEJP) village. The village aims to increase safety, security, and privacy for the village's residents. Tanulku [8] agreed that, in present-day Turkey, safety has grown into a crucial factor, particularly in large cities such as Istanbul, Turkey. She also stated that this factor leads individuals to move to gated communities which are believed to protect residents from urban troubles. To reach the aim, it needs to have gated screening and controlling processes for getting in and out of a person or vehicle in the village. Generally, a village hires a company that allows SGs to perform these processes. This is called a gated and guarded community. We will call it a gated community.

Mohammad et al. [9] and Tahir and Hussin [10] studied the physical characteristics of gated communities in Malaysia, and this can be learned from several previous explicit pieces of evidence. The result is that access control with SGs is common in all communities. In addition, these communities are also equipped with many types of security devices, such as closed-circuit television or CCTV systems and an emergency alarm system. This is to enhance the security levels of the communities. However, from the studies, few communities can describe in detail the appropriate procedures for the gated community in Malaysia. These procedures are important features of the gated community, as agreed by [11]. We also believe that these procedures are important and want to develop a digital information system for access control for this type of community or HEJP village. We want that the system can be along with the appropriate procedures that enhance security for the gated community.

Tahir and Malek [12] studied safety priorities in gated communities, and the result is that access control to residential areas is the most critical criterion. The second most important one is the demand to have physical barriers such as fences, walls, or other elements to enhance the safety of the communities. Then the next ones are the CCTV system, lighting equipment, guard towers, and landscapes. These researchers also stated that these criteria are needed to be considered and can ensure a high level of physical security in gated communities.

Digital timestamps such as the checked-in and checked-out time stamps are important [13, 14, 15]. The real-time timestamps can help to authenticate the entrances of visitors to gated communities [13, 14, 15]. In our testing gated community, this digital timestamps data can help police to investigate some incidents. For example, a security camera in this community can record when a visitor steals something from the community. Somehow, the camera cannot record the visitor's vehicle license plate number. The timestamps from our system can be used as a time frame to identify, for example, how many visitors in that period of time. This can ease the police from performing further investigations.

**2.2. Existing systems and feature comparisons.** We considered only some systems and some of their functions that relate to the gated community access data collecting and monitoring system. MyMooBan [13] is a collection of applications for both a resident and owner of an HEJP village. For example, one of the applications is for a resident to be notified when his/her visitor has arrived at the gate. Another application can collect visitors' trip information with optical character recognition or OCR, for example. LivingOS [16] is also a collection of applications for both a resident and owner of an HEJP village.

One of the applications is called visitor control which can manage all types of vehicles that get into a village. This is to ease efficient communications between a resistant and a visitor.

MyGate [17] can be an application for an HEJP village as well. It makes an HEJP village secure and progressively supportive for residents by confirming the visitor that is coming into the village. SG can efficiently manage passages for the visitor. DiGintry [15] system can digitize manual activities for gated communities, such as a hostel. This system aims to enhance security by assisting in registering the details of the visitors. This is to maintain the tracked records and to perform analysis on them digitally rather than manually. The system satisfied the visitors' needs by shortening the time involved at the doors for actually registering every visitor's details. Finally, iNEST [18] is a platform that can deal with all the security requirements of a gated community. A resident can invite visitors from his/her mobile phone using a mobile application. The resident can also set the time duration of the visit and generate a pin for a visit. The pin will be sent to the visitor via SMS to gain automatic access to the community's area (such as the main entrance doors or the public areas).

We aim to implement all functions or features of all existing systems above. There are seven main features of the systems. They are F1 to F7, and F1 is when a system can support when a resident both made and did not make pre-booking with a visitor. F2 is when a system allows a resident to approve a visiting trip's checking-in and checking-out statuses. These statuses include digital timestamps. F3 is when a system allows an SG to collect digital checking-in and checking-out digital evidence/data (e.g., citizen identification number (CIN), license place number (LPN), or driving license number (DLN)) of a visiting trip. F4 is when a system supports food delivery services. F5 is when a system can send notification messages to a resident when a visitor has arrived at the gate for an incoming trip. F6 is when a system supports bar-code, QR-code, or card and PIN pad readers. F7 is when a system can collect both digital checking-in and checking-out status data of a visiting trip. These statuses also include digital timestamps. As we have discussed above, Table 1 summarizes the feature comparison among the existing systems based on F1 to F7.

