Assignment 2

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April 20, 2020

1 Introduction

In this assignment, we aim to simulate three types of scheduling algorithms (as described in the problem statement) and analyze their performance. The following acronyms have been used, as done in the problem statement:

1. N: Number of input and output ports in the switch (both are equal as mentioned in the problem). Default value of $N = 8$.
2. B: Buffer size of both input and output ports (both are equal as mentioned in the problem). Default value of $B = 4$.
3. p: Packet generation probability. Default value of $p = 0.5$.
4. *queue*: Type of scheduling algorithm used (can be one of $INQ/KOUQ/iSLIP$).
5. K: Argument knockout as described in the problem statement. We take K as a fraction of N. Default value of $K = 0.6$.

The simulation is done using C++. Each case is simulated for N = 4, 5, ..., 100 and the required graphs are plotted by varying a single parameter at a time while assigning rest of the parameters their default value. All experiments have been conducted for 10,000 time slots (default value of maxtimeslots). To compare different scenarios, we use the following measures:

1. Average Packet Delay($avgPD$): The mean packet delay computed for all transmitted packets.
2. Standard Deviation of Packet Delay($stdPD$): Standard Deviation of the packet delay computed for all transmitted packets.
3. Average KOUQ Drop Probability($KDProb$): KOUQ Drop Probability is the probability per slot that more than K packets were generated for an output port. We call the average of this quantity over all time slots as $KDProb$.

4. Average Output Port Link Utilization(OLU): Output port link utilization is the fraction of time an output port has been used for transmitting a packet, with respect to the entire simulation duration. We call its mean value as OLU.

5. Average Input-Output Link Utilization($IOLU$): Input-Output Link utilization is the fraction of time an input port-output port link has been used for sending a packet from input port to output port, with respect to the entire simulation duration. We call its mean value as $IOLU$.

In the subsequent sections, we compare the Scheduling Schemes, B and K based on the above measures.

2 Comparison of Scheduling Schemes

2.1 Average Packet Delay

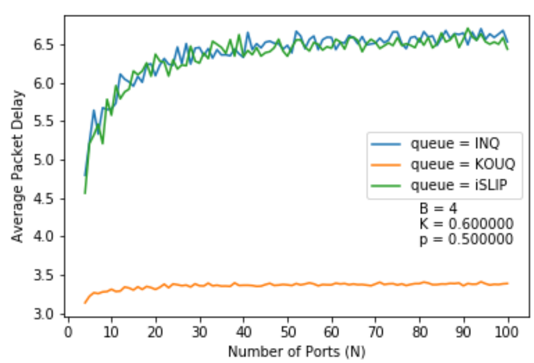

Figure 1: Variation of $avgPD$ with N for different $queue$ values

From Fig.1, it can be inferred that $KOUQ$ scheduling algorithm ensures a low packet delay on an average, as compared to INQ and $iSLIP$ which have similar, and much higher values of $avgPD$. Also, irrespective of scheduling algorithm, with increase in N, the value of $avgPD$ sharply increases, as N is increased from $N = 4$, and gradually the curve flattens, and $avgPD$ almost becomes constant on an average after a certain value of N.

2.2 Standard Deviation of Packet Delay

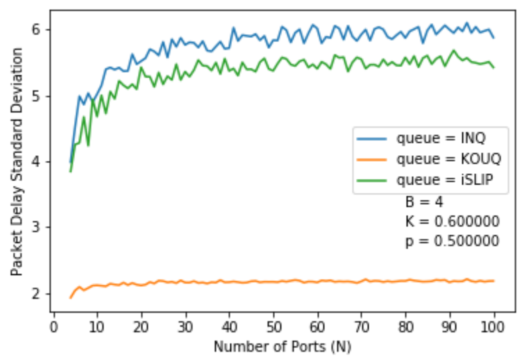

Figure 2: Variation of $stdPD$ with N for different $queue$ values

A high value of $stdPD$ for INQ scheduling shows that the packet delay of packets in case of INQ is highly fluctuating. INQ is closely followed by $iSLIP$, while in case of $KOUQ$, the packets have the lowest variation in their packet delay time.

