1. Introduction

In this assignment, we have compared various queue scheduling techniques such as INQ, KOUQ and ISLIP. These have been implemented in C++.
Switch operation consists of three phases :

- Traffic Generation
- Packet Scheduling
- Packet Transmission

1.1 Traffic Generation

All the packets/data will be generated at the beginning of the time slot and it is available for transmission only in the next time slot.
The details of every packet is stored in the structure of Packet only if it enters the input buffers.The generation of a packet depends on the packet-generation probability.

```
struct Packet
{
    int InputPort ;
    int OutputPort ;
    int arrivalTime ;
    int deptTime ;
};
```

```
double temp = (double)(N)/p ;
int val = rand()%(int)(ceil(temp)) ;
if(val<N)
{
    input[i].first = arrtime(generator) ;
    input[i].second = rand()%N ;
}
```

1.2 Packet Scheduling

In this phase the scheduler decides which packets should be transmitted in that time slot.The algorithms followed by scheduler:

- **INQ** : At each output port, if there is only 1 incoming packet, transmit it directly. Else randomly select 1 packet for transmission. Rest of the packets remain in the input buffers
- **KOUQ** : At each output port, at most K (knockout), a number of packets are pushed to the output buffer. Remaining are dropped.
- **ISLIP** : Each input port sends requests to each output port, for which it has a packet in the virtual output queue. Each output port which receives requests, grants 1 request based on a priority, decided by round robin fashion. Each input which receives grants, accepts 1 request based on a priority, decided by round robin fashion. This accepted packet is transmitted and the round robin priority is updated at both input and output port.

1.3 Packet Transmission

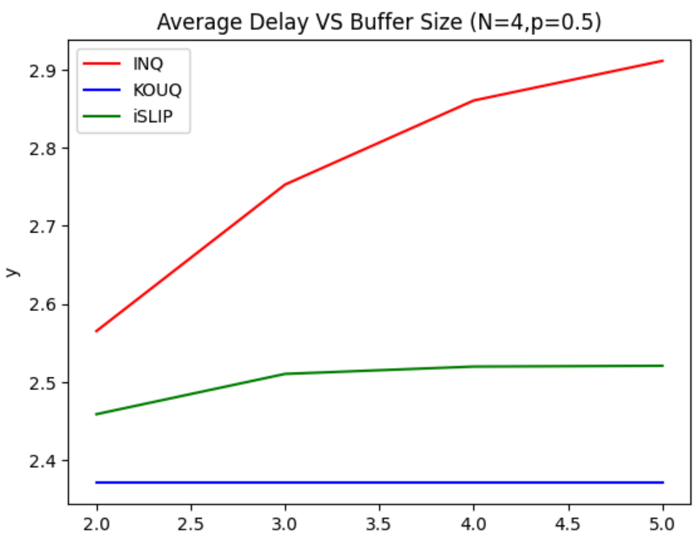
In this phase, packets at the head of each of the output queues are transmitted and the departure time is assigned to each packet for the calculation purpose.

