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# Queuing Simulation Modelling for the Interview Process at the Technical and Vocational Education and Training (TVET) Institutions

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**Abstract:** *Queuing simulation modelling is one of the indicators used to determine the effectiveness of procedures that incorporate queuing simulation modelling. As a result, this paper utilised queueing theory throughout the Technical and Vocational Education and Training (TVET) institution's interview process in Malaysia. The simulation reveals that the queuing simulation comprises a single queue connecting to multiple servers. Each interview stage involves serving more than two (2) candidates concurrently. As a result, the model used in this case study is a multiple-server model, in which more than two (2) servers concurrently serve a single waiting line in parallel. The purpose of queuing simulation modelling is to quantify operational characteristics such as the average number of candidates in the line, the average number of candidates in the system, and the average wait time for candidates in the line and the system. The results indicate that all steps are well-organised and completed within the time constraints associated with each stage. Identifying individuals who combine necessary skills with the ability to overcome challenges, manage stress, deal with ambiguity, work effectively in a team, and demonstrate resourcefulness will benefit the organisation in the short and long term. Therefore, the organisation developed a procedure in which job candidates are immersed in unusual settings to elicit the most useful information about their fitness, personality, critical thinking ability, creativity, and interpersonal skills.*

**Keywords**: Queuing Simulation Modelling, Operating Characteristics, Interview Process, TVET

## 1. Introduction

Queuing theory is used in many industries and necessitates the study of queueing models to forecast the performance of processes that attempt to meet randomly generated demands. By utilising queueing models, one may make judgments regarding the waiting line, resulting in increased productivity. Mathematical modelling may simulate a production system to forecast certain performance metrics (Nithya & Haridass, 2021). This paper studies the queuing simulation for the interview process at one of Technical and Vocational Education and Training (TVET) institutions in Malaysia.

The streamlined recruiting process is a recruitment technique consisting of many stages. The firm engages in talent analysis across all phases, selects applicants from its pool of possible

prospects, and eventually employs the most highly qualified individuals. The interview will be conducted within a single day, commencing at 7:30 a.m. and concluding at 5:30 p.m. and consists of six (6) stages: The recruitment process consists of six stages. The first stage involves candidate registration, where individuals express their interest in the position. Following this, the second stage entails a psychometric test, which assesses various psychological attributes of the candidates. In the third stage, candidates are required to do a bleep test or fitness test to evaluate their physical capabilities. The fourth stage involves a hands-on test, where candidates are assessed based on their practical skills. In the fifth stage, candidates participate in a group panel interview, where they are evaluated via a collective discussion. Finally, the sixth stage involves a mock-up teaching session, where candidates are observed while delivering a simulated teaching lesson.

The primary objective of this study was to evaluate the queuing system implemented during the interview process. The study sought to investigate the existing state of the queuing system and propose recommendations for enhancing its efficiency by employing queue theory and simulation techniques such as the mean number of candidates in the queue, the mean number of candidates at all stages, and the average waiting time for candidates in the queue at each stage.

## 2. Research Methodologies

This case study illustrates the queuing system, which consists of a single queue that leads to a sequence of multiple servers. Each session in each interview stage involves more than one (1) candidate. Thus, as illustrated in Figure 1 below, the model for this case study is a multiple server model in which more than two (2) servers serve a single waiting line in parallel.

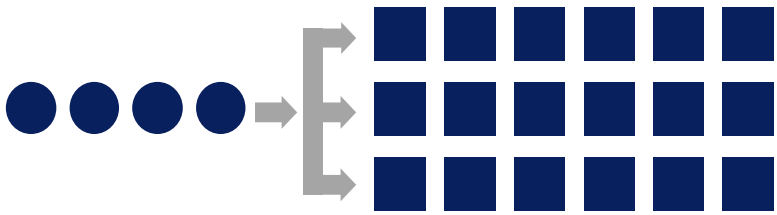

**Figure 1: Multiple Server Queuing System**

The queuing formulas for a multiple-server queuing system model (Bernard W. Taylor III, 2011) are as follows:

