CHAPTER FOUR

SIMULATION

This chapter presents the detailed implementation of the proposed methods, namely, Gentle BLUE (GB), Two State Markov Modulate Bernoulli process (GB-MMBP-2) and Gentle BLUE Fuzzy Logic (GBFL). At the beginning of the chapter, "Network Simulation" tool environment, which is used to implement the proposed methods, is discussed. Then, an overview of the implementation is given. Next, the parameters setting of the proposed methods are presented. Then, the simulation cycle and the performance measures calculations are explained. Next, the validation model is explained. Finally, this chapter is wrapped with a conclusion and summary.

This chapter is organized as follows. Section 4.1 introduces simulation details of the proposed methods. Section 4.2 explains the phases that used to implement of the proposed methods via simulation. Section 4.3 describes the validation process for the proposed methods method. Finally, Section 4.4 provides the summary and the conclusions.

4.1 GB, GB-MMBP-2 and GBFL Simulation

GB, GB-MMBP-2 and GBFL are simulated using discrete-time queues with a single router buffer in Java environment. A basic time unit called a slot is used and single or multiple events can occur in each slot (Abdel-Jaber et al. (b), 2008; Zhou and Wang, 2008; Abdel-Jaber et al., 2015). A packet may arrive at and/or depart from the same time slot(Abdel-Jaber et al. (b), 2008; Zhou and Wang, 2008). All simulations use the first come first serve (FCFS) queuing procedure. The packets arrive and depart distinctly, packet by packet. The GB and GBFL simulation applies BP to model the arrival process discussed in Chapter Two, Section 2.7. On the other hand, MMBP-2 is used to model the arrival process of GB–MMBP-2. For GB and GBFL the probability of packet arrival in a slot is denoted by α .where's in MMBP-2 denoted by $\alpha 0$ and $\alpha 1$. The probability of packet departure is modeled using geometric distribution for all simulation methods in a slot is denoted by β.

The simulation environment consists of a single router buffer node. Packet arrival for GB–MMBP-2 has two modes. However, packet arrival for GB and GBFL has a single mode. Packet departure is performed in a single mode for all simulation methods. Packet inter-arrival times are geometrically distributed with a mean of $1/\alpha 0$ or $1/\alpha 1$ for GB–MMBP-2, whereas packet service times have a mean of $1/\beta$ (Fiems et al. 2004). GB and GBFL Packet inter-arrival times and service times are estimated at $1/\alpha$ and $1/\beta$, respectively. The following Figure explains general simulation architecture.

