Using Hybrid Technique: the Integration of Data Analytics and Queuing Theory for Average Service Time Estimation at Immigration Service, Suvarnabhumi Airport

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ABSTRACT

In the past few years, Thai tourism industry has become one of the big markets in the world that makes the number of air passenger has growth rapidly. The survey shows that 15,883,928 passengers arrived at Suvarnabhumi international airport, Thailand in 2015 which increase around 11% every year. Due to this reason, the airport needs to seek for effective strategies to operate an immigration service in order to avoid long waiting time. The effective immigration operation actually can gain passenger satisfaction. In addition, the fast immigration process provides the significant benefit for businesses in the airport because short immigration waiting time would be able to increase the purchase amount in shopping area. This paper aims to propose the hybrid method, the intregration of data analytics and queuing theory, for average service time estimation at the immigration unit, Suvarnabhumi airport. From the experimental study, the proposed technique can estimate the average service time, server utilization and average number of passengers in a queue based on the statistic of arrival passengers. The result shows that the number of opened counter and month are the factors to provide different results.

Keywords: Queuing theory, data analytics, immigration, airport.

I INTRODUCTION

Since Suvarnabhumi international airport has become one of the biggest hub in ASEAN countries, airport has been facing the rapid growth of the number of arrival passengers in the past few year. This makes an immigration has become a challenging task. Waiting in the long queue at the immigration service is no one's favorite activity. The passenger's experience can be stressful and time consuming. From the unofficial data (refer to http://tastythailand.com/how-long-does-it-take-to-get-through-suvarnabhumi-airport-bangkok-immigration), one passenger has to spend at least 15 – 30 minutes in the queue to finish the immigration process. From the observation at arrival area, the airport provides immigration counters in 3 zones, totally 130 counters. In practical way, the average number of active immigration counters is only 15 for each zone which totally 45 counters opened for serving the passengers. Moreover, a traditional queuing system has been used at immigration service, which makes the service time much longer than using a single line queuing system as shown in the following figure.

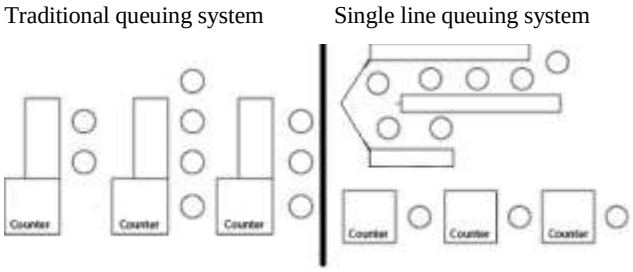

Figure 1. Two different queuing systems

Consequently, airport needs to seek an efficient, strategic approach to manage queues that aims for a balance between service to passengers. Many questions have to be taken into serious issues such as how long the service will take, how long does a passenger expect to wait in the queue before they are served, what is the average length of the queue and what is the expected utilisation of the serving counter? By using an effective queuing system, airport will be able to gain many benefits. Reducing the time spent at immigration unit will increase purchasing volume in shopping and service areas. In addition, the good queuing system will also gain passenger satisfaction. This paper aims to propose the hybrid method, the integration of data analytics and queuing theory, to reveal the performance of queuing system at the immigration service, Suvarnabhumi international airport. M/M/C queuing model (single line queuing system with multi-servers) is applied in the proposed technique. This model shows many benefits over the current traditional queuing system. Before the proposed technique will be described, some related works have been studies in the following section.

II RELATED WORKS

In 1908, Agner K. Erlang identified that the number of telephone conversations and telephone holding time fit into Poisson distribution and exponentially distributed (Agner, 1908). This was the beginning of the study of queuing theory. At present, queuing theory has been widely adopted to many businesses as the queue is a common every-day experience. Queuing theory is the mathematical study of waiting lines, or queues (Sundarapandian, 2009). In queuing theory, a model is constructed so that queue lengths and waiting time can be predicted.

Queuing models can be divided into many types: M/M/C, M/M/1, M/M/C/K, M/M/1/K, M/G/1, M/G/∞, G/M/1, M/Er/1 etc, (Adan & Jacque, 2015). Different models are suitable for different queuing system depending on the system characteristic. This theory is a well-known model applied for dealing the problems which involve queuing in both visible and invisible waiting line, such as, customers waiting for service at supermarket, bank, or restaurant including users waiting for a response from ATM machine or call center. In order to serve customers fast and efficiently, one of many solutions applied in many service organizations is providing adequate manpower to handle customers in the waiting line. Hence, it is essential that service providers can seek the effective way to predict the number of customers and prepare the sufficient number of employee to serve the customers so that each customer does not have to wait too long in the queue. In airport operations, waiting times also affect customer satisfaction significantly. Reducing waiting time would increase service quality and customer satisfaction.