a) The arrival rate, the average number of arrivals per time period, $\lambda$
b) The service rate, the average number served per time period, $\mu$
c) The number of servers, c
d) The mean effective service rate for the system which must exceed the arrival rate, c$\mu$
e) The probability that there are no candidates in the system (all servers are idle) is:

$$P_0 = \frac{1}{\left[\sum_{n=0}^{n=c-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right] + \frac{1}{c!}\left(\frac{\lambda}{\mu}\right)^c \left(\frac{c\mu}{c\mu - \lambda}\right)}$$

f) The probability of n candidates in the queuing system is:

$$P_n = \frac{1}{c!\, c^{n-c}} \left(\frac{\lambda}{\mu}\right)^n P_0, for\ n > c$$

$$P_n = \frac{1}{n} \left(\frac{\lambda}{\mu}\right)^n P_0, for\ n \leq c$$

g) The average number of candidates in the queuing system is:

$$L = \frac{\lambda\mu \left(\frac{\lambda}{\mu}\right)^c}{(c-1)!\,(c\mu - \lambda)^2} P_0 + \frac{\lambda}{\mu}$$

h) The average time a candidate spends in the queuing system (waiting and being served) is:

$$W = \frac{L}{\lambda}$$

i) The average number of candidates in the queue is:

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

j) The average time a candidate spends in the queue, waiting to be served is:

$$W_q = W - \frac{1}{\mu} = \frac{L_q}{\lambda}$$

k) The probability that a candidate arriving in the system must wait for service (the probability that all the servers are busy) is:

$$P_w = \frac{1}{c!} \left(\frac{\lambda}{\mu}\right)^c \frac{c\mu}{c\mu - \lambda} P_0$$

## 3. Data and Results

This paper applies the formula for a multiple-server queuing system, as described in the research methodologies section, to assess the operational attributes of the multiple server system. Specifically, it calculates key operational characteristics, including the average number of candidates in the queue, the average number of candidates in the system, and the average waiting time for candidates in both the queue and the system, across all stages of the interview process.

### 3.1 The Initial Stage: Candidate Registration

Before the second stage, all 40 candidates must complete their registration process, which takes around an hour. The secretariats conducted a simulation of the registration process and estimated that it takes around three minutes for a candidate to complete. Thus, each counter can serve up to 20 candidates in an hour. However, the secretariats arrange three service counters for the registration process.

**Queuing Analysis: Multiple Server Queuing System**

**Inputs:**

| | | |
|---|---|---|
| a) Arrival rate (λ) | **40.00** | candidates per hour |
| b) Service rate per server (μ) | **20.00** | candidates per hour |
| c) Numbers of servers, c | **3** | service counters |

**Working Calculations:**

| | | |
|---|---|---|
| Average time between arrivals | **0.03** | hour |
| Average service time per server | **0.05** | hour |
| d) Combined service rate (cμ) | **60** | service counters |
| λ/μ | **2.00** | |
| c! | **6** | |

**Performance Measures:**

| | | |
|---|---|---|
| Average server utilization, ρ | **0.67** | |
| e) Probability the system is empty, $P_0$ | **0.11** | |
| f) Probability of n candidates in the queuing system, $P_n$ | **0.50** | |
| g) Average number in the system, L | **2.22** | candidates |
| h) Average time in the system, W | **3.60** | minutes |
| i) Average numbers waiting in the queue, $L_q$ | **0.22** | candidates |
| j) Average time waiting in the queue, $W_q$ | **0.60** | minutes |

**Probability of candidates arriving in the system must wait for service (servers busy):**

| | |
|---|---|
| Probability, $P_w$ | **0.00** |

### 3.2 Second Stage: Psychometric Test

Following the registration process, all candidates arrive at the same time. As a result, the rate of arrival is 40 candidates per minute. Secretariats have a total of 10 candidates per minute to distribute the questions, and all 40 candidates take the test concurrently in 20 minutes (number of servers, c = 40). As a result, the service rate is as follows:

$$\mu = \frac{10 \text{ candidates}}{1 \text{ minute}} + \frac{40 \text{ candidates}}{20 \text{ minutes}} = 12 \text{ candidates per minute}$$