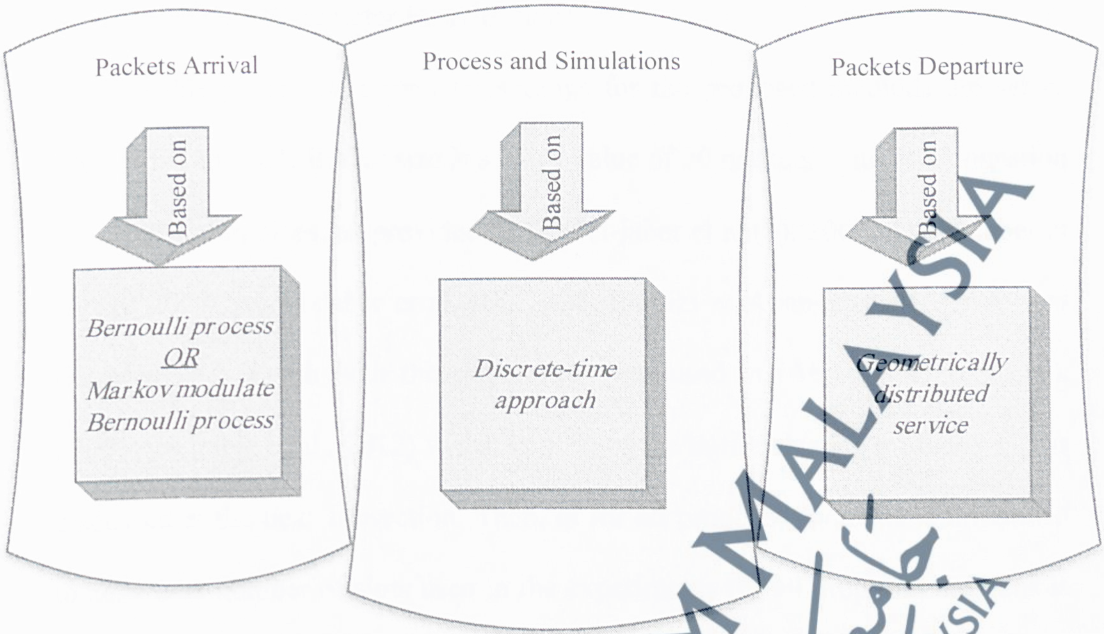

Figure 4.1: General Simulation Architecture

4.2 Simulation Phases for the Proposed (GB, GB-MMBP-2 and GBFL) Methods

The framework, which shows the processes used to build the proposed methods, is illustrated in Figure 4.2. The explanations of the five phases are presented in the following subsections.

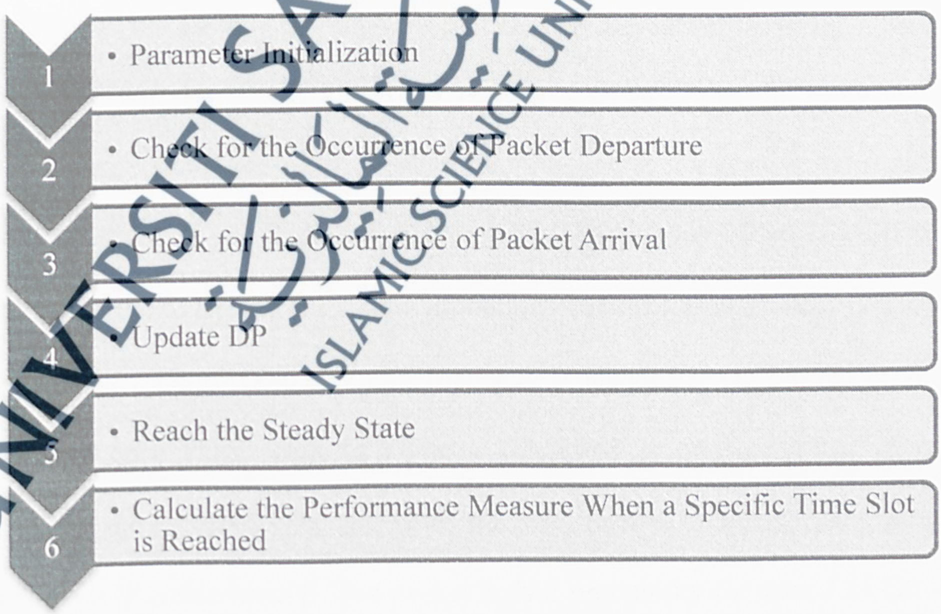

Figure 4.2: GB Simulation Process

4.2.1 Phase One (Parameter Initialization)

In this phase, the parameter settings for the proposed methods are set as shown in Table 4.1. Buffer size is set to a value of 20 packets to detect congestion for small buffer sizes, as provided in (Abdel-jaber et al.(b), 2007; Abdel-Jaber et al. (a), 2008; Abdel-Jaber et al. (b), 2008; Baklizi & Ababneh, 2016). GB and GB-MMBP-2 set Th with the same value was used in (Abdel-jaber et al. (b), 2007; Al-Diabat et al., 2012) which is 60% of the buffer size (the value is 12) as discussed at the next subsection. Then, ql for all proposed methods is initialized to zero. The number of slots used in the experiments for all proposed methods is 2,000,000 to obtain an accurate measurement of the performance results, to ensure that the results are not biased, and to cover a sufficient length of warm-up period (Abdel-jaber & Ababneh, 2011; Baklizi et al., 2013). The warm-up period is terminated when the system reaches a steady state, as reported in (Abdel-jaber & Ababneh, 2011; Baklizi et al., 2013). The value of initiDP is the same as that used in (Feng et al., 2002; Abdel-jaber et al. (b), 2007). Single or multiple events can occur in each slot. Packets may arrive and/or depart from the same slot. Packet departure probability (β) is set to 0.5 to detect congestion for small buffers. This value is the same as that used in (Abdel-jaber et al. (b), 2007; Baklizi et al., 2013). The packet arrival probability (α) for GB and GBFL are set to several values, i.e., 0.18–0.93 (Abdel-jaber & Ababneh, 2011; Baklizi et al., 2013), where each value leads to either a congested or non-congested state. Consequently, no congestion occurs when α is less than β, whereas, congestion occurs when α is greater than β. The packet arrival probability for state 1 in GB–MMBP-2 (α0) is set to several values (0.18–0.93), with each value generating either a congested or non-congested state. Thus, congestion will not occur when the value of packet arrival probability is less than that of packet departure probability. However, congestion will occur when the value of packet arrival probability is higher than that of packet departure probability. The values of packet arrival probability for state 2 in GB–MMBP-2 (α1) is set to 0.5 to decrease the number of arriving packets, reduce congestion when high traffic load occurs, and avoid throughput deterioration (Guan et al., 2007). As previously mentioned, GB–MMBP-2 has two distinct states. Thus, each incoming packet can remain in the same state or transfer to another state. The probability that a packet will remain in the same state is 0.9, whereas the probability that a packet will transfer to another state is 0.1, which is discussed in detail in Step 3.

