A comparative study of performance of Fuzzy Based PBMS with PBMS and vital scheduling algorithm

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To accomplish high speed communication in optical network, need to schedule incoming packets for quality of service. In existing algorithms are provided that the un-optimized solution. In this paper, make out the novel method of optimal solution to handle the variable length of packet in Priority Based Multi Scheduling through fuzzy and assignment method. Here fuzzy is used in scheduling algorithm to reduce the total space and processing time. An assignment method is applied to maintain the quality of service resultant to the variable length of packet with less latency, high throughput and best response time and the research effort deliberate, each packet must be processed by sustained circular queue.

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1. Introduction

High-speed network need to have the capability, to handle the variable length of packets and more reasonable that incoming packets pass through a scheduler based on a packet-by-packet scheduling scheme. Scheduling is used to minimize the resource starvation, it will also require high throughput, less latency including turnaround / response time / waiting time and switching context etc. Earlier cell scheduling algorithms are proposed for scheduler these algorithm handle only with fixed size of packet, after that a high-performance variable-length packet scheduling algorithm was proposed for efficiently switching and the performance of the proposed method is evaluated in terms of packet latency. The result of that proposed work is overall performance is better than the conventional scheduling algorithms [7]. Moreover that algorithm produced only the reduction of cell latency.

The main purposes of fuzzy assignment method to support variable length of packet in priority based multi-scheduling for optical network to achieve high speed network. The scheduling algorithms are, to reduce resource starvation and guarantee fairness amongst the users. Scheduling deals with the problem of deciding the outstanding request is to be allocated or not. There are many different scheduling algorithms were proposed, like simplest best-effort scheduling algorithms are round-robin, fair queuing or a max-min fair scheduling algorithm, proportionally fair scheduling and high throughput. If guaranteed quality of service is offered, as opposed to best-effort communication, weighted fair queuing technique may be utilized. If the sequence of message is send without fixing the size of packet, and then the preprocessing time delay is reduced as well as the performance also increased through prune of memory space. So it leads to transmit the variable length of packets in networks [8].

Fuzzy logic and assignment method play the vital role to reduce the preprocessing space, time of the scheduler and, to maintain the QoS resultant to supports the variable length of packets with less latency, high throughput and good response time.

2. Fuzzy set

2.1. Fuzzy membership value

The result of that proposed work is overall performance is better than the conventional scheduling algorithm like PBMS [1]. This could be possible using fuzzy rules and assignment methods. The most appropriate place to introduce fuzzy concepts for demonstrating uncertainty in scheduling of task's allocation time [9]. A fuzzy set [2] is characterized through a membership function and its values maps an element of a domain, space, or the universe of discourse X to the unit interval [0, 1] i.e. $A = \{(x , \mu_A (x)); x \in X \}$. Here $\mu_A : X \to [0,1]$is a mapping called the degree of membership function of the fuzzy set A and $\mu_A (x)$ is called the membership value of $x \in X$ in the fuzzy set A. These membership values are represented through real numbers interval like [0, 1].

2.2. Fuzzy with assignment problem:

Fuzzy assignment problem is used to solving problem in engineering and management science. It is offers an effective way for handling the fuzzy assignment problem [10] by using LING 0.90 and the same problem has been solved using Generalized Assignment Problem (GAP) [3] for solving a difficult combinational optimization problem to achieve exact optimal solution of an assignment problem by using linear assignment problem method through compare the existing algorithms [11].

State of survey of scheduling and fuzzy logic is cited, in [4]. In that, procedure of routing algorithm is separated into two phase. First phase is connection node establishment and second phase is multipath transmission from the connection node to destination. The author's T. Kavitha and V. Rajamani concludes the proposed scheduling algorithm for transmision efficiency has been improved in Optical WDM mesh networks. Sasikala k. et.al [5] provides a fuzzy logic in routing for Wireless Mesh Network (WMN). It is for oblivious to perform high level data to reach the destination node with any kind traffic occurred in network, it's to be ensured and data to be send on efficiently on their network.

3. Proposed work

3.1. Fuzzy assignment method

To implement a fuzzy assignment method, we consider that there are 'n' packets are processed by circular based 'm' queues called circular queue. An importance of using circular queues is to avoid the starvation. To maintain the quality of service, we apply fuzzy assignment method to minimize the total space of the circular queues and to minimize the total processing time. To obtain an optimal solution we need to plan task assignment [12] [13], the task assignment plan should be fulfill the following constrains:

- Circular queue can handle more than one packet and ensure the null packet has been processed.
- Zero length of packet also enter in to queue.
- To balance the total number of packet between the circular queues, it is necessary to order the number of circular queue for task assignment.
- Based on the weight limit the circular queue accept the task to be process.
- Circular queue 'i' has able to handle some

Packets 'j'and if queue probably takes more time to process the packet, in such case processor 'i' will be driven out the process.