**Queuing Analysis: Multiple Server Queuing System**

**Inputs:**

| | | |
|---|---|---|
| a) Arrival rate (λ) | **40.00** | candidates per minute |
| b) Service rate per server (μ) | **12.00** | candidates per minute |
| c) Numbers of servers, c | **40** | service counters |

**Working calculations:**

| | | |
|---|---|---|
| Average time between arrivals | **0.03** | minutes |
| Average service time per server | **0.08** | minutes |
| d) Combined service rate (cμ) | **480** | service counters |
| λ/μ | **3.33** | |
| c! | **8.16E+47** | |

**Performance Measures:**

| | | |
|---|---|---|
| Average server utilization, ρ | **0.08** | |
| e) Probability the system is empty, $P_0$ | **0.04** | |
| f) Probability of n candidates in the queuing system, $P_n$ | **0.00** | |
| g) Average number in the system, L | **3.33** | candidates |
| h) Average time in the system, W | **0.08** | minutes |
| i) Average numbers waiting in the queue, $L_q$ | **0.00** | candidates |
| j) Average time waiting in the queue, $W_q$ | **0.00** | minutes |

**Probability of candidates arriving in the system must wait for service (servers busy):**

| | | |
|---|---|---|
| k) Probability, $P_w$ | **0.00** | |

### 3.3 Third Stage: Bleep Test or Fitness Test

All candidates arrive at the same time after finishing the second stage. As a result, the rate of arrival is 40 candidates per 60 minutes.

$$\lambda = \frac{40 \text{ candidates}}{60 \text{ minutes}} = 0.67 \text{ candidates per minute}$$

Each group is made up of ten candidates. Thus, the number of servers, c is ten. This stage takes approximately 15 minutes per group. As a result, the service rate is as follows:

$$\mu = \frac{10 \text{ candidates}}{15 \text{ minutes}} = 0.67 \text{ candidates per minute}$$

**Queuing Analysis: Multiple Server Queuing System**

**Inputs:**

| | | |
|---|---|---|
| a) Arrival rate (λ) | **0.67** | candidates per minute |
| b) Service rate per server (μ) | **0.67** | candidates per minute |
| c) Numbers of servers, c | **10** | service counters |

**Working calculations:**

| | | |
|---|---|---|
| Average time between arrivals | **1.50** | minute |
| Average service time per server | **1.50** | minute |
| d) Combined service rate (cμ) | **6.67** | service counters |
| λ/μ | **1.00** | |
| c! | **3628800** | |

**Performance Measures:**

| | | |
|---|---|---|
| Average server utilization, ρ | **0.10** | |
| e) Probability the system is empty, $P_0$ | **0.37** | |
| f) Probability of n candidates in the queuing system, $P_n$ | **0.00** | |
| g) Average number in the system, L | **1.00** | candidates |
| h) Average time in the system, W | **1.50** | minute |
| i) Average numbers waiting in the queue, $L_q$ | **0.00** | candidates |
| j) Average time waiting in the queue, $W_q$ | **0.00** | minute |

**Probability of candidates arriving in the system must wait for service (servers busy):**

| | |
|---|---|
| k) Probability, $P_w$ | **0.00** |

### 3.4 Fourth Stage: Hands-On Test

Candidates who complete the bleep test will advance to the Hands-On Test. The secretariats will proceed with the Group 1 Hands-On Test once the group reaches a size of twenty candidates. Thus, the number of servers, c is twenty. The arrival rate is determined by the number of each group that completes the bleep test. Ten candidates arrived at the fourth stage after completing the bleep test. Thus, the arrival rate is as follows:

$$\lambda = \frac{10 \text{ candidates}}{15 \text{ minutes}} = 0.67 \text{ candidates per minute}$$