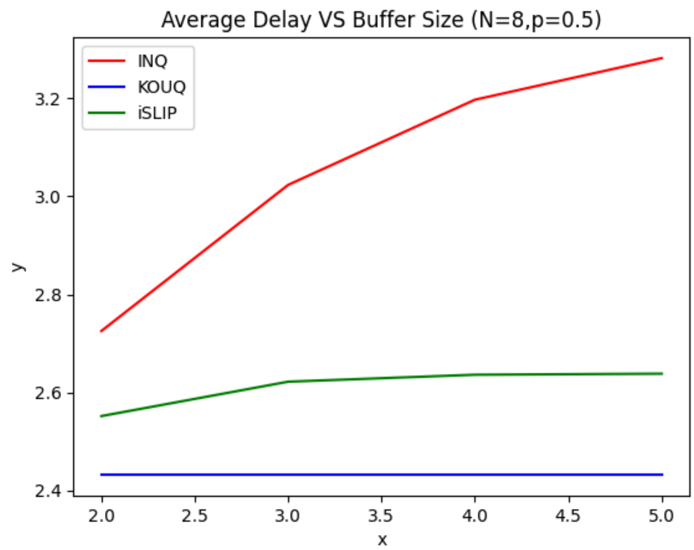
2 Performance Analysis

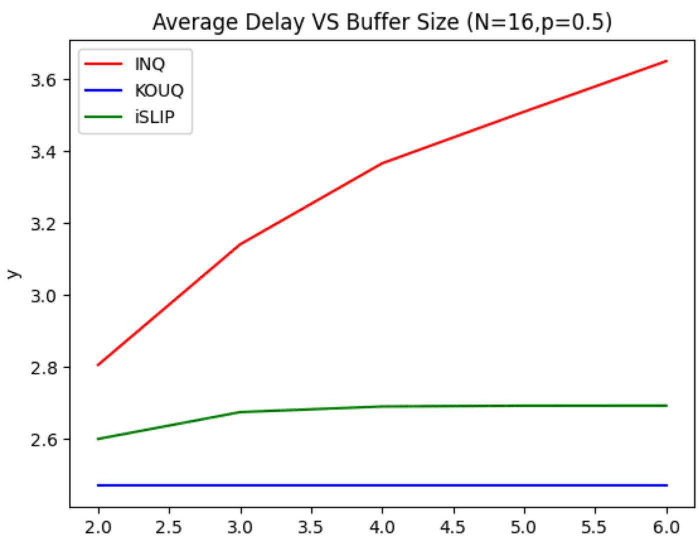
In this analysis we are comparing the all three scheduling schemes on the variation of the parameters such as the N(# ports),B(buffer size),p(packet gen probability) are varied.

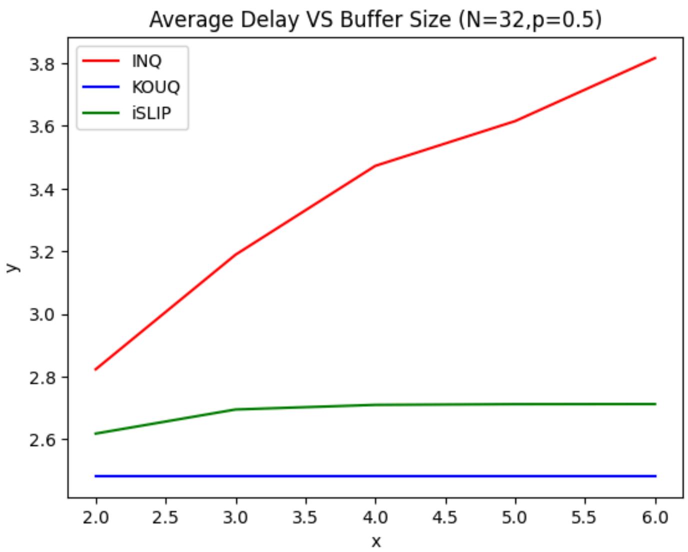
2.1 Average delay Vs Buffer Size

We are plotting the average delay vs buffer size for all three schemes with varying the N and B values.