TABLE 1. Feature comparison

| System | F1 | F2 | F3 | F4 | F5 | F6 | F7 |
|---|---|---|---|---|---|---|---|
| MyMooBan [13] | √ | √ | √ | | √ | | √ |
| LivingOS [16] | | √ | √ | | | √ | |
| MyGate [17] | √ | | √ | √ | √ | | |
| DiGintry [15] | | | √ | | | √ | √ |
| iNEST [18] | | | | √ | √ | √ | √ |

2.3. **The overview of the proposed system.** We will develop GCMS that has all the features we have discussed above, as shown in Table 1. Based on these features from the table, Figure 1 shows the system overview of GCMS. The overview demonstrates how the system works in terms of the system procedures of a resident and SG. There are five main steps of the procedures; see the small circles with numbers 1 to 5. In step 1, a resident inputs food delivery or visitor details into the system via a smartphone. This step shows that a resident of house number 9/70 is ordering food from the 'Food Delivery' platform with the order id as 'ORD-1098' and with the rider's information as 'RD-1, XYZ-987'.

In step 2, the resident can press the 'Inform Order' button to let GCMS know the information from step 1. In step 3, when the rider arrives at the main gate, he can show the information to an SG to be checked into the village and then deliver the order. In

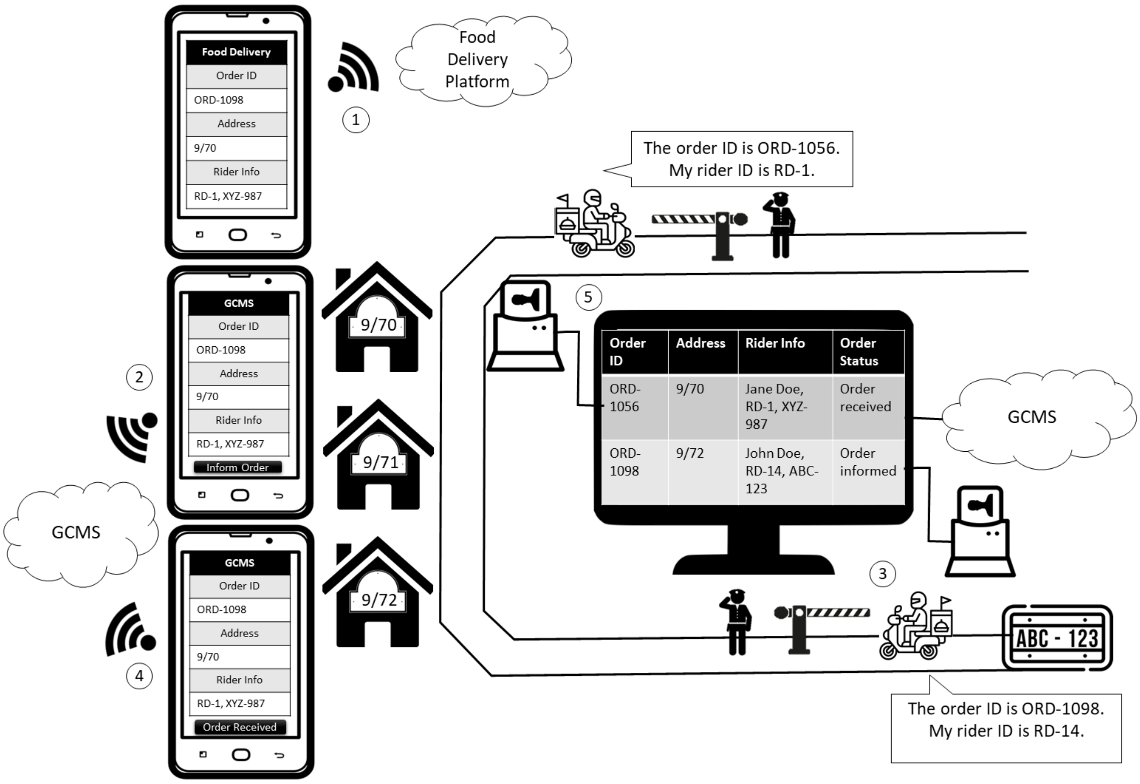


FIGURE 1. Overview of the proposed system (GCMS)

step 4, after the resident gets his order, he can press the 'Order Received' button on the phone to generate checking-out data to allow the rider to be checked-out by the SG and out from the village. These generating checking-out data process and checking-out process are considered as step 5. Both checking-in and checking-out processes can obtain the identification data from the rider via card reader devices, such as a bar-code scanner.

3. **System Design and Implementation of the Proposed System.** This section discusses the system design and implementation of GCMS based on the system overview above.

3.1. **The associated data to GCMS.** A visitor can be a rider or a resident's guest. The rider can be of Grab [19], foodpanda [20], or LINE MAN [21] platforms. The resident can order products from these platforms. The name of each platform is called 'platform data (PD)'. A ticket is data that is provided by a resident, including a license place number (LPN), delivery order number (DON), or guest's name. A checking-in data (CID) for authentication of a visitor can be a citizen identification number (CIN), LPN, or driving license number (DLN). Checking-out data was mainly a current digital timestamp (DT) when a resident pressed the 'received' button on GCMS. DT can be seen by SG in the GCMS web application/app for the checking-out process before allowing a visitor to get out from the gate.