This stage takes approximately 30 minutes per group. As a result, the service rate is as follows:

$$\mu = \frac{20 \text{ candidates}}{30 \text{ minutes}} = 0.67 \text{ candidates per minute}$$

**Queuing Analysis: Multiple Server Queuing System**

**Inputs:**

| | | |
|---|---|---|
| a) Arrival rate (λ) | **0.67** | candidates per minute |
| b) Service rate per server (μ) | **0.67** | candidates per minute |
| c) Numbers of servers, c | **20** | service counters |

**Working calculations:**

| | | |
|---|---|---|
| Average time between arrivals | **1.50** | minutes |
| Average service time per server | **1.50** | minutes |
| d) Combined service rate (cμ) | **13.33** | service counters |
| λ/μ | **1.00** | |
| c! | **2.43E+18** | |

**Performance Measures:**

| | | |
|---|---|---|
| Average server utilization, ρ | **0.05** | |
| e) Probability the system is empty, $P_0$ | **0.37** | |
| f) Probability of n candidates in the queuing system, $P_n$ | **0.00** | |
| g) Average number in the system, L | **1.00** | candidates |
| h) Average time in the system, W | **1.50** | minutes |
| i) Average numbers waiting in the queue, $L_q$ | **0.00** | candidates |
| j) Average time waiting in the queue, $W_q$ | **0.00** | minutes |

**Probability of candidates arriving in the system must wait for service (servers busy):**

| | |
|---|---|
| k) Probability, $P_w$ | **0.00** |

### 3.5 Fifth Stage: Group Panel Interview

The face-to-face group panel interview will begin once the secretariats have completed inserting the results of the hand-on test ranking. This stage's queue discipline is the result of a hands-on test. The highest marks will be placed in the first group, while those with the lowest marks will be placed in the last group.

All the candidates are required to be ready for the session of the group panel interview. The arrival rate of candidates is 40 candidates per 60 minutes.

$$\lambda = \frac{40 \text{ candidates}}{60 \text{ minutes}} = 0.67 \text{ candidates per minute}$$

This stage takes approximately 30 minutes per group comprising five candidates. As a result, the service rate is as follows:

$$\mu = \frac{5 \text{ candidates}}{30 \text{ minutes}} = 0.17 \text{ candidates per minute}$$

**Queuing Analysis: Multiple Server Queuing System**

**Inputs:**

| | | |
|---|---|---|
| a) Arrival rate (λ) | **0.67** | candidates per minute |
| b) Service rate per server (μ) | **0.17** | candidates per minute |
| c) Numbers of servers, c | **5** | service counters |

**Working calculations:**

| | | |
|---|---|---|
| Average time between arrivals | **1.50** | minutes |
| Average service time per server | **6.00** | minutes |
| d) Combined service rate (cμ) | **0.83** | service counters |
| λ/μ | **4.00** | |
| c! | **120** | |

**Performance Measures:**

| | | |
|---|---|---|
| Average server utilization, ρ | **0.80** | |
| e) Probability the system is empty, $P_0$ | **0.01** | |
| f) Probability of n candidates in the queuing system, $P_n$ | **0.11** | |
| g) Average number in the system, L | **4.14** | candidates |
| h) Average time in the system, W | **6.21** | minutes |
| i) Average numbers waiting in the queue, $L_q$ | **0.14** | candidates |
| j) Average time waiting in the queue, $W_q$ | **0.21** | minutes |

**Probability of candidates arriving in the system must wait for service (servers busy):**

| | |
|---|---|
| k) Probability, $P_w$ | **0.14** |

### 3.6 Sixth Stage: Mock-Up Teaching

Candidates who complete the group panel interview will move on to the mock-up teaching stage. The candidate's arrival rate is assumed to be equal to the service rate of the previous stage:

$$\lambda = \frac{5 \text{ candidates}}{30 \text{ minutes}} = 0.17 \text{ candidates per minute}$$