2.3 KOUQ Drop Probability

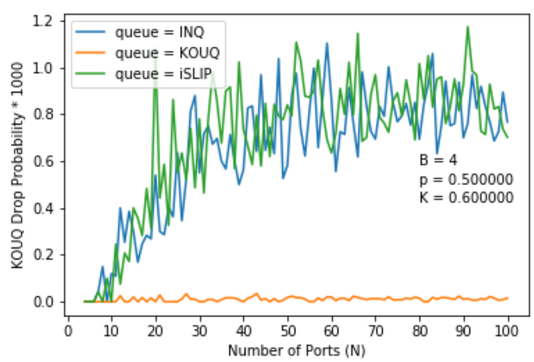

Figure 3: Variation of $KDProb$ with N for different $queue$ values

Fig.3 shows that the average value of $KDProb$ first increases in case of INQ and $iSLIP$, and eventually becomes almost constant on an average, although with fluctuating values. In case of $KOUQ$, on the other hand, the value is almost constant and close to zero, as compare to values of other two algorithms.

2.4 Average Output Port Link Utilization

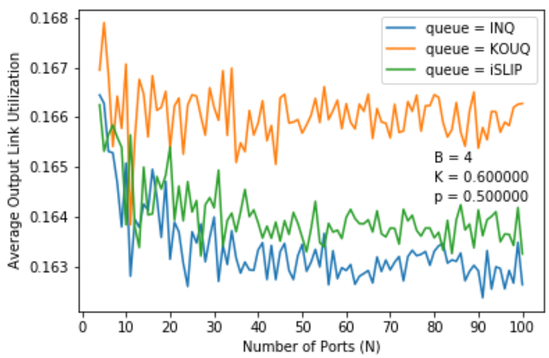

Figure 4: Variation of OLU with N for different $queue$ values

From Fig.4, it can be inferred that $KOUQ$ provides the maximum output link utilization, followed by $iSLIP$, while INQ provides the least output link utilization.

2.5 Average Input-Output Link Utilization

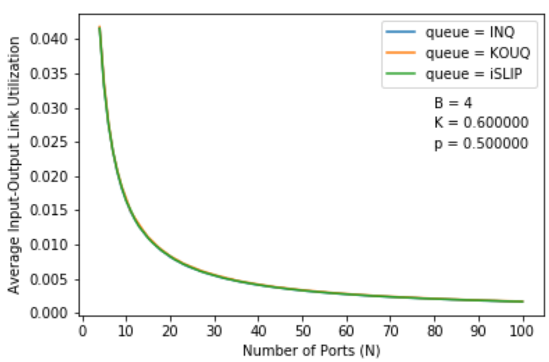

Figure 5: Variation of $IOLU$ with N for different $queue$ values

No visible variation of $IOLU$ with respect to $queue$ can be observed.

3 Comparison of B values

3.1 Average Packet Delay

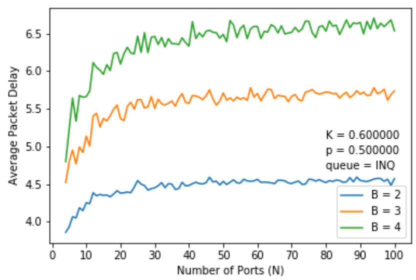

Figure 6: Variation of $avgPD$ with N in INQ for different B values

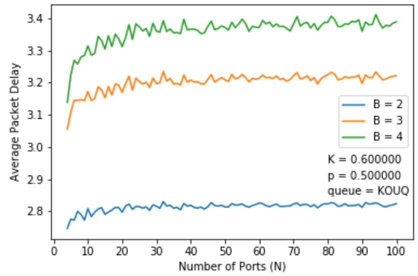

Figure 7: Variation of $avgPD$ with N in $KOUQ$ for different B values

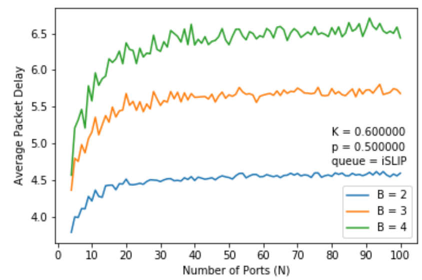

Figure 8: Variation of $avgPD$ with N in $iSLIP$ for different B values

Fig.6 - Fig.8 show that irrespective of the scheduling algorithm, average packet delay increases with increase in buffer size.

