

# The Quantitative Analysis of Round Robin Matching Scheduling Algorithms for VOQ Packet Switch Architecture

Sharjeel Afridi, Jamil Ahmad, Muhammad Yameen, Ahmed Waqas

**Abstract** – Virtual output queue is the pragmatic and high performance packet switching architecture used to eliminate head-of-line (HOL) problem. There are some simple iterative algorithms proposed for the virtual output queue architecture and lot of research has been done. The detailed simulated analysis of iSlip, FIRM and maximum size matching algorithm called Static round robin (SRR) is investigated in this paper. The SRR (static round robin) algorithm is found more accurate and works well in variant traffic models.

**Keywords** – Head of line, iSlip, FIRM, Static Round Robin, Virtual output queuing.

## I. INTRODUCTION

The conventional output queue is admired due to high performance. Output queue achieves 100% throughput for NxN switch, but it cannot be built for large number of ports due to high internal speed. On the other hand input queue operate with the internal rate equal to the external speed[1]. Since FIFO (first in first out) pattern is employed in input queuing (IQ), the HOL (head of line) blocking reduces the throughput about the 58% [2] at uniform load and even worse at different load models. The issue of HOL can be fixed by using the virtual output queue [4]. Under this mechanism instead of using single queue for all cells, multiple queues are inserted for cells headed towards different output ports. The performance of VOQ entirely depends on the scheduling algorithm.

A number of scheduling algorithms have been developed, broadly classified into two categories, MSM (maximal size matching) and MWM (maximal weight matching). MWM is considered to be much better than MSM due to its 100% [5]-[6] throughput at any traffic model. But its practical implementation is restricted due to time complexity. In this paper the performance of pragmatic algorithms RRM, iSlip and FIRM[7] is evaluated.

Based on the Desynchronisation, a new algorithm static round robin (SRR) is implemented and found to be much better when compared with the previous algorithms.

The rest of the paper is organised in such a manner that section II describes the background study of scheduling algorithms while section III discuss the Pointer desynchronization effect with architecture of the proposed algorithms (SRR) in IV. Simulation results and the possible hardware design are shown in section V and IV respectively. Then paper is concluded in the last section VII.

## II. MAXIMUM SIZE MATCHING

Maximum size matching is projected by using a bipartite graph consisting on two parts containing N nodes representing input port and output port. The requests from the input port to output port are indicated by solid lines. The algorithm proposed for this matching is named as 'maxsize' [11]. Although this algorithm finds maximum matching but due to high converging times it is impractical [3]. There are some algorithms that have better performance and also easily implemented in hardware. The basic idea to get maximum matching is to find whether each VOQ is occupied or empty. This is done in an iterative pattern. In this iteration only the unmatched input output ports take part.

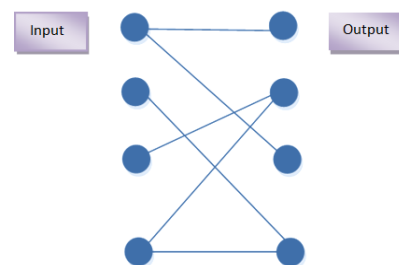


Fig.1. Bipartite graph

Three of these such algorithms RRM, iSlip and FIRM are summarise below.

Round robin algorithm is a very basic algorithm low performance 65% at uniform load even worse at other traffic modes. This algorithm works on the following three steps.

1. Each input sends request to every output for which it contain queued cells.
2. If an output receives more than one requests, it accept the one that appear very next in the round robin schedule beginning from the highest priority element. The output appries each input whether its request was granted or not. The pointer is incremented to one location beyond the granted one whether the grant is accepted or not. The pointer remains unchanged if there is no request for that output.
3. If an input receives more than one grant, it accepts the one that appears very next in the priority table. The pointer is incremented to one location beyond the accepted location. The pointer stays unchanged if there is no grant[7].

iSlip is derived from the RRM, much better in speed and easily implemented in hardware. It has 100% throughput at Bernoulli load and comprehensively good performance at other traffic modes. iSlip has same

working principle except a little bit but very important change. The only difference is in step 2 where in iSlip the highest priority output pointer is updated only when the grant is accepted by input [8].

FIRM is short for first come first serve (Fcfs) in Round robin matching has almost the same characteristics like RRM and iSlip. The main difference is the updating process of pointers among these algorithms. It plays important role in improving the performance of algorithm which is claimed in [12] that FIRM provides better improvement in average delay when compared with iSlip. In desynchronization of pointers under heavy uniform traffic, when VOQ corresponding to a highest priority pointer is empty, the iSlip will lose its desynchronization where as FIRM retains it.