Normally, many service organizations improve the performance of service delivery process by either increasing the number of service providers or reducing processing times. However, the number of staff that can reduce the waiting time needs to match with number of customers. So, the prediction of number of arrival customers is also a key for manpower planning. If service organizations can forecast the amount of arrival customers in each period of time, they will be able to allocate sufficient staff to provide services efficiently. The study of patterns of customers can be done in many ways. Simply, historical data of customers can be collected and analyzed to understand the behaviors and patterns of customers. From those statistical data, the organization can easily see the customer patterns and predict the future trends.

In the present, as Information technology plays an important role in almost every part of business process, data analytics is one of the techniques widely used in many fields of businesses, for example, customer churn prediction in telecommunication industry (Yan, Wolniewicz, Dodier, 2004), demand forecasting in supply chains (Carbonneau, Yahidov, Laframboise, 2008) and prediction of customer demand in energy market (Parra & Kiekintveld, 2013). Likewise, for airport business, the passenger forecast is crucial issue because the passenger congestion at each service points including check-in counters, security checkpoints and immigration counters is a main problem of many international airports which is affecting passenger satisfaction towards airport itself.

In the study of De Lange (2013) which realized the problem of increasing passenger traffic volume at a large international airport located in Western Europe and proposed to use virtual queuing help shifting the demand of passengers at the security checkpoints from the peak periods to idle periods, they found that the application of virtual queuing can reduce waiting time and operating costs. However, there are still some constraints of using virtual queuing at the airport because passengers' schedule is not flexible but fixed by the departure or arrival time of their flights. Thus, to provide more accurate results of improving the service time at the airport, the data used in this study is the statistical data of arrival passengers. Then, data analytics is applied to predict the number of arrival passengers at each period of time and the queuing theory is also integrated to analyze the estimated service time. The proposed methodology will be clearly discussed in the following section.

III USING HYBRID METHOD FOR AVERAGE SERVICE TIME ESTIMATION AT IMMIGRATION UNIT

In this section, the proposed technique that integrated two methodologies is described. This technique aims to improve the service time for immigration at Suvarnabhumi international airport by applying queuing theory to statistics of arrival passengers. Therefore, the proposed method consists of two main steps: **1)** a process of analysis the previous arrival passenger data, and **2)** a process of queuing analytics as shown in the following Figure 2.

From figure 2, the arrival passenger data analytics is regarded as the first process in the proposed technique. To perform this step, arrival passenger data needs to be collected from department of tourism website (refer to http://www.tourism.go.th/home/listcategory/11/217). Then, the statistical method is applied to entire data to analysis the average number of passengers in different months as shown in figure 3.

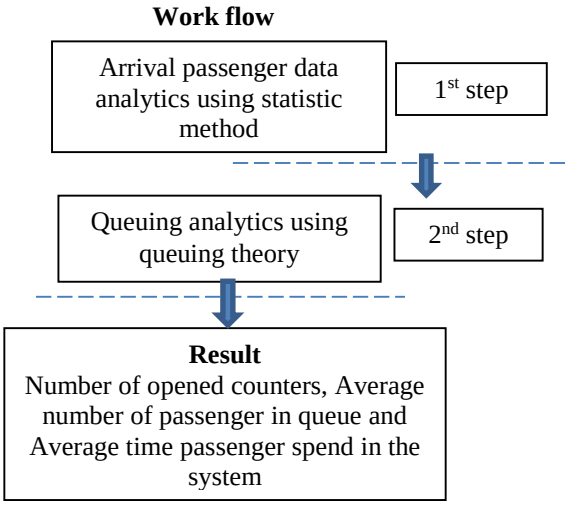

Figure 2. System Architecture

Figure 3. Statistics of arrival passengers.

The extracted average number of passengers in different months will then be used as an input data for queuing analytics process in next step. In this research, the data is categorized by month because different months have different traffic rates. However, to use the queuing theory in the next step, three variables are needed as an input data: C = number of active counters, λ = Arrival rate, and μ = Service rate. From observation at Suvarnabhumi airport, the average number of active counters opened at immigration service is around 45 which each counter normally spent around one minute for one passenger. These three variable will lead to the next process. In the second step, the M/M/C queuing model, known as multi-server queuing model (Harrison & Naresh, 1992), is applied to three extracted variables from the previous process. This model is used in this research because it matches with the characteristic of immigration unit as depicted in the following figure.