$\tilde{s}_{ij}$, $\tilde{t}_{ij}$ and $\tilde{q}_{ij}$, stands for space, processing time and the QoS where i=1,2,3,……m, j=1,2,3,……n.

Space and time required completing a task with assured level of qualities; it's highly interrelated with complex task and the capability of circular queue.

QoS is relating to the processing time and the space, a task/job can be completed in-time. Job may be consuming reasonable latency, as quality of service is an acceptable. So, need to make decision before the tasks are completed, it is difficult to find the concrete values of following fuzzy variables $\tilde{s}_{ij}$, $\tilde{t}_{ij}$ and $\tilde{q}_{ij.}$ Assumes are made in order to obtain a decision, through an experimental evaluation, the membership functions of these fuzzy variables can be obtained.

We suppose that the membership functions of $\tilde{s}_{ij}$, $\tilde{t}_{ij}$ and $\tilde{q}_{ij}$ (i=1,2,…m, j=1,2,...n) have been given then the space matrix, the utilized time matrix and the quality matrix individually of the space, time and quality assignment problem is shows below Table 1.

Table 1. Space, time and quality assignment problem

Queue↓/Packets →	1	2	.	.	N
1	S_{11}	S_{12}	.	.	S_{1n}
	t_{11}	t_{12}	.	.	t_{1n}
	q_{11}	q_{12}	.	.	q_{1n}
2	S_{21}	S_{22}	.	.	S_{2n}
	t_{21}	t_{22}	.	.	t_{2n}
	q_{21}	q_{22}	.	.	q_{2n}
.	.	.	.	.	.
.	.	.	.	.	.
M	S_{m1}	S_{m2}	.	.	S_{mn}
	t_{m1}	t_{m2}	.	.	t_{mn}
	q_{m1}	q_{m2}	.	.	q_{mn}

$$\tilde{S} = (\tilde{s}_{ij})_{m\times n} = \begin{pmatrix} \tilde{s}_{11} & \tilde{s}_{12} \cdots & \tilde{s}_{1n} \\ \vdots & \vdots & \vdots \\ \tilde{s}_{m1} & \tilde{s}_{m2} \cdots & \tilde{s}_{mn} \end{pmatrix}$$

$$\tilde{T} = (\tilde{t}_{ij})_{m\times n} = \begin{pmatrix} \tilde{t}_{11} & \tilde{t}_{12} \cdots & \tilde{t}_{1n} \\ \vdots & \vdots & \vdots \\ \tilde{t}_{m1} & \tilde{t}_{m2} \cdots & \tilde{t}_{mn} \end{pmatrix}$$

$$\tilde{Q} = (\tilde{q}_{ij})_{m\times n} = \begin{pmatrix} \tilde{q}_{11} & \tilde{q}_{12} \cdots & \tilde{q}_{1n} \\ \vdots & \vdots & \vdots \\ \tilde{q}_{m1} & \tilde{q}_{m2} \cdots & \tilde{q}_{mn} \end{pmatrix}$$

The cited multi-objective fuzzy assignment problem, total space, total processing time and maintained quality level is to be optimized individually then the problem can be formulated from eqn.(1) (2) (3)

$$\text{Minimize} \quad \sum_{i=1}^{m} \sum_{j=1}^{n} \tilde{S}_{ij} x_{ij} \; ; \qquad (1)$$

$$\text{Minimize} \quad \sum_{i=1}^{m} \sum_{j=1}^{n} \tilde{T}_{ij} x_{ij} \; ; \qquad (2)$$

$$\text{Minimize} \quad \sum_{i=1}^{m} \sum_{j=1}^{n} Q_{ij} x_{ij} \; ; \qquad (3)$$

Subject to $\sum_{i=1}^{m} x_{ij} = 1$ j=1,2,…….n

$\sum_{j=1}^{n} x_{ij} = 1$, i=1,2,…….m

$\chi_{ij} =$ 0, if task 'j' is assigned to processing queue '1'

1, otherwise

Where i=1, 2……….m, j=1, 2……….n

Single objective assignment problem has been obtained from Multi-objective assignment problem using eqn. (4) (5) and then the De-fuzzed assignment problem can be converted into linear programming problem.