The number of servers is five due to the availability of the mock-up teaching room. This stage takes approximately 15 minutes. As a result, the service rate is as follows:

$$\mu = \frac{5 \text{ candidates}}{15 \text{ minutes}} = 0.33 \text{ candidates per minute}$$

**Queuing Analysis: Multiple Server Queuing System**

**Inputs:**

| | | |
|---|---|---|
| a) Arrival rate (λ) | **0.17** | candidates per minute |
| b) Service rate per server (μ) | **0.33** | candidates per minute |
| c) Numbers of servers, c | **5** | service counters |

**Working calculations:**

| | | |
|---|---|---|
| Average time between arrivals | **6.00** | minutes |
| Average service time per server | **3.00** | minutes |
| d) Combined service rate (cμ) | **1.67** | service counters |
| λ/μ | **0.50** | |
| c! | **120** | |

**Performance Measures:**

| | | |
|---|---|---|
| Average server utilization, ρ | **0.10** | |
| e) Probability the system is empty, $P_0$ | **0.61** | |
| f) Probability of n candidates in the queuing system, $P_n$ | **0.00** | |
| g) Average number in the system, L | **0.50** | candidates |
| h) Average time in the system, W | **3.00** | minutes |
| i) Average numbers waiting in the queue, $L_q$ | **0.00** | candidates |
| j) Average time waiting in the queue, $W_q$ | **0.00** | minutes |

**Probability of candidates arriving in the system must wait for service (servers busy):**

| | |
|---|---|
| k) Probability, $P_w$ | **0.00** |

## 4. Discussion

As mention earlier, this paper applies the formula for a multiple-server queuing system to assess the operation of interview process by taking the process information. The following are the results of the data analysis of the interview queuing system calculated using the queuing formulas for the multiple-server queuing system model:

**Table 1: Operating Characteristics of Interview Process**

| Interview Stage | Average number in the system, L | Average time in the system, W | Average numbers waiting in the queue, $L_q$ | Average time waiting in the queue, $W_q$ | Probability the system is empty, $P_0$ |
|---|---|---|---|---|---|
| | Candidates | Minute | Candidates | Minute | |
| First Stage | 2.22 ≈ 3 | 3.60 | 0.22 ≈ 1 | 0.60 | 0.11 |
| Second Stage | 3.33 ≈ 4 | 0.08 | 0 | 0.00 | 0.04 |
| Third Stage | 1 | 1.50 | 0 | 0.00 | 0.37 |
| Fourth Stag | 1 | 1.50 | 0 | 0.00 | 0.37 |
| Fifth Stage | 4.14 ≈ 5 | 6.21 | 0.14 ≈ 1 | 0.21 | 0.01 |
| Sixth Stage | 0.50 ≈ 1 | 3.00 | 0 | 0.00 | 0.61 |

The findings indicate that the average number of candidates in each stage of the interview process is below six and further demonstrate that candidates were allocated a maximum average of 6.21 minutes during the fifth stage, the group panel interview. The findings indicated that only the first stage, registration, and the fifth stage, group interview sessions, had a single candidate waiting among the many stages. The waiting durations for these sessions were

recorded as 0.60 minutes and 0.21 minutes, respectively, which may be very small. The very short waiting period indicates that the duties at each stage are effectively coordinated and promptly accomplished. Finding individuals with the required skills and the ability to overcome challenges, manage stress, deal with ambiguity, work effectively in a team, and be resourceful will result in both short-term and long-term benefits for an organisation.

## 5. Conclusion

In conclusion, the primary objectives of this modelling effort have been met, which were to evaluate and analyse the operational characteristics of the candidate selection during interview process for TVET institutions. We have determined several critical metrics that shed light on the efficacy and efficiency of this process through careful analysis.

The results have ultimately produced valuable insights into the operation of the candidate selection procedure. These findings not only provide a complete picture of the current operational characteristics, but also serve as a basis for making informed decisions and optimising the process for future interview session. Considering these findings, it is evident that the process can be refined to identify suitable candidates for TVET institutions more effectively, potentially leading to improvements in the overall quality of candidates selected and the selection process's efficacy.

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