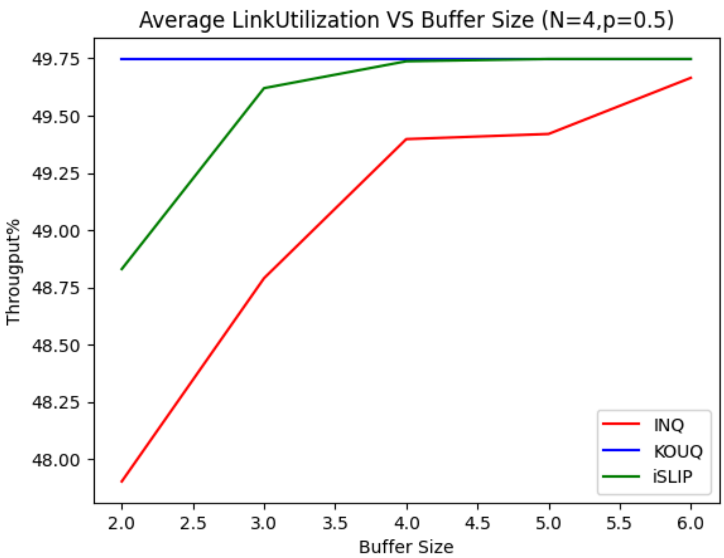


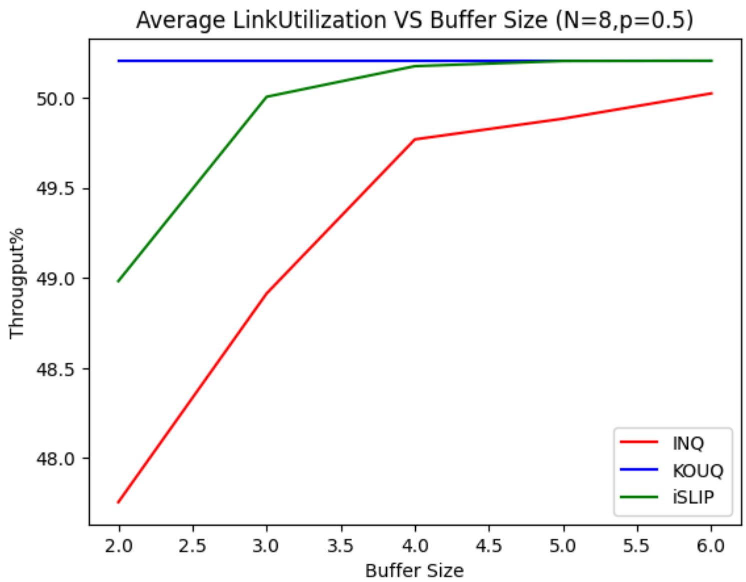
Observations:

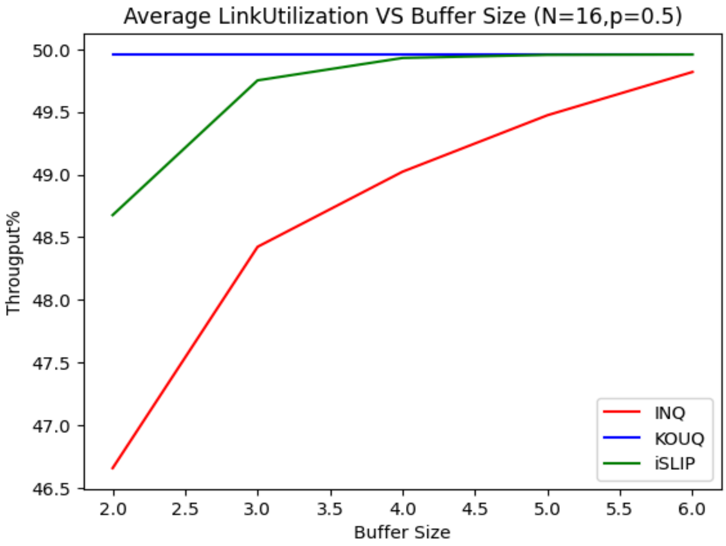
- The INQ Algorithm exhibits the highest average packet delay compared to other algorithms. With increasing buffer size for a fixed N value, the average packet delay for the switch employing the INQ algorithm increases nearly linearly, particularly evident when N equals 8, 16, and 32.
- Also as the N value increases the Average packet delay for INQ Algorithm also increases for constant value of Buffer Size and constant p value.
- The iSLIP Algorithm's average packet delay falls between INQ and KOUQ algorithms. Increasing buffer size for fixed N causes a slight initial increase in iSLIP's average packet delay before stabilizing. Notably, with N values of 16 and 32, iSLIP's delay approaches that of KOUQ.
- Also as the N value increases the Average packet delay for iSLIP Algorithm also increases for constant value of Buffer Size and constant p value.
- For the KOUQ Algorithm the average packet delay is the least as compared to other implemented algorithms. The average packet delay in case of KOUQ remains constant with variation in the buffer size for fixed N value.We here have used a constant K Value which is = 4