Table 1. Pointer updating Schemes

		RRM	iSlip	FIRM
Input	No grant	Unchanged		
	Granted	One location beyond the accepted one		
Output	No request	unchanged		
	Grant Accepted	One location beyond the granted one		
	Grant not accepted	One location beyond the granted one	Unchanged	The granted one

### III. POINTER DESYNCHRONIZATION

From the above discussion it is clear that among the three algorithms there is only difference in the pointer updating that make a vast difference in performance. This is a fact that if several outputs grant the same input, only one grant is accepted at a time while the other remains idle. In order to improve the speed it is essential that each output grant the different inputs that can be achieved by pointer DE synchronisation. The following graph shows the number of synchronised output pointer for RRM, iSlip and FIRM [8]-[9].

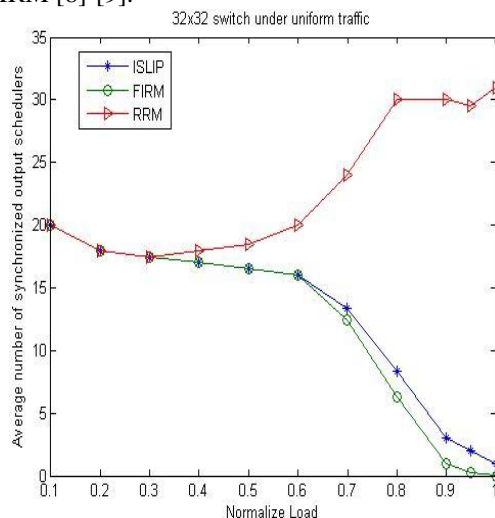


Fig.2. Synchronization of two algorithms for i.i.d Bernoulli arrivals.

The above graph shows that RRM has much higher synchronise pointer even at low load, this is due to the fact that in RRM all the pointers are initialise at the same values and they advances in same manner.

### IV. STATIC ROUND ROBIN ALGORITHM

From the previous discussion the importance of pointers desynchronization is revealed. This can be achieved by static round robin algorithm. SRR is based on the idea of initializing all the pointers at different locations. If all the output pointers start from the different locations and advances synchronously, the algorithm is named as single static round robin (SSRR) and if both the input pointers are initialise in the same manner, it is named as (double static round robin) DSRR, but disadvantage of the DSRR algorithm that the inputs may be treated unfairly, this issue is fixed by a scheme named "rotating pointers". in this scheme clockwise and counter clock rotations are used alternatively which gives the same chance to each input to be served. this improved algorithm is termed as RDSRR (rotating DSRR). Here we just focus on SSRR to make it compare with iSlip and FIRM and analyse which is better in different traffic scenarios [7].

#### a. SINGLE STATIC ROUND ROBIN

In SSRR all the input pointers are sets at 0's, while all the output pointers are initialize such that there is no duplication.

The iteration consists on the following steps.

Step 1. Each input sends request to every output for which it contain queued cells.

Step 2. If an output receives more than one requests, it accept the one that appear very next in the round robin schedule beginning from the highest priority element. The output apprises each input whether its request was granted or not. The pointer is incremented to one location beyond the granted one whether the grant is accepted or not.

Step 3. If an input receives more than one grant, it accepts the one that appears very next in the priority table. The pointer is incremented to one location beyond the accepted location. The pointer stays unchanged if there is no grant[9][10].

### V. SIMULATION RESULTS

The simulation results for single static round robin are gathered from 32x32 port switch. In which cells getting delay at VOQ before transmitted. We evaluate the static round robin, iSlip and FIRM under three traffic model: uniform, bursty and hotspot which runs for 1000,000 time slots and values gathered from 100,000 time slots. Relative average delay is calculated which is the average delay divided by the average delay of an output queued switch of the equal size. Normalized load is the percentage of time slots that have cells arriving, over all inputs. In uniform traffic the packets are i.i.d. Bernoulli with destinations uniformly distributed over all outputs, for bursty the destination are uniformly distributed burst by burst over all outputs and if output has hotspot and each flow is Bernoulli, it means that the hotspot has twice as

much as load as the other outputs.