Table 4.1: Initial Parameter Settings

Parameters	GB Method	GB-MMBP-2 Method	GBFL Method
Queue length	0	0	0
Average Queue Length	0.0	0.0	0.0
Throughput	0.0	0.0	0.0
Delay	0.0	0.0	0.0
Packet Loss	0.0	0.0	0.0
Mean Queue Length	0.0	0.0	0.0
Dropping Probability	0.0	0.0	0.0
Packet Arrival Probability(α)	0.18–0.93	………	0.18–0.93
Packet arrival probability for state 1 (α0)	………..	0.18–0.93	………
Packet arrival probability for state 2 (α1)	………..	0.5	……..
Probability that the next packet remains in state 1	……..	0.9	……..
Probability that the next packet remains in state 2	……..	0.9	……..
Probability transition between state 1 and state 2	……..	0.1	……..
Probability transition between	……..	0.1	……..

state 2 and state 1			
Packet departure probability (β)	0.5	0.5	0.5
Maximum Probability Value		0.1	0.1
Number of slots	2000000	2000000	2000000
Capacity of The Buffer	20	20	20
Threshold	12	12	----
InitDP	0.05	0.05	…….
A	25173	25173	25173
B	13849	13849	13849
M	4294960	4294960	4294960

4.2.2 Phase Two (Check for the Occurrence of Packet Departure)

This phase checks for the possibility of packet departure based on the congestion status of the router buffer. The checking process is implemented by generating a random number and comparing it with β as illustrated in Figure 4.3. The occurrence of packet departure is considered only when the obtained value is less than β. If departure occurs, then ql is decreased by one, whereas the number of packet departures is increased by one. Otherwise, no packet will depart.

Random number generation yields a wide range of numbers and is achieved based on the linear congruential generator method, which is given in Equation 4.1 (Suess & Trumbo, 2010).

$Z_n = A*Z(i) + B \bmod M$,…………………………………………………… (4.1)

where A denotes the value of a multiplier, B denotes the increment, Z(i) is the seed, and M is the modulus. To obtain uniform random numbers within the range (0, 1), Equation 4.2 is used.

$U_n = Z_n / M$……………………………………………………………(4.2)

Selecting appropriate values for A, B, and M is crucial. Equation 4.1, which can shuffle integers within the range of (0, 1, 2,..., M−1) that has passed numerous tests for randomly shuffled integers, should provide a good selection of A, B, and M (Suess & Trumbo, 2010).