3.2 Standard Deviation of Packet Delay

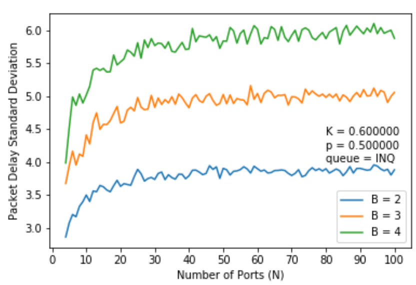

Figure 9: Variation of $stdPD$ with N in INQ for different B values

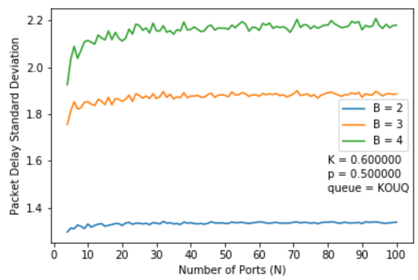

Figure 10: Variation of $stdPD$ with N in $KOUQ$ for different B values

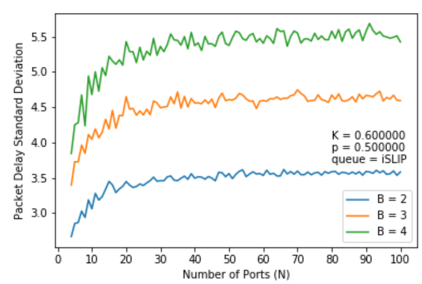

Figure 11: Variation of $stdPD$ with N in $iSLIP$ for different B values

It can be easily inferred from Fig.9 - Fig.11 that $stdPD$ follows similar trend as $avgPD$. Thus, in case of $B = 4$, packet delays are highly varying, while the variation is lowest in case of $B = 2$.

3.3 Average Output Port Link Utilization

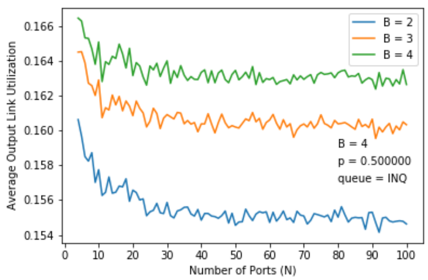

Figure 12: Variation of OLU with N in INQ for different B values

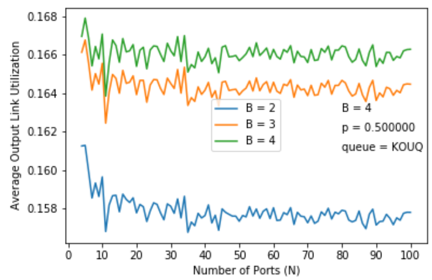

Figure 13: Variation of OLU with N in $KOUQ$ for different B values

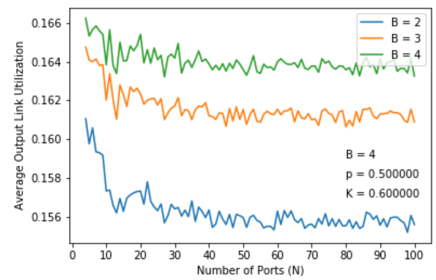

Figure 14: Variation of OLU with N in $iSLIP$ for different B values

We can see from Fig.12 and Fig.14 that $B = 4$ provides highest OLU as compared to other two values of B. $B = 4$ is followed by $B = 3$, while $B = 2$ provides the least value of output link utilization.