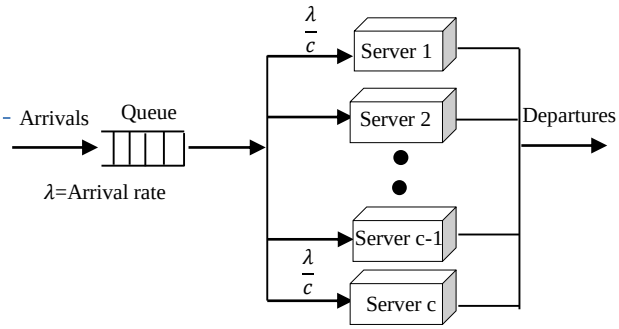

Figure 4. Characteristic of queuing system at immigration unit applied by M/M/C model.

The main characteristics of thus M/M/C model can be described by using the following formula.

$$L_q = \left[\frac{1}{(c-1)!}\left(\frac{\lambda}{\mu}\right)^c \frac{\lambda\mu}{(c\mu-\lambda)^2}\right] P_0$$

$$L_s = L_q + \frac{\lambda}{\mu}$$

$$L_s = \frac{c\mu}{c\mu-\lambda}$$

$$W_q = \frac{L_q}{\lambda}$$

$$W_s = \frac{L_s}{\lambda}$$

$$\rho = \frac{\lambda}{c\mu}$$

Where:
c = Number of server (Counter)
λ = Arrival rate
μ = Service rate
ρ = Average server utilization
L_q = Average number of passengers in the queue
L_s = Average number of passenger in the system
W_q= Average waiting time in the queue
W_s= Average service time in the system

For further understanding, the example of using proposed technique with arrival passenger data in November 2015 is revealed. In Suvarnbhumi international airport, November has been regarded as the busy month for airline business. The immigration service at Suvarnbhumi international airport is opened 24 hours a day, 7 days a week. The total number of arrival passengers in November is 1,362,749. So, a total arrival rate or λ is around 1,893 per hour. From observation at the airport, the average number of counters or C opened at immigration service is around 45 which each counter normally spends around one minute for one passenger. This makes service rate or μ is around 60 passengers per hour. Consequently, final analysis report is founded in the following.

$$L_q = \left[\frac{1}{(c-1)!}\left(\frac{\lambda}{\mu}\right)^c \frac{\lambda\mu}{(c\mu-\lambda)^2}\right] P_0 \quad = 0.0371$$

$$L_s = L_q + \frac{\lambda}{\mu} \quad = 31.58$$

$$L_q = \frac{c\mu}{c\mu-\lambda}$$

$$W_q = \frac{L_q}{\lambda} \quad = 0.0012$$

$$W_s = \frac{L_s}{\lambda} \quad = 1.0012$$

$$\rho = \frac{\lambda}{c\mu} \quad = 0.7011$$

From the final report, the most important issue that airport needs to know is three values: average service time in the system (period from passenger enter a queue until service finished) or W_s, average number of passengers in the queue or L_q and number of counters opened or *C*. As noticed in this report, this provides significant benefit for airport to gain more passenger purchase volume and increase passenger satisfaction if airport applies the proposed technique to queuing system. In addition, airport is also able to plan appropriate manpower by identifying suitable number of service counters.

IV EXPERIMENTAL STUDIES

In this section, an experiment for analyzing the average service time passenger spent in the system and number of counter opened is presented. Statistics of arrival passenger data were used as an input in the experimental study. Data used is collected from department of tourism website (refer to http://www.tourism.go.th/home/listcategory/11/217). The following table shows some examples of statistics of arrival passenger data used in the experiment.

Table 1. A statistics of arrival passenger data

	Number of arrival passengers			
Nationality	**Jan-55**	**Feb-55**	**…**	**Nov-58**
East Asia	492,817	497,469	…	704,362
Europe	470,717	434,910	…	383,056
The Americas	86,408	76,421	…	87,420
South Asia	79,951	83,012	…	98,154
Oceania	55,334	45,764	…	40,413
Middle East	42,335	41,574	…	40,641
Africa	8,456	7,687	…	8,703
Grand Total	1,236,018	1,186,837	…	1,362,749

In order to determine whether the proposed method is appropriate for analyzing the average service time passenger spent in the system and number of counters need to be opened for effective immigration service, the experiment was studied in two points of view: 1) the appropriate number of counters need to be served at immigration unit and 2) the average service time passenger spent in the system in different months.