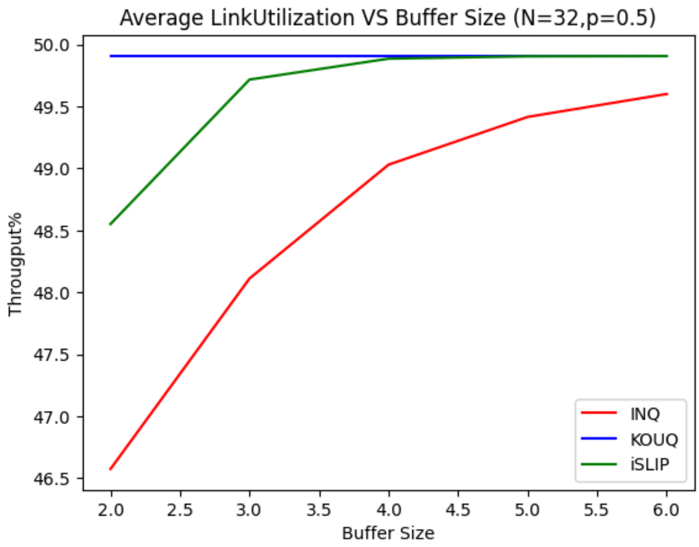
2.2 Average Link Utilization Vs Buffer Size

We are plotting the Average Link Utilization vs buffer size for all three schemes with varying the N and B values.