3.2. **Main adopted technologies.** The main technologies to be adopted to build GCMS are the following. [22] states that 'a Webhook is an HTTP callback for applications to provide commands and information to other applications'. Shared hosting is a web hosting service and Internet domain registration [23]. LINE [24] is a chat application/app and has become a full-grown social media platform, as well as becomes a platform to support all platforms. LINE is also equipped with an efficient communicating interface called a chatbot that can be used for communication through dialogue or text, mimicking human communication [25]. In [26], this LINE chatbot is also used as artificial intelligence (AI)-powered health chatbot in a healthcare-related system.

Thus, we also apply a LINE chatbot to building GCMS. We call this chatbot a Gbot app, for short, Gbot. The Gbot was developed using a Webhook to integrate this bot application with LINE messaging application programming interfaces (APIs). This development is also done by [22]. This API allows data from Gbot to be sent to the LINE Platform and (Gbot's) app server [27]. When a resident sends a message via Gbot, a Webhook will be triggered, and the LINE Platform sends a request to Gbot's app server Webhook URL. The server also can send a request to the LINE Platform to respond to the resident's request.

3.3. **System architecture.** Figure 2 shows a system architecture of GCMS, partially applied from [22, 27]. We developed GCMS based on this architecture. And based on the main technologies adopted to build GCMS discussed in Section 3.2, GCMS has five main components; see the five italics and underlined texts in the figure. They are the Gbot app, Python app, LINE Platform, Gbot app's server, and GCMS web app. The eight main working steps in the architecture are the following. 1) When a resident inputs ticket/DT data to Gbot, it sends a Webhook event as a JSON message of this data to the LINE Platform. 2) The platform directs the ticket/DT data to the Webhook URL of https://x.com/webhook; this is an example URL. 3) The platform also performs the Webhook HTTP POST to send the ticket/DT data to the Gbot app's server. The server is with a prepared Webhook URL of https://x/webhook. 4) The Python app in the server gets the ticket/DT data, then sends it to the prepared shared hosting, and stores the ticket/DT data into the database in the hosting. 5) GCMS (PHP) web app in the shared hosting can query the ticket/DT data from the database. 6) The web app can display the ticket/DT data to SG. 7) This web app also allows SG to input CID data back into the app and store the data in the database in step 8.