In the first point of view, this paper aims to identify the appropriate number of counters needed to be served at immigration unit. Arrival passenger data in November is used to be the case study. A total arrival rate or λ is around 1,893 per hour and each counter normally spends around one minute for one passenger. Different number of servers or *C* ranged from 32 to 55 will be tested in the experiment in order to find the appropriate number of opened counters as shown in the following.

Figure 5. Average time passengers spent in immigration system with different number of counters.

Discussion of above result, 51 is the best number of counters needed to be opened for serving the passengers as it is the lowest number of counters which makes passengers do not have to wait in the queue. Airport seeks for a strategy to reduce the cost as much as possible. Meanwhile, they are still able to gain the passenger satisfaction. Noticed from the results, 32 counters is the lowest number that save the cost, but the passengers have to wait in the queue for 2.0166 minutes and spend time to get the service for 1 minutes, so total service time spent in the system is 3.0166 minutes. On the other hand, 52, 53, 54 and 55 are not good numbers because the airport wastes the money to hire too many officers while passengers do not have to wait in the queue at 51 counters onward.

In the second angle, different months show the different traffic amount at the airport. However, the pattern of number of arrival passengers each year looks similar as shown in the figure 3. The difference is the number of passengers increase around 11% every year. This paper also aims to reveal the average service time passenger spent in the system or W_s in different periods of time in the entire year. In addition, average server utilization identified by ρ and average number of passengers in the queue or L_q are also revealed in the following figure. 45 is set to be the number of counters in this experiment.

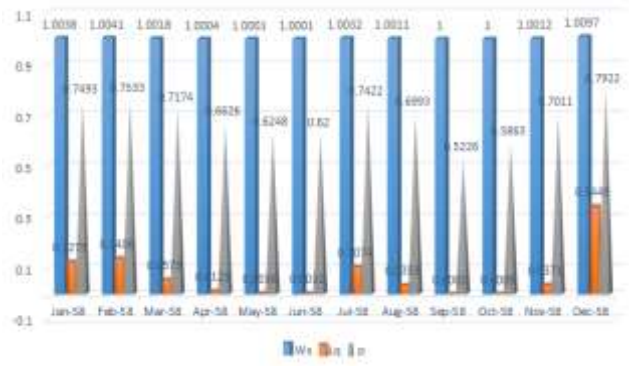

Figure 6. Comparison of average service time, average server utilization and average number of passengers in the queue in different months.

The characteristic for effective queuing system is maximum server utilization, minimum average number of passenger in the queue and minimum average service time. From figure 6, the passengers do not have to wait in the queue in the months of September and October. In contrast, their average service time spent in the system is different for the others depending on the traffic volume. It can be noticed that maximum server utilization occurs in the month of December which means all immigration officers keep working around 79.22% of whole time and idle time is around 20.78%. However, December is the busiest month in the year and this makes passengers have to spent long time in the queue and system.

Discussion of results, multichannel service facility makes the immigration service more efficient. It clearly indicates that as soon as the passengers enters the system, they are being served. Once the serving capacity increases, it will bring more profit, purchase volume in the shopping area and passenger satisfaction to the airport. However, it is necessary for the airport to make a smart decision and plan on the appropriate manpower capacity ahead for each month due to the different of traffic amount. This effective management will lead to the cost optimization.

V CONCLUSION

Due to the rapid increase of air passengers in the last decade, it is necessary for airport to seek the strategy to implement effective queuing system for the immigration. The survey shows that some airports still use the traditional queuing system which makes the passengers have to spend 15 – 30 minutes at the immigration service. This can lead to the decreasing of purchase capacity and passenger satisfaction as they have to wait at immigration for long time. Consequently, this paper aims to propose the hybrid method, the intregration of data analytics and queuing theory, to reveal the performance of queuing system. M/M/C queuing model was applied in the proposed technique for immigration service, Suvarnabhumi international airport. The experiment shows that the proposed technique provides a significant benefit for immigration service. This technique can be used to suggest the appropriate number of counter opened at immigration, in order to gain maximum server utilization, minimum average number of passenger in the queue and minimum average service time spent in the system. By using the proposed technique, airport can plan the manpower capacity and make a smart decision on managing immigration system for getting the cost effective.

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