Analysis of Priorities Queuing Model (N-P) System With Multiple Channel Multiple Phase and Simple Additive Weighting

Herman Putra Rajagukguk¹, Muhammad Zarlis², and Sutarman³

Department of Information Technology, Universitas Sumatera Utara Medan, Indonesia

*herman@asia.com

Abstract. The queue is a situation where people/goods must wait to get a turn of service. This happens because the number of arrivals is greater than the number of services. Generally, there are 4 queuing methods, namely FIFO (First In First Out), FILO (First In Last Out), SIRO (Services in random order), and PS (Priority Services). In this research, the authors conducted priority queues based on weighting using the SAW algorithm. Queue modeling uses Multiple channel Multiple Phase, where there are 2 phases that will be passed on the queue system. In phase 1, an assessment will be made using the SAW algorithm to produce weights value for each queue. Then in phase 2, a call will be made based on the priority value. In the priority queue, the queue can get service faster or slower according to the queue category. Tests are carried out following (M/M/1:GD/∞/∞) dan (M/M/3:PS/∞/∞) modeling with 100 test data with random variables.

In this queue model, the arrival distribution follows a Poisson distribution, and the service distribution follows an exponential distribution. After testing, the results of the queue were obtained: 15.3% effective in the low category, 65% effective in the normal category, 100% effective in the medium category, 100% effective in the high category. From the results it can be concluded that the queue system is effective in the queue with Normal, Medium and High categories. Queues will not effective in low category.

1. Introduction
The queue is a situation where people/goods must wait to get a turn of service [1]. Queue is a situation where we enter into the waiting line for a service [2]. Generally, there are 4 queuing methods, namely FIFO (First In First Out), FILO (First In Last Out), SIRO, PS (Priority) [6]. However, almost all queue services use the FIFO queue method, where the service number the same as the queuing number. Customers who the first queue, will be served first than customers who queue afterward. The weakness of the FIFO queue is that it only refers to one variable, time of arrival. When there is a customer queuing with urgent conditions, they must wait for the same time turn with the customer who is in better condition. According to the author, the FIFO queue is more appropriate if all queues have the same variables, such as gender, age, and health level.

If viewed from the side of justice and humanity, the queue should be included in the urgent category to get service first compared to the queue with the normal category.

This study uses the Multi-Attribute Decision Making Simple Adaptive Weighting (SAW) algorithm, which is a multi-attribute weighting algorithm that is used as a decision maker. By using the SAW algorithm the results of weighting are more objective, compared to without the weighting
algorithm. [3] The study of service queues will be useful to form a service system that can produce an effective and efficient queuing system.

![Normal queue](Image)

**Normal queue**
- In a normal queue, the queue is arranged based on the time of arrival. The queue that comes first will get the front queue.

**Weighting process**
- At this stage, the queue will be assessed based on conditions.

**Queue based on weighting**
- At this stage, the queue sequence is based on the results of the assessment. The highest value queue will get high priority.

![Figure 1. Priority Queue](Image)

2. **Research Method**

The research method used in this study are:

**2.1. Discipline of Priority Services queues**

Priority services are services provided to customers who have a higher priority than customers who have a lower priority. In the queue model [6] based on priority, there are 2 rules that can be followed:

2.1.1. **Preemptive Rules**

In this rule, the queue with a low priority service can still be determined by a service facility queue system together with a higher priority queue.

2.1.2. **Non-Preemptive (N-P) Rules**

In this rule, the queue that has entered the service facility, the customer will continue to be served until the queue process is completed, even though the queue comes with a higher priority.

**2.2. Kendal Notation**

Kendal Notation To describe the type typology of a queue. First stated D.G Kendall in the form of a/b/c, then known as Kendal notation. Then add the symbol d / e so that it becomes a/b/c/d/e which is then known as Kendal-lee notation [5]. The Kendall-lee notation needs to be added to the symbol f [5] so that the characteristics of a queue can be denoted in the standard format (a/b/c) :(d/e/f).