$$\text{Minimize} \quad \sum_{i=1}^{m} \sum_{j=1}^{n} \tilde{p}_{ij} x_{ij} \qquad (4)$$

$$\text{Where} \quad \tilde{p}_{ij} = (\tilde{s}_{ij} + \tilde{t}_{ij} + \tilde{q}_{ij}) \qquad (5)$$

Subject to $\sum_{i=1}^{m} x_{ij} = 1$, j=1,2…….n

$\sum_{j=1}^{n} x_{ij} = 1$, i=1, 2…….m

3.2. Defuzzification

To calculate the crisp values the defuzzification [6] process has been done. Universally accepted technique for defuzzification is Robust's Ranking. This technique represents the average value of the trapezoidal fuzzy numbers.

3.3. Pseudo code

The task priority play the vital role in this approach, then minimized assignment problem has been processed.

```
Begin fuzzy
    {
      //construct-multi-objective fuzzy assign problem
   Compute     S̃ = ( s̃ij ) m x n; Space   S̃

   Compute     T̃ = ( t̃ij ) m x n; Time   T̃

   Compute     Q̃ = ( q̃ ij) m x n;
                        Quality of Service   Q̃

        //convert multi-objective fuzzy assign to single object fuzzy assignment problem
     }
   Begin defuzzy
     {
       //fuzzy assignment problem to assignment problem
       Fuzzy assignment problem
             {
               If (queue ≠ packets)
                  {
                   for (i=0; i≥ n ; i++)
                       {
                         for (j=0; j≥n; j++)
                          {
     Add dummy queue & packets;
     Avoid the smallest element in column;
                  }
               }
     compute
              {
                Sij = Sij – smallest element;
              }
if ((no. of assignment = =no. of 'n')||( Sij ≥ 0 && Sij ==0))
         {
           else if
              {
               for (i=0; i≥ n; i++){
               for(j=0 ; j≥ m; j++)        {   assign ( □ ) to zero & cross off(X)}}
            }
return optimal solution
         }
     }
else if
     {
          mark(√) rows that do not have any assigned zero
          mark(√) columns that have zero in the marked rows
          mark(√) rows that have assigned zero in the marked columns.
```

```
        }
    }
else if
        {
Find the smallest elements of the reduced matrix not covered by any of the lines;
Subtract element from all the uncovered elements and add the same to all the elements lying at the intersection of any two lines;
        }
    }
}
```

3.4. Analytical example

Table 2 shows the analytical example of fuzzy assignment problem, now consider a fuzzy assignment problem, here Queue Q_1,Q_2 and Q_3 are row representation and Jobs J_1, J_2 and J_3 are columns representation. In this table the space, time and quality measures ($\tilde{s}_{ij}$), ($\tilde{t}_{ij}$) and ($\tilde{q}_{ij}$) are given, these term values are obtained based on the trapezoidal fuzzy number rule.

The solution of given example is optimal assignment of jobs in queues, so that it reduces the total space, processing time of the packet scheduler and it also maintains the quality of service.

Table 2. Analytical example

Queue	Jobs			Measures
	J_1	J_2	J_3	
Q_1	(6,4,3,10)	(7,2,5,12)	(10,17,25,8)	s_{ij}
	(11,12,0,8)	(5,11,12,14)	(8,3,1,18)	t_{ij}
	(1,5,3,7)	(1,5,7,9)	(1,3,5,7)	q_{ij}
Q_2	(3,2,8,9)	(11,14,17,3)	(12,15,16,17)	s_{ij}
	(14,25,1,8)	(10,11,17,16)	(14,21,19,20)	t_{ij}
	(1,8,9,7)	(1,3,7,9)	(3,5,7,9)	q_{ij}
Q_3	(18,25,14,2)	(18,24,23,8)	(1,4,6,7)	s_{ij}
	(6,7,14,24)	(18,21,17,16)	(8,9,30,10)	t_{ij}
	(1,3,7,9)	(1,5,3,7)	(1,7,8,9)	q_{ij}