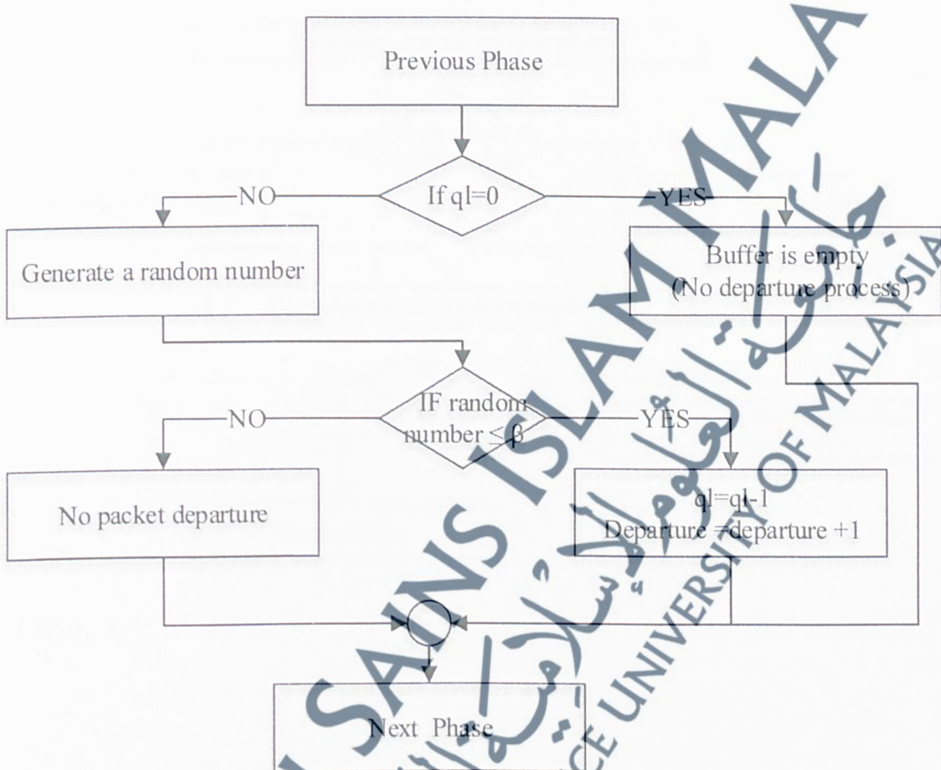

Figure 4.3: Check for the Occurrence of Packet Departure

4.2.3 Phase Three (Check for the Occurrence of Packet Arrival)

This phase checks for packet arrival using random process. In general, a random number is generated according to linear congruential generators. If the generated random number is less than probability of packet arrival, then packet arrival occurs; otherwise, no packet has arrived. The GB and GBFL have a single mode packet arrival so the generated random number is compared with α as illustrated in Figure 4.4. But the Packet arrival for GB–MMBP-2 has two modes (state 1 and state 2) so the generated random number compared in terms of the state of arrival. That is, if the packet arrives to state 1 the random number will be compared with α0. And if the packet arrives to state 2, the generated random number will be compared with α1 as illustrated in Figure 4.5.

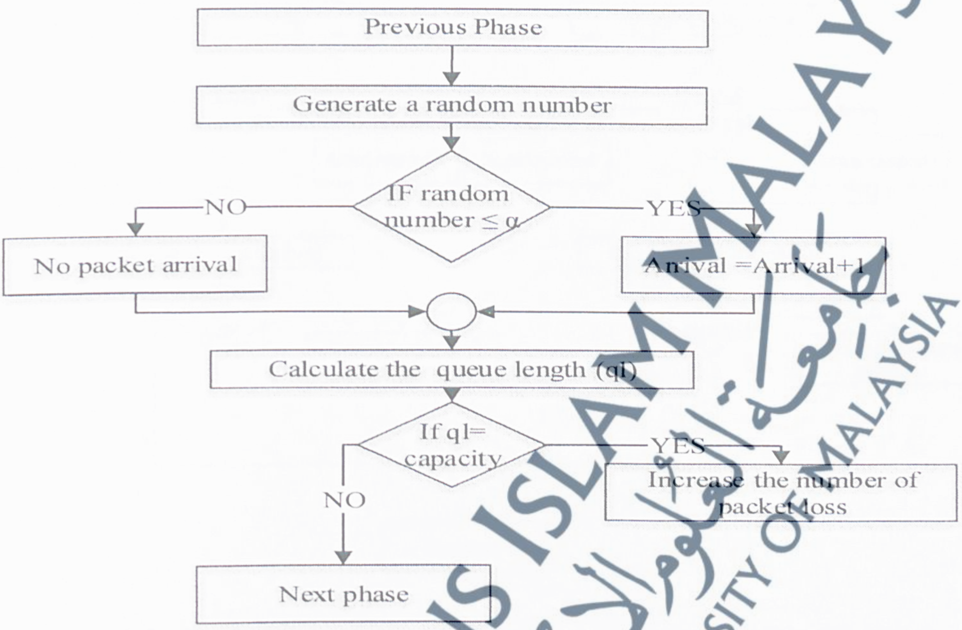

Figure 4.4: Check for the Occurrence of Packet Arrival for GB and GBFL.