**2.3. Multiple Channe Multiple Phase Modified.**

Multiple Channel is meant there are several for service operating systems, and Multiple Phase is shown more than one operating process carried out in the queue system[6]. In modified multiple channels multiple phases, the queue discipline is not FIFO, but Priority Services.

![Figure 2. Multiple Channel Multiple Phase System](Image)
2.4. Simple Adaptive Weighting (SAW)

SAW (Simple Additive Weighting) is a weighting method for multi-attribute that affects decision making. The basic concept of this method is to carry out the weighted sum of each work rating on the alternatives of all attributes [3]. The method steps in the SAW method are:

- Make a Z decision matrix measuring $m \times n$, where $m =$ alternative will be selected and $n =$ criteria.
- Give $x$ value for each alternative (i) on each criterion (j) that has been determined, where, $i = 1, 2, ... m$ and $j = 1, 2, ... n$ in the Z decision matrix.
- Give preference weight ($W$) by the decision maker for each predetermined criterion. $W = [W_1 W_2 W_3 ... W_j]$
- Normalize the Z decision matrix by calculating the normalized performance rating value ($r_{ij}$) of the $A_i$ alternative on the attribute.
- The results of normalized performance rating values ($r_{ij}$) form a normalized matrix (N)
- Perform a ranking process by multiplying the normalized matrix (N) with the preference weight value ($W$).
- Determine the preference value for each alternative ($V_i$) by summing the results between the normalized matrix (N) with the preference weight value ($W$). A larger $V_i$ value indicates that the alternative $A_i$ is the best alternative

$$V_i = \sum_{j=1}^{n} w_j r_{ij}$$

(1)

3. Result and Discussion

Multiple Channel Multiple Phase System for Priority Queuing Models with Simple Adaptive Weighting. In this study, the author uses Multiple Channel Multiple Phase to produce a category and priority, where priority is based on weighting using the SAW MCDM algorithm.

![Figure 3. Priority Queues Scheme](image)

In this research, there were 5 assessment criteria used to produce weightings and categories. Each criterion has a compatibility rating, level of importance and type of attribute used in the calculation using the SAW weighting method.

| Criteria     | Assessment Variable | Match Rating | Interest level | Atributm Type |
|--------------|---------------------|--------------|---------------|---------------|
| Sex          | Male                | 1            | 3             | Max           |
|              | Female              | 0.9          |               |               |
| Age          | Toddlers            | 1            | 5             | Max           |

Table 1. Value of criteria
There are 4 queue categories, namely low category, normal category, medium category, and high category. Each of these categories represents the level of urgency in each queue. The results of this study will prioritize the queue which has a higher level of urgency and weight compared to the others.

**Table 2. Queue Category**

| Category | Range Value |
|----------|-------------|
| Low      | >= 3.3 And < 3.475 |
| Normal   | >= 3.475 And < 3.65 |
| Medium   | >= 3.65 And < 3.825 |
| High     | > 3.825     |

In phase 1 queue, queue rule follows (M/M/1):(GD/∞/∞), arrival distribution follows a Poisson distribution, and service distribution follows an exponential distribution, and the number of servers is 1. While queue discipline follows General Discipline FIFO (First in first out). Whereas in the phase 2 queue, the queue rule follows (M/M/3):(PS/∞/∞), the arrival distribution and service distribution are the same as phase 1 queues, with the number of servers is 3. For queue discipline, in phase 2 queues follow the priority queue discipline.