3.4 Average Input-Output Link Utilization

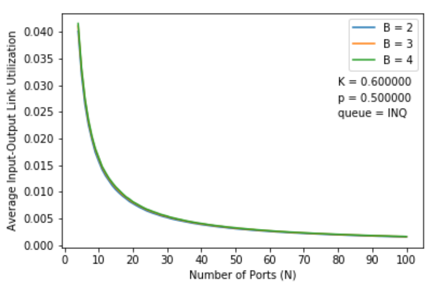

Figure 15: Variation of $IOLU$ with N in INQ for different B values

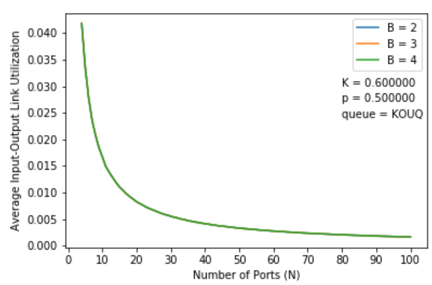

Figure 16: Variation of $IOLU$ with N in $KOUQ$ for different B values

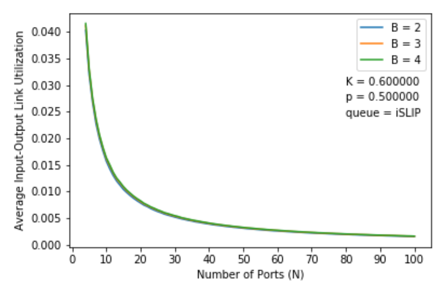

Figure 17: Variation of $IOLU$ with N in $iSLIP$ for different B values

From Fig.15 - Fig.17, if we observe carefully, in case of INQ and $iSLIP$, the graph for B = 2 lies a bit lower than the graph for $B = 4$. However, in case of $KOUQ$, the graph for all values of B overlap. Thus, we can say though B doesn't affect $IOLU$ drastically, $IOLU$ increases slightly with increase in B.

4 Comparison of K values

The graphs except for those for $KDProb$ have been plotted only for $KOUQ$ since K is not involved in other two algorithms. Although, since K affects $KDProb$ measure itself, the graphs for $KDProb$ have been plotted for all the three algorithms.

4.1 Average Packet Delay

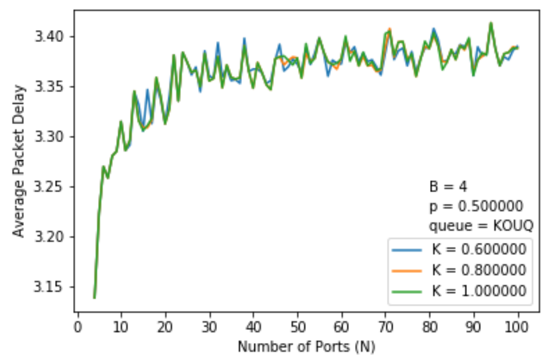

Figure 18: Variation of $avgPD$ with N for different K values

It is clear from Fig.18 that changing K doesn't have any effect on the $avgPD$ values since all three graphs are almost overlapping.

4.2 Standard Deviation of Packet Delay

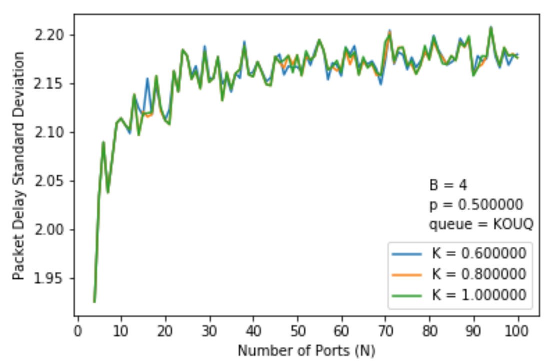

Figure 19: Variation of $stdPD$ with N for different K values

From Fig.19, it is evident that changing K doesn't have any change on $stdPD$ values.