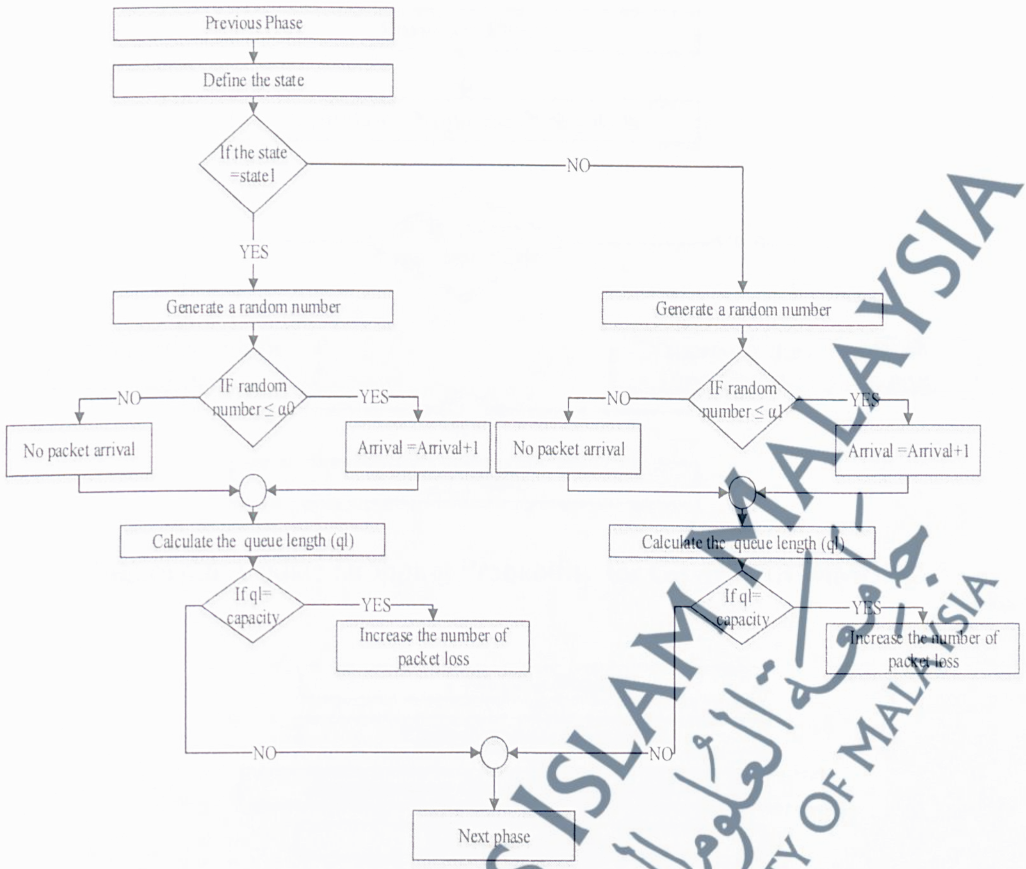

Figure 4.5: Check for the Occurrence of Packet Arrival for GB-MMBP-2

4.2.4 Phase Four (Updating of DP)

As previously mentioned, the proposed GB and GBFL methods predicts congestion before it occurs and responds using dynamically updated values. GB uses Th and ql as congestion indicators to update DP using Equations 3.1 and 3.2 in Section 3.3 as illustrated in Figure 4.6. However GBFL use FL as congestion indicator as discussed at chapter 3 section 3.4 as illustrated in Figure 4.7.