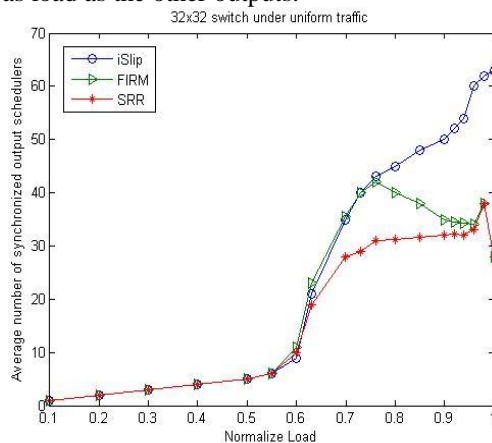


Fig.3. Average delay as a function of normalized load for a 32x32 switch under uniform traffic

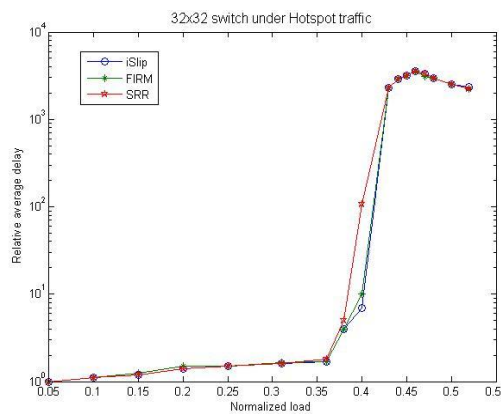


Fig.4. Average delay as a function of normalized load for 32x32 switch hotspot traffic.

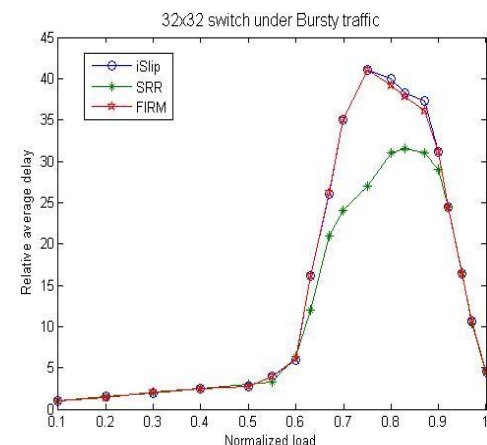


Fig.5. Average delay as a function of normalized load for a 32x32 switch under Bursty traffic.

The figure above shows the result of uniform, bursty and hotspot traffic. We analyse that in figure 3 and 5 the traffic scenarios SSR is much better than the iSlip and FIRM specially (over 0.5) it shows significant good result. But in figure 4 SSR become little worse in between the load 0.35 to 0.4, else it will be same as iSlip.

## VI. STATIC ROUND ROBIN IMPLEMENTATION

The execution of the SRR is simple and employs the same architecture as iSlip. There are  $2N$  arbiters in the scheduling chip:  $N$  grant arbiter that arbitrates on behalf of the outputs and the second set of  $N$  accept arbiter arbitrates on the behalf of inputs. the grant arbiters fetch the request information from the inputs and make arbitration. These arbitration results are sent to the accept arbitrators. The input arbitration is done by accept arbiters and finally the result goes to the decision register. The pointer updating is mode simpler because the pointers are always incremented by one whether the grant is accepted or not that make the design more simpler.

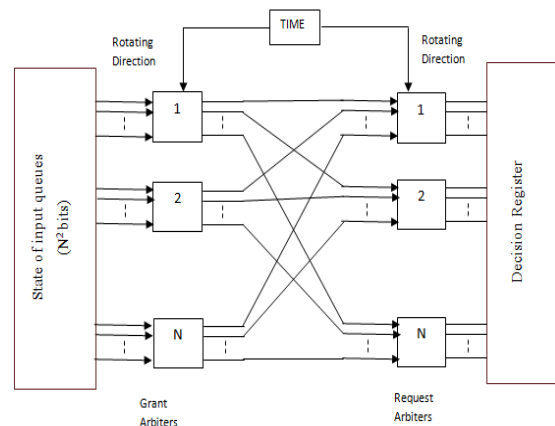


Fig.6. Implementation of Static Round robin Schemes.

## VII. CONCLUSIONS

In this paper, a practical scheduling algorithm- static round robin is introduced and compared with the traditional algorithms - RRM, iSlip and FIRM. SRR is found to be much batter under different traffic models like uniform, bursty and modest in hotspot traffic mode. The hardware implementation of SRR is fast and simpler then iSlip and FIRM due to efficient pointer updating scheme.

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