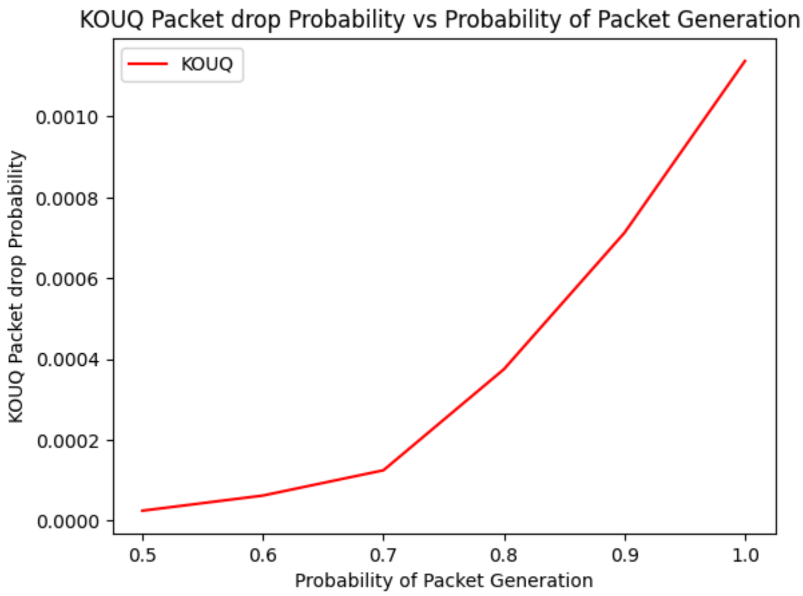


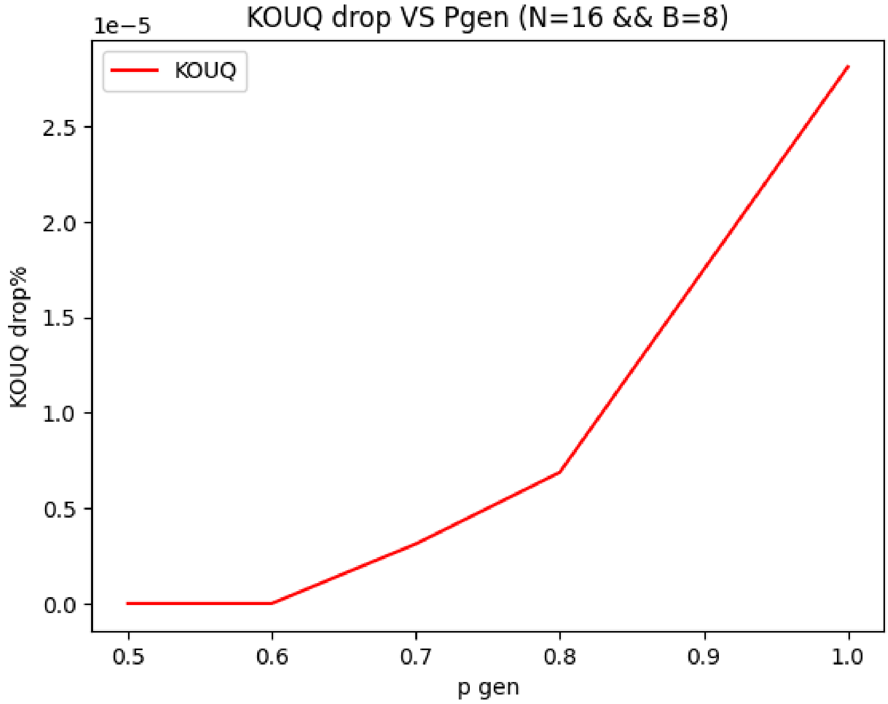
Observations:

- On increasing the buffer size the link utilization increases because the packets in the buffer makes the output port busy.
- On Increasing the buffer size the link utilization of iSLIP scheme increases a bit and goes for a saturation which is nearly equal to the link utilization in the KOUQ scheme.
- If we increase the N then the link utilization decreases because an increase in the number of ports means more chances of collisions at the output ports.

2.3 KOUQ Packet drop Probability vs p(packet generation)

The graph is plotted at the values of **N=8 ,B=4 ,K=4** and varying the p for calculating the drop probability



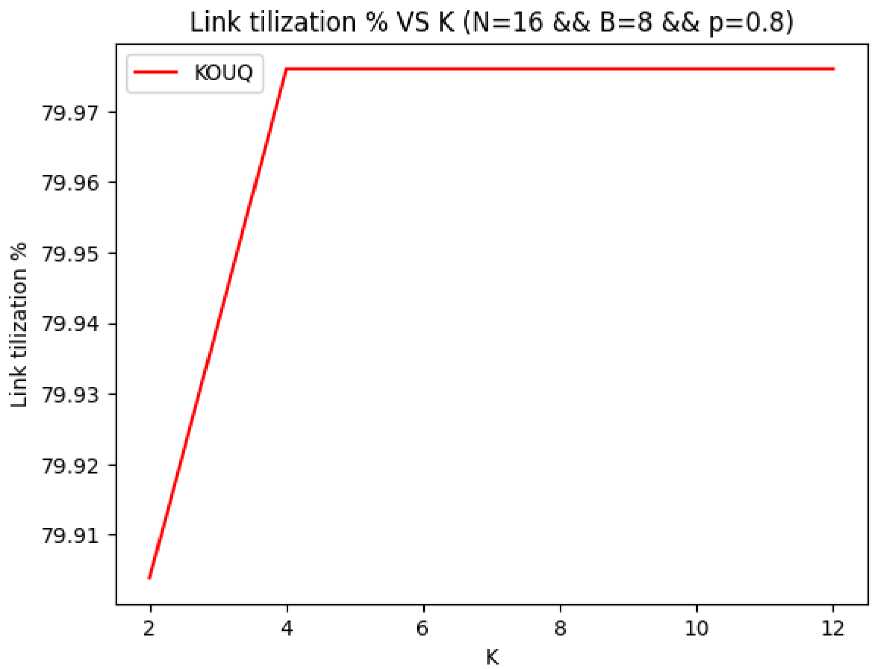


Observations:

- As we increase the p value (probability of packet generation) the packet drop probability value in KOUQ algorithm with K=0.6*N increases almost polynomially.
- This shows as the p value is larger the KOUQ Algorithm is likely to drop more packets which is not a good sign for a scheduling algorithm.
- As we increase the N for a given probability the KOUQ drop decreases because the probability of getting more than **K** packets for a given output port is very low(Uniform distribution).