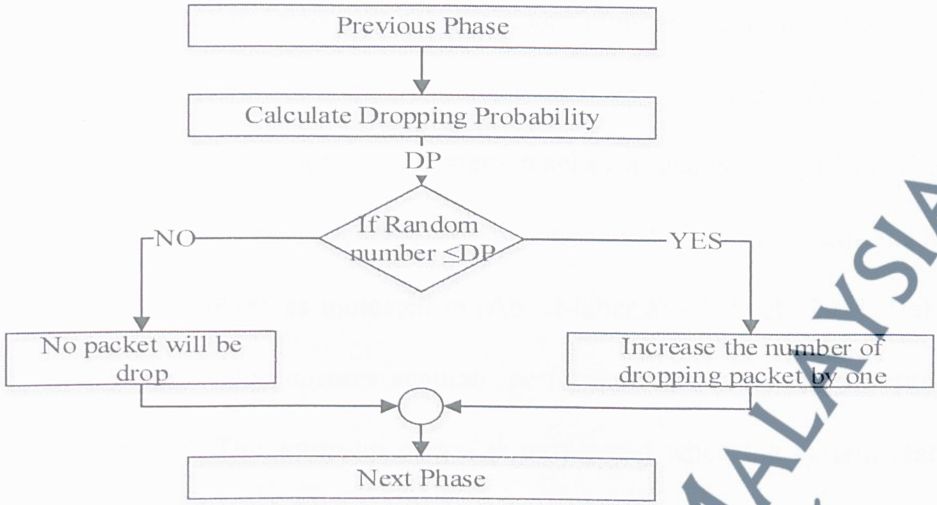

Figure 4.6: Update Dropping Probability for GB and GB-MMBP-2.

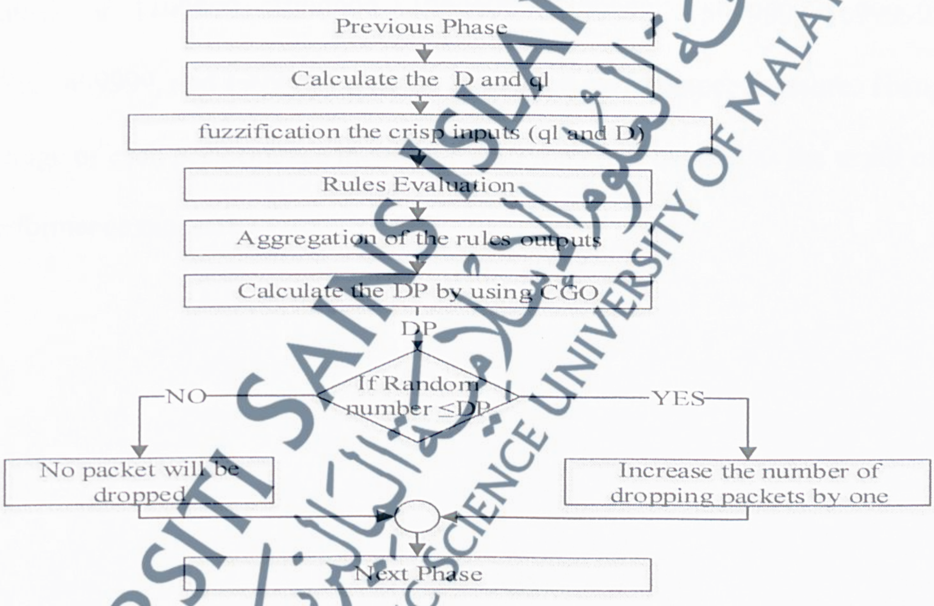

Figure 4.7: Update Dropping Probability for GBFL.

4.2.5 Phase Five (Calculation of Performance Measure)

Network performance is evaluated by using a set of metrics commonly known as network performance measures (Kasera et al., 2005; Kalav & Gupta, 2012). These measures are used to evaluate congestion control methods (described in the following subsections). Performance measures are computed 10 times in 10 different runs, where each run uses a different seed, as illustrated in

Figure 4.8. Different seeds will aid in random number generation and will avoid bias toward the results of one performance measure over others. All performance measures are collected after the system reaches a steady state (Thiruchelvi & Raja, 2008). Therefore, these measures are calculated after the system reaches the slot value of 1100000, as indicated in (Abdel-jaber & Ababneh, 2011; Baklizi et al., 2013). This value ensures accurate performance measures and a sufficient warm-up period. The warm-up period is terminated when the system reaches a steady state.

The calculation of performance measures is repeated when the slot reaches the values of 1199999, 1299999, 1399999, 1499999, 1599999, 1699999, 1799999, 1899999, and 1999999 at each run of each performance measure. Then, the average of each performance measure for 10 runs will be used as the result of this performance measure.