To obtain a space, time and quality matrix for optimal assignment of the above example

$$\tilde{S} = \begin{pmatrix} (6,4,3,10) & (7,2,5,12) & (10,17,25,8) \\ (3,2,8,9) & (11,14,17,3) & (12,15,16,17) \\ (18,25,14,2) & (18,24,23,8) & (1,4,6,7) \end{pmatrix}$$

$$\tilde{T} = \begin{pmatrix} (11,12,0,8) & (5,11,12,14) & (8,3,1,18) \\ (14,25,1,8) & (10,11,17,16) & (14,21,19,20) \\ (6,7,14,24) & (18,21,17,16) & (8,9,30,10) \end{pmatrix}$$

$$\tilde{Q} = \begin{pmatrix} (1,5,3,7) & (1,5,7,9) & (1,3,5,7) \\ (1,8,9,7) & (1,3,7,9) & (3,5,7,9) \\ (1,3,7,9) & (1,5,3,7) & (1,7,8,9) \end{pmatrix}$$

$$\tilde{P} = \tilde{S} + \tilde{T} + \tilde{Q} = \begin{pmatrix} (18,21,6,25) & (13,18,24,35) & (19,23,31,33) \\ (18,35,18,24) & (22,28,41,28) & (29,41,42,46) \\ (25,35,35,35) & (37,50,43,31) & (10,20,44,26) \end{pmatrix}$$

Robst's Ranking method: Membership function of the triangular fuzzy number (18, 21, 6, 25) is

$$\mu(x) = \begin{cases} \dfrac{x-21}{3}, 21 \le x \le 24 \\ 1, x = 24 \\ \dfrac{24-x}{3}, 24 \le x \le 27 \\ 0, otherwise \end{cases}$$

$$R(\tilde{a}_{11}) = R(21, 24, 27) = \int_0^1 0.5(a^l_\alpha, a^u_\alpha) d\alpha$$

$$= \int_0^1 0.5(48)=24$$

Where,
a^l_α and a^u_α is lower and upper limit of the triangular fuzzy number.

$$R(\tilde{a}_{12}) = R(16, 19, 22) = 19$$
$$R(\tilde{a}_{13}) = R(22, 25, 28) = 25$$
$$R(\tilde{a}_{21}) = R(21, 24, 27) = 24$$
$$R(\tilde{a}_{22}) = R(25, 28, 31) = 28$$
$$R(\tilde{a}_{23}) = R(32, 35, 38) = 35$$
$$R(\tilde{a}_{31}) = R(28, 31, 34) = 31$$
$$R(\tilde{a}_{32}) = R(40, 43, 46) = 43$$
$$R(\tilde{a}_{33}) = R(13, 16, 19) = 16$$

$$S + T + Q = \begin{pmatrix} 24 & 19 & 25 \\ 24 & 28 & 35 \\ 31 & 43 & 16 \end{pmatrix}$$

$$\approx \begin{pmatrix} 5 & (0) & 6 \\ (0) & 4 & 11 \\ 15 & 27 & (0) \end{pmatrix}$$

The solution of zero's assignment is (1,2),(2,1) and (3,3) fuzzy optimal solution is

$$\tilde{a}_{12} + \tilde{a}_{21} + \tilde{a}_{33} = R(16,19,22) + R(21,24,27) + R(13,16,19)$$
$$= R(50,59,68)$$

The above mentioned analytical report show that the total space, processing time of the packet scheduler and maintenance of the quality of service.

4. Experimental results

Based on the analytical report, Table 3 show the inputs has been simulated to acquire the optimal resultant solution to support the variable length of packet with less latency, high throughput and good response time

Table 3. Packet Parameters Adopted in the Numerical studies

Number of Packet	Packet Size	Queue weight	Number of Queue
10	0KB-100 KB	50 KB	2
50	1KB-10MB	5MB	2
75	5MB-1GB	50MB	4
100	10GB-00GB	10GB	10

4.1. Comparison of fairness

Fig. 1 as indicate the fairness index calculated for each offered load in the case of fundamental algorithms namely priority, round robin with PBMS and fuzzy based PBMS.

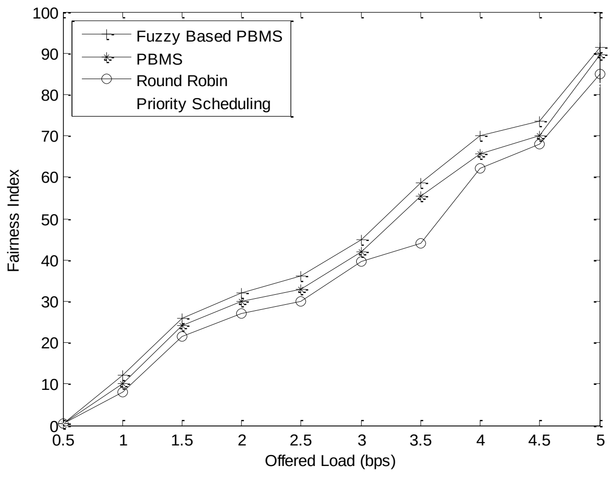

Fig. 1. Analysis of fairness index with Basic scheduling algorithm

The traffic rate is improved above 4.5 bps at fairness index is 86, in fuzzy based PBMS is significantly less weigh against to the PBMS, it perfectly fairness deliberates they efficiency of the algorithms.

