Computer Networking - Lab 4

Group 35

Srinjoy Som	220123074
Shubham Kumar Jha	220123081
Yash Singhal	220123072
Priya Sharma	220101081

Scheduling Algorithms:

1. Priority Scheduling: Priority scheduling determines the order in which an output interface transmits traffic from its queues, thus ensuring that queues containing important traffic are provided better access to the outgoing interface. Priority scheduling is achieved by examining the assigned priority of each individual queue.

2. Weighted Fair Queuing (WFQ): Weighted Fair Queuing is a network scheduling algorithm that manages bandwidth allocation among multiple data flows. It ensures that each flow gets a fair share of the network resources, proportional to its assigned weight. This mechanism is crucial in preventing network congestion and ensuring smooth data transmission.

3. Round Robin (RR): A multiplexer, switch, or router that provides round-robin scheduling has a separate queue for every data flow, where a data flow may be identified by its source and destination address. The algorithm allows every active data flow that has data packets in the queue to take turns in transferring packets on a shared channel in a periodically repeated order. Hence, the scheduling tries to prevent link resources from going unused.

4. iSLIP: The SLIP algorithm uses rotating priority (“round-robin”) arbitration to schedule each active input and output in turn. iSLIP is based on the parallel iterative matching algorithm (PIM). PIM uses randomness to avoid starvation and reduce the number of iterations needed to converge on a maximal-sized match.

The iSLIP algorithm improves upon Round Robin by reducing the synchronization of the output arbiters. iSLIP achieves this by not moving the grant pointers unless the grant is accepted.

Implementations:

Here, we have created 8 input ports and 8 output ports. Each input queue has a buffer size of 64 packets and switching fabric implements various scheduling algorithms.
We have also considered uniform, non-uniform and bursty traffic.

Performance of Different Algorithms:

Priority Scheduling:
Uniform Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 416
Average Turnaround Time: 4385 ms
Average Waiting Time: 4370 ms
Total Packet Drops at input: 92
Total Packet Drops at output: 0
Total Buffer Occupancy: 908
Elapsed Time: 15 seconds
```

Non-Uniform Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 414
Average Turnaround Time: 4053 ms
Average Waiting Time: 4038 ms
Total Packet Drops at input: 190
Total Packet Drops at output: 0
Total Buffer Occupancy: 810
Elapsed Time: 15 seconds
```

Bursty Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 203
Average Turnaround Time: 3167 ms
Average Waiting Time: 3152 ms
Total Packet Drops at input: 314
Total Packet Drops at output: 0
Total Buffer Occupancy: 686
Elapsed Time: 7 seconds
```

Weighted Fair Queuing(WFQ):

Uniform Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 395
Average Turnaround Time: 3690 ms
Average Waiting Time: 3675 ms
Total Packet Drops at input: 180
Total Packet Drops at output: 0
Total Buffer Occupancy: 820
Elapsed Time: 15 seconds
```

Non-uniform Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 404
Average Turnaround Time: 4285 ms
Average Waiting Time: 4271 ms
Total Packet Drops at input: 183
Total Packet Drops at output: 0
Total Buffer Occupancy: 817
Elapsed Time: 16 seconds
```

Bursty Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 133
Average Turnaround Time: 2191 ms
Average Waiting Time: 2177 ms
Total Packet Drops at input: 379
Total Packet Drops at output: 0
Total Buffer Occupancy: 621
Elapsed Time: 5 seconds
```

Round Robin:

Uniform Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 397
Average Turnaround Time: 4802 ms
Average Waiting Time: 4787 ms
Total Packet Drops at input: 102
Total Packet Drops at output: 0
Total Buffer Occupancy: 898
Elapsed Time: 15 seconds
```

Non-Uniform Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 395
Average Turnaround Time: 4259 ms
Average Waiting Time: 4244 ms
Total Packet Drops at input: 209
Total Packet Drops at output: 0
Total Buffer Occupancy: 791
Elapsed Time: 15 seconds
```

Bursty Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 195
Average Turnaround Time: 3324 ms
Average Waiting Time: 3310 ms
Total Packet Drops at input: 327
Total Packet Drops at output: 0
Total Buffer Occupancy: 673
Elapsed Time: 7 seconds
```

iSLIP Algorithm:

Uniform Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 414
Average Turnaround Time: 4599 ms
Average Waiting Time: 4584 ms
Total Packet Drops at input: 86
Total Packet Drops at output: 0
Total Buffer Occupancy: 914
Elapsed Time: 15 seconds
```

Non-Uniform Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 416
Average Turnaround Time: 4003 ms
Average Waiting Time: 3988 ms
Total Packet Drops at input: 208
Total Packet Drops at output: 0
Total Buffer Occupancy: 792
Elapsed Time: 15 seconds
```

Bursty Traffic:

```
Simulation Metrics:
--------------------
Total Packets Processed: 202
Average Turnaround Time: 3160 ms
Average Waiting Time: 3146 ms
Total Packet Drops at input: 318
Total Packet Drops at output: 0
Total Buffer Occupancy: 682
Elapsed Time: 7 seconds
```

In the case of Uniform Traffic, the lowest packet delay is incurred by Weighted Fair Queuing (WFQ). WFQ provides a fair allocation of bandwidth by giving proportional service based on weights. It achieves low packet delay for uniform traffic because it ensures each flow gets its fair share of service.

In the case of Non-Uniform Traffic, the lowest packet delay is incurred by iSLIP and WFQ. iSLIP performs well under non-uniform traffic, handling packet contention and varying load effectively. It may achieve moderate delay overall, but it's not optimized for weighted service differentiation like WFQ. WFQ excels under non-uniform traffic because it adjusts bandwidth allocation based on flow weights. It minimizes delay for heavy flows by assigning more resources to them.

In the case of Bursty Traffic, the lowest packet delay is incurred by iSLIP. iSLIP is designed to efficiently match resources, even in high-load or bursty conditions. It can achieve low delays under bursty traffic by quickly resolving contention for resources.

Priority Handling

The Priority Scheduling algorithm explicitly assigns a priority to each input queue based on the priority of the packets arriving in that queue. This ensures that higher-priority packets are always processed before lower-priority packets, regardless of the load on the network, which can result in the starvation of low-priority traffic if high-priority traffic dominates.

In contrast, Weighted Fair Queueing (WFQ) does not explicitly prioritize packets based solely on packet-level priorities. Instead, queues with a higher number of packets are given more bandwidth. If high-priority packets are present in these queues, they are processed faster. This ensures that high-priority traffic is served efficiently, without completely starving lower-priority traffic.

In the case of Round Robin, there is no mechanism for handling priority. All queues are treated equally, and each queue is served in turn, regardless of the priority of the packets in the queue.

Similarly, the iSLIP algorithm, which is based on the Round Robin scheduling principle, does not prioritize high-priority packets. It focuses on resolving contention among input-output pairs rather than providing explicit preferential treatment for high-priority traffic.

Fairness

Weighted Fair Queueing (WFQ) provides the highest fairness among the listed algorithms. Fairness in this context refers to the ability of the scheduling algorithm to allocate resources (such as bandwidth) proportionally among different traffic flows according to their weights or priorities.

1. WFQ assigns each flow a weight, and the bandwidth is divided