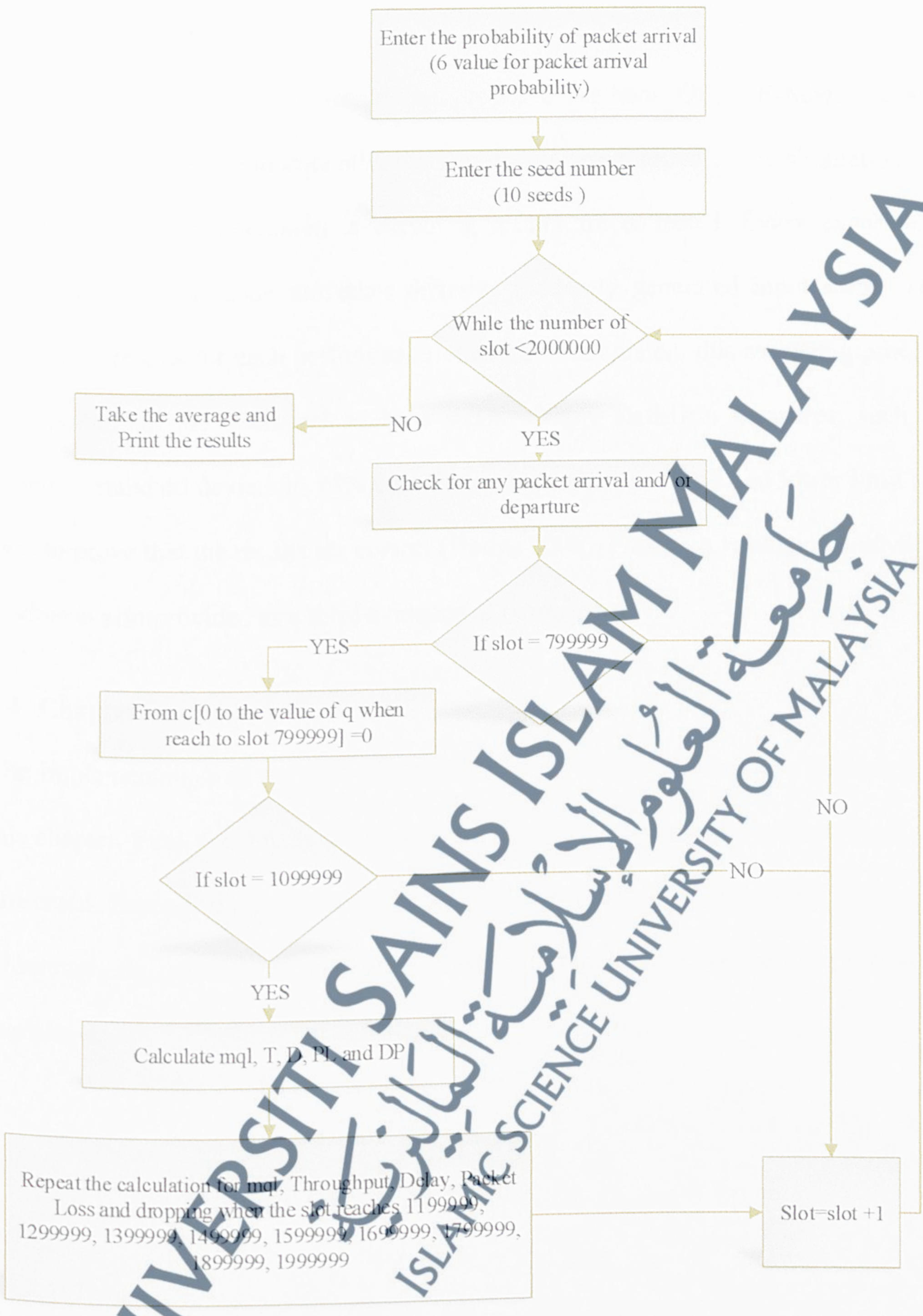

Figure 4.8: Calculation of Performance Measures

4.3 Validation process

In this section, validations of the proposed methods GB, GB-MMBP-2 and GBFL are presented. Subsequently, the parameters are inputted to the simulation for all methods. After simulation is executed, results are collected. Every experiment comprises 10 runs. Each run takes different randomly generated input seeds. The average of results for each performance measure is calculated, this averaging process is important in the statistical analysis stage. Many statistical measures, such as variance, standard deviation, 95% confidence interval, upper limit and lower limit are used to prove that the results are correct (Dodge 2006). Finally, a validation analytical module is also provided as a third evidence of correctness.

4.4 Chapter Summary

The implementation of the GB, GB-MMBP-2 and GBFL methods are discussed in this chapter. First, the details of the simulation and implementation environments are presented. Second, the processes used to build the proposed methods are discussed. Moreover, the simulation process is presented. Finally, the validation process is explained.