4.2. Comparison of throughput

Fig. 2 shows the throughput result is defined as number of packets that gets as per the time scheduled, for maximum throughput result provided by fuzzy based PBMS from 40% to 90% Which indicate the achieves high throughput by a fuzzy based PBMS over the round robin and priority and pbms scheduling.

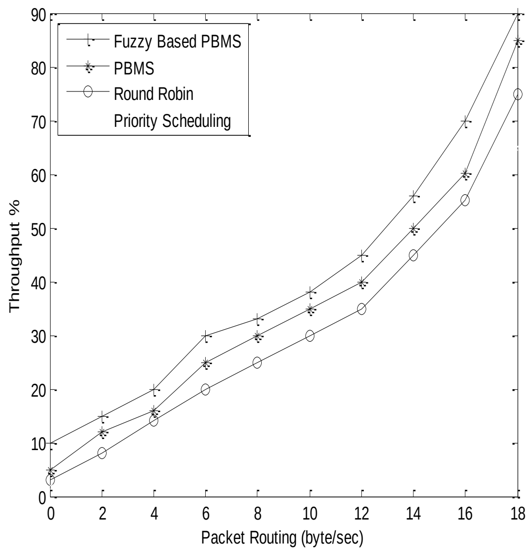

Fig. 2. Analysis of throughput with basic scheduling algorithm

4.3. Comparison of latency

Fig. 3 represents the change of the latency in (micro sec) for the different scheduling method.

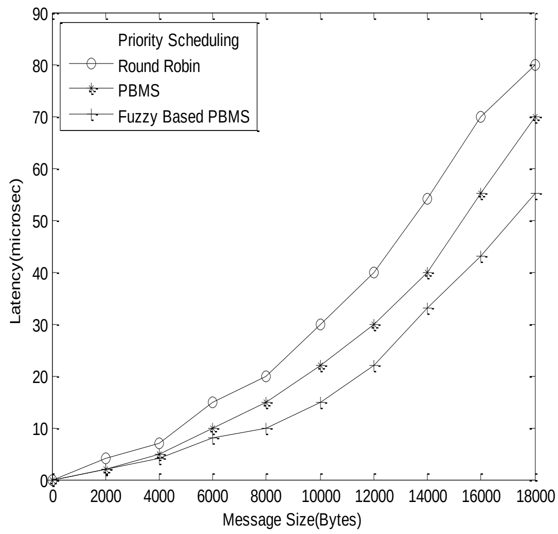

Fig. 3. Analysis of latency with basic scheduling algorithm

Here, the basic priority scheduling algorithm with PBMS take the transmission time (5-8) microsecond for 4000 bytes of packet, but require same packet size transmission time is (5-6) ms in the casing of fuzzy based

PBMS. However it is situated entirely in a much lower increased total time when message size (bytes) is increased over the fundamental scheduling algorithms.

5. Discussion

In this section, Table 4 shows the comparative results of the proposed fuzzy and assignment PBMS algorithm with PBMS, priority and Round robin scheduling algorithm.

Table 4. Comparative results

Quality Parameters	Algorithm			
	Priority based Scheduling	Round Robin	Pbms	Fuzzy based Pbms
Fairness Index (%) Vs load offered (bps)	68	70	76	85
Throughput (%) Vs Packet Routing(byte/sec)	40-66	40-70	40-85	40-90
Latency(micro sec) Vs Message size(byte)	15-18	10-15	5-8	5-6

The analysis is divided into three parts, first we calculate the offered load, throughput and latency of the variable length packets supporting for fuzzy based PBMS in comparison with PBMS, round robin and priority based scheduling algorithm. Four models are compared with simulation result by using NS2 simulator, after that, we evaluate the performance of the switch architecture and sending rate average time delay in optical network.

6. Conclusion

In this paper, an analytical example contains uncertainty values (fuzzy number) of space, time and quality of service. Robust's ranking method as used to find the crisp value of fuzzy number and by applying assignment method to crisp value to obtain the optimal solution to maintain the variable length of packet with less latency, high throughput and best response time. This has been done through the network simulator.

Here, we have considered fuzzy and assignment method for scheduling the input packets. In future incorporate the proposed algorithm in switching module.

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