2.4 Link Utilization Vs Knockout

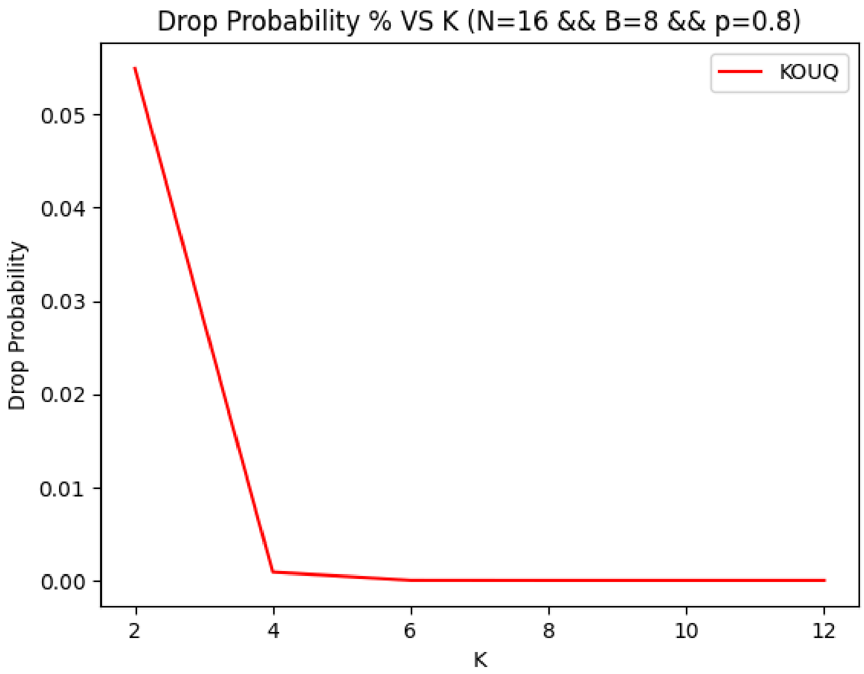
The graph is plotted on taking the values **N=16,B=8,p=0.8** varying the **K** value to see the throughput.



Observations:

- Since we are increasing the **K** value so the maximum number of packets in the output buffer increases which keep the link busy so the throughput increases.
- As the K value approaches the B the throughput becomes constant since the output buffer can occupy only B packets.

2.4 K vs Packet Drop Probability



- From the above plot we can observe that as the Knockout value increases the packet drop probability for KOUQ algorithm decreases gradually.
- As the knockout value gets closer to the N value the packet drop probability starts getting saturated which means it decreases with a very small factor for increasing Knockout value and gets closer to 0.

3 Conclusions

- The iSLIP algorithm is a preferred scheduling solution, offering high average link utilization and low average packet delay compared to INQ. Compared to KOUQ, iSLIP demonstrates similar performance but with fewer packet drops, especially with smaller knockout values. Empirical analysis shows iSLIP efficiently transmitting the largest number of packets within a timeframe. It's the optimal choice for scenarios requiring maximum packet transmission, mitigating packet drop risks, especially with smaller knockout values in KOUQ.
- The KOUQ Algorithm proves advantageous in scenarios where trading off efficiency for potential packet drops is acceptable. With increasing packet generation probabilities, the likelihood of packet drops also rises within the KOUQ framework. The Knockout value (K) holds significant importance in the KOUQ algorithm, influencing both average link utilization and average packet delay substantially. Higher Knockout values correspond to increased average link utilization but also result in higher average packet delays. Additionally, higher Knockout values reduce packet drop probabilities, approaching zero as the Knockout value nears N, the total number of ports.
- The INQ scheduling algorithm, characterized by its brute force approach, exhibits notably poor performance, particularly for large values of N. In comparison to other algorithms, INQ demonstrates the lowest average link utilization and the highest average packet delay values.

4 Assumptions

- The packets generated at the t-t+1 slot will be transmitted in the t+1-t+2 slot if there is no contention .Since the scheduler transmits the packets at the beginning of the time slot.
- The size of the output buffer in the KOUQ is considered to be of size **B.**