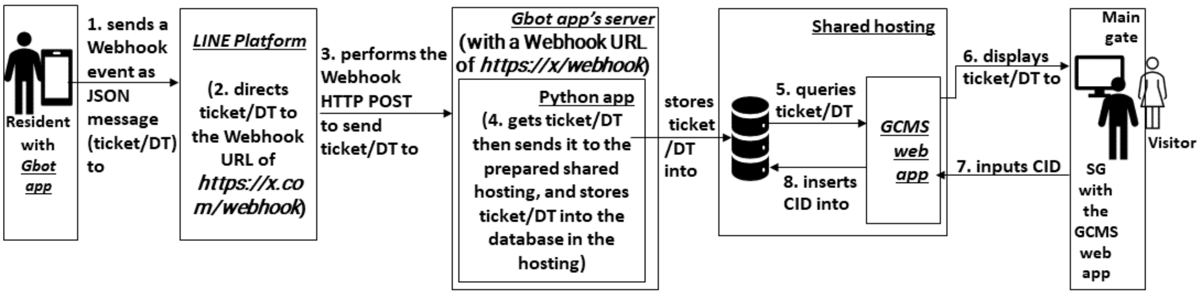


FIGURE 2. System architecture of GCMS, partially applied from [22, 27]

3.4. **The developed GCMS handling three cases.** Based on the system architecture of GCMS above, GCMS can handle three cases or scenarios of usage. The best case or Case A is when a resident provides complete information or data to GCMS. This data is from i) and ii). i) is when a resident provides both PD and a ticket. ii) is when a visitor can provide his/her CID for the authentication of this visitor. The common case or Case B is when a resident only gives some information to the system. This is when either b1 or b2 has occurred. B1 is when a resident has only PD, and b2 is when a visitor cannot provide any of his/her CID for authentication. The worst case or Case C is when the resident did not inform the system that someone would come in. This was when c1 and c2 occurred. C1 is when a resident has no ticket information, and c2 is when a visitor cannot provide any of his/her CID for authentication.

4. **Results and Discussions.** After the development of GCMS, this section discusses the results and discussions of our experiment for the measurement of the time consumed by the authorization or gate-entering processes of the old method and GCMS. We will call the time consumed by gate-entering processes TC. The results of this experiment can be used to compare the TCs of both the old method and GCMS. A sample is an undergrad student. We have 61 samples of the old method and 79 samples for the GCMS (Case A for 38 samples, Case B for 20 samples, and Case C for 21 samples).

The results for the measurement of TCs for gate-entering processes of the old method and GCMS are shown in Figure 3 and Figure 4. Figure 3 shows TCs comparison of GCMS and the old method. See the thick line shaded boxes in the figure; minimum TC (min_TC), maximum TC (max_TC), and average TC (avg_TC) of GCMS are 2, 62, and 17 seconds, respectively. While seeing the dot line boxes in the figure, min_TC, max_TC, and avg_TC of the old method are 24, 101, and 48 seconds, respectively. Thus, by avg_TC, GCMS is faster than the old method, about 2.82 (48 seconds/17 seconds) times.