4.3 KOUQ Drop Probability

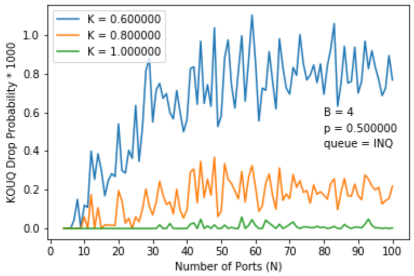

Figure 20: Variation of $KDProb$ with N in INQ for different K values

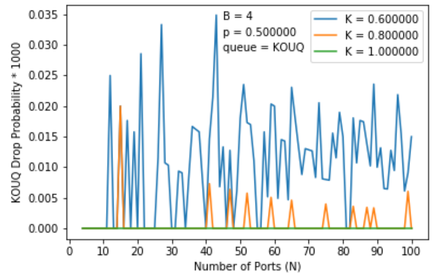

Figure 21: Variation of $KDProb$ with N in $KOUQ$ for different K values

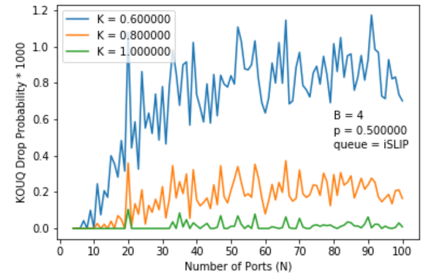

Figure 22: Variation of $KDProb$ with N in $iSLIP$ for different K values

From Fig.20 - Fig.22, it can be inferred that $KDProb$ value increases with increase in K values in all three algorithms.

4.4 Average Output Link Utilization

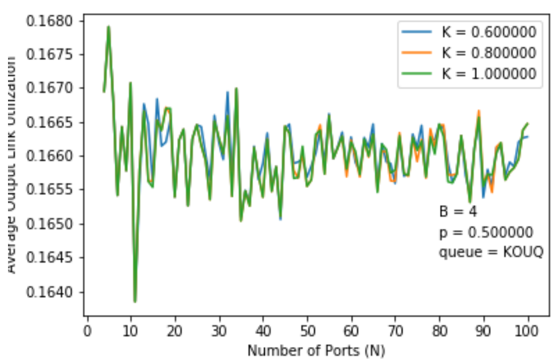

Figure 23: Variation of OLU with N for different K values

It is evident from Fig.23 that K does not have any effect on OLU values.

4.5 Average Input-Output Port Link Utilization

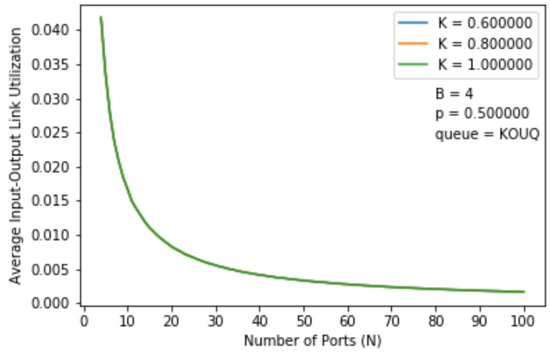

Figure 24: Variation of $IOLU$ with N for different K values

No visible variations of $IOLU$ with K values can be observed in Fig.24.

5 Conclusions

We come to the following preliminary conclusions based on the experiments performed:

1. **Section 2**: We can achieve a far lower average packet delay, with least variations, in $KOUQ$ as compared to $iSLIP$ and INQ. Also, the average KOUQ drop probability is the least in $KOUQ$. $KOUQ$ also defeats the other two algorithms in having the highest value of output link utilization, followed by $iSLIP$.

2. **Section 3**: Buffer size has significant impact on algorithm performance. Irrespective of the algorithm, increasing buffer size leads to a higher packet delay, along with increased variations in packet delay and improved performance in terms of output link utilization.

3. **Section 4**: K value only effects only KOUQ drop probability among all the measure used. With increase in K, average KOUQ drop probability increases for all three algorithms.

4. **Overall Trend**: Average packet delay and its standard deviation, along with KOUQ drop probability, initially increase drastically with increase in N (from 4) and eventually become almost constant. Average output link utilization, on the other hand, decreases initially with increase in N, until it gradually becomes almost constant. Input-Output Link Utilization follows a hyperbolic curve and decreases monotonically from $N = 4$ to $N = 100$. Also, the curve is not much affected by other parameters and there is no visible variation.