**Table 3. Rule of queue**

| Phase | Data set | Queue discipline | Number of server | Kendall notation |
|-------|----------|------------------|------------------|------------------|
| Phase 1 | 100      | FIFO             | 1                | (M/M/1):(GD/∞/∞) |
| Phase 2 |          | PS               | 3                | (M/M/3):(PS/∞/∞) |

After testing using a rule, the results of the queue can be obtained based on the following:

a. Queue graph

The queue graph generated in the priority queue is different from the queue graph with the FIFO queue discipline. Priority Queue produces a fixed, up and down the graph, because the queue number can be different from the dialing number. While the graph of the FIFO queue is consistently straight because the queue number corresponds to the calling number.
Figure 4. Graph of Queue

b. Results in the queue category

Table 3.2. show results obtained in all queue categories. Criteria FIFO > PS, Indicates that the queue service number generated by the PS is smaller than the FIFO queue.

| Criteria      | Queue category | Low | Normal | Medium | High |
|---------------|----------------|-----|--------|--------|------|
| PS > FIFO     |                | 8   | 61.5%  | 9      | 22.5%| 0      | 0 %  | 0 %  |
| FIFO > PS     |                | 2   | 15.3%  | 26     | 65.0%| 34     | 100% | 13    | 100% |
| PS = FIFO     |                | 3   | 23.1%  | 5      | 12.5%| 0      | 0 %  | 0 %  |
| Jumlah FIFO   |                | 100%| 100%   | 100%   | 100% |

Table 5. Increase and decrease of queue

| Category | Increase | Decrease |
|----------|----------|----------|
|          | Min | Max | Average | Min | Max | Average |
| Low      | 1   | 0   | 1       | 3   | 3   | 1.975   |
| Normal   | 1   | 6   | 3.3     | 1   | 73  | 19.75   |
| Medium   | 1   | 7   | 3.0     | 0   | 0   | 0       |
| High     | 1   | 6   | 3.4     | 0   | 0   | 0       |

3.1 Distribution of Arrival and Distribution of Services

- Distribution of Arrival

The arrival distribution test is carried out using SPSS. The results obtained are arrival distributions following the Poisson distribution.

One-Sample Kolmogorov-Smirnov Test

|              | Kolmogorov-Smirnov Z | Asymp. Sig. (2-tailed) |
|--------------|----------------------|------------------------|
| N            | 7                    | 0.005                  |
| Poisson Parameter | 13.14                |                        |
| Most Extreme Differences | Absolute | 2.49 |
|                  | Positive | 2.49 | Negative | 2.40 |
| Kolmogorov-Smirnov Z | 0.699          |                        |
| Asymp. Sig. (2-tailed) | 0.778           |                        |

Figure 5. Arrival Distribution
• Distribution of services
The services distribution test is carried out using SPSS. The results obtained are services distributions following the exponential distribution.

| Table 1: One Sample Kolmogorov-Smirnov Test |
|---------------------------------------------|
| N                           | 9       |
| Exponential parameter *    | Mean    | 11.11 |
| Most Extreme Differences  | Absolute| 0.393 |
|                           | Positive| 0.340 |
|                           | Negative| -0.593|
| Kolmogorov-Smirnov Z      | 1.780   |
| Asymp. Sig (2-tailed)     | 0.004   |

* Test Distribution is Exponential.

Figure 6. Service Distribution

4. Conclusions
Based on Multiple Channel Multiple Phase System for Priorities Queuing Model (N-P) with Simple Adaptive Weighting, conclusions can be drawn as follows:

- The arrival distribution follows the Poisson distribution, and the service distribution follows the exponential distribution.
- Queues with the "low" category will produce a service number below the queue number. As many as 61.5% (8 people) of the queue in the low category experienced a decrease in service numbers, with an average decline of up to 20 people.
- Queues in the "normal" category, resulting in 65% (26 people) of queues experiencing an increase in queue service numbers on average by 2 people. But in this queue, as many as 22.5% of the queue experienced an average decline in service numbers of 5.6 people.
- Queues in the "middle" category, resulting in 100% (34 people) of queues experiencing an increase in queue service numbers by an average of 3 people.
- Queues with the "high" category, resulting in 100% (13 people) the queue experienced an increase in queue service numbers by an average of 3.4 people.
- Queues with "middle" and "high" categories, get the queue service number generated effectively. This is because 100% of service numbers in this category are lower than the queue number. It can be concluded that this model successfully prioritizes customers who are considered to need priority.

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