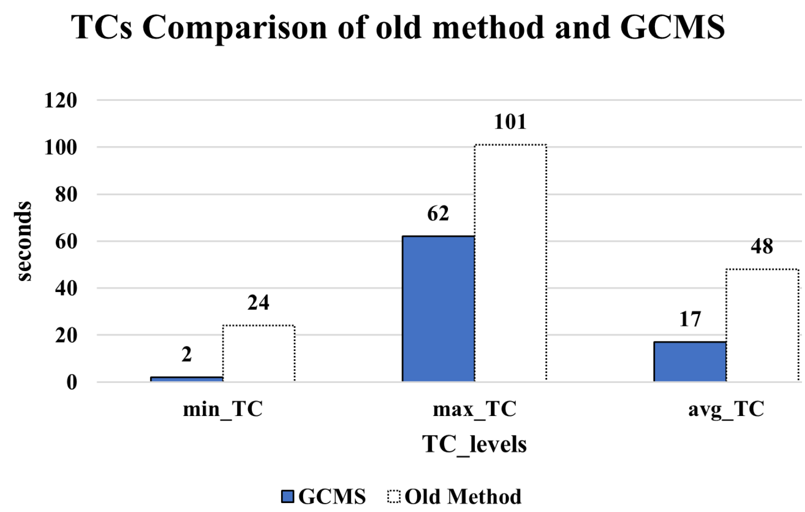


FIGURE 3. TCs comparison of GCMS and the old method

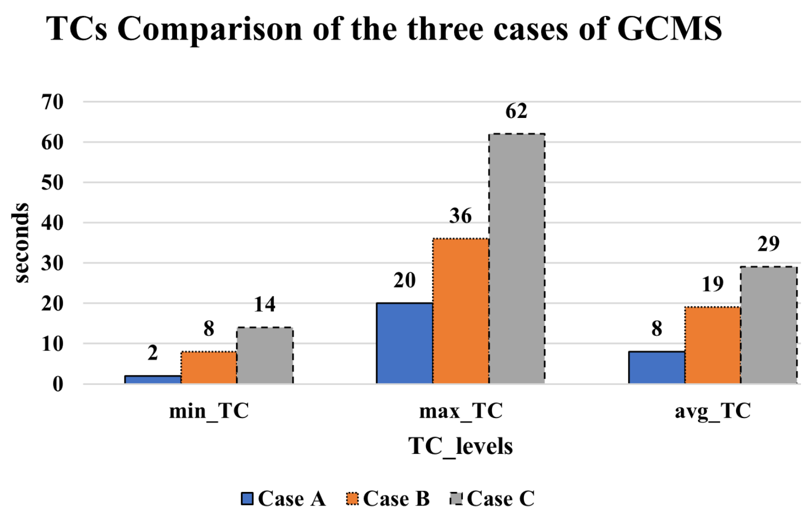


FIGURE 4. TCs comparison of the three cases of GCMS

Figure 4 shows a TCs comparison of the three cases of GCMS. See the thick line boxes in the figure; min_TC, max_TC, and avg_TC of Case A are 2, 20, and 8 seconds, respectively. While seeing the dotted line boxes in the figure, min_TC, max_TC, and avg_TC of Case B are 8, 36, and 19 seconds, respectively. Finally, see the dashed line boxes in the figure;

min_TC, max_TC, and avg_TC of Case C are 14, 62, and 29 seconds, respectively. Thus, by avg_TC, Case A is faster than Case B about (19 seconds/8 seconds) 2.38 times, Case C about (29 seconds/8 seconds) 3.63 times, and the old method about (48 seconds/8 seconds) 6 times.

Figure 5 shows a box plot of the results of the experiment. From the figure, the X-axis is method names, and Y-axis is TC in seconds (from about 0-90 seconds). Ignoring the three outliers or the four small circles in the figure, and, from the box plot, min_TC of Case A is lower than all min_TCs of the other methods, see all the lowest-horizontal lines under all the four boxes. See all the highest-horizontal lines above all four boxes, the max_TC of Case A is also lower than all the max_TCs of the others. Finally, see the four median values of TCs (median_TC) of all the methods or the horizontal lines inside all the four boxes, median_TC of Case A is still lower than all other methods. Even the max_TC of Case A (20 seconds) is still lower than the min_TC of the old method (24 seconds). Thus, again, Case A is the best and fastest scenario. However, to achieve Case A, a resident needs to provide complete information or data to GCMS. This data is from i) and ii). i) is when a resident provides both PD and a ticket. ii) is when a visitor can provide his/her checking-in data (such as CID) for authentication.

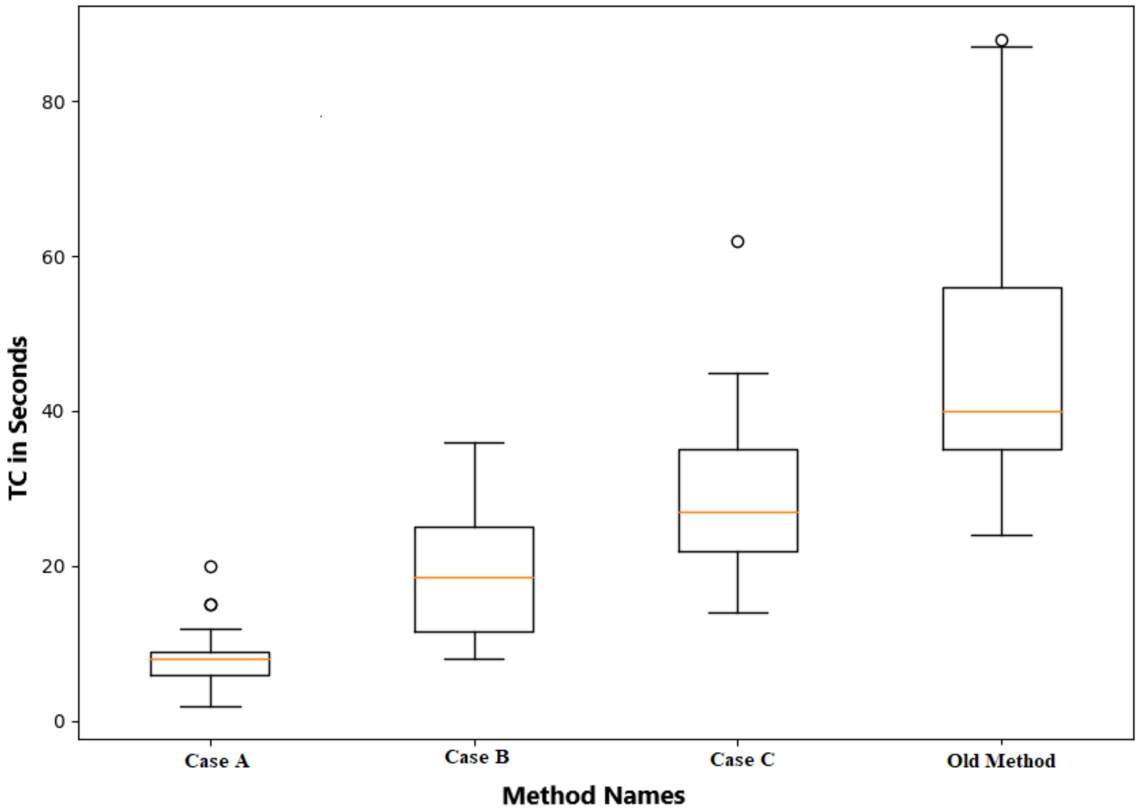


Figure 5. Box plot of all methods

5. **Conclusions and Future Work.** This work considers a system for gated community access data collecting and monitoring or GCMS. The system is mainly operated on mobile phones with a LINE chatbot for residents of a gated community. The purposes of using the system are to decrease the bottleneck at the main gate of the community, collect digital data, and reduce additional payments from phone calls. These purposes can be achieved by when a resident uses GCMS's chatbot to provide data on GCMS visitors' incoming and outgoing trips. At the same time, a gated community's security guard can use GCMS's web application to monitor the data from the resident and to provide another checking-in and checking-out data to GCMS. All these digital data allow the guard to appropriately

complete the checking-in and checking-out processes at the main gate. This can affect the resident's personal safety, security, and privacy. Based on these purposes, the architecture of GCMS has been proposed.

From the experiment in our testing environment, on average, the time consumed by the authorization or gate-entering processes of the proposed system is lower than the old manual system by about six times. However, the proposed system still needs more automatic features, such as the face recognition feature. For example, when a visitor arrives at the main gate, this feature can automatically deal with the checking-in and checking-out digital data of the visitor without providing any identification cards. We can add the feature to GCMS with available tools, such as one provided by [28]. This feature and the finalized GCMS will be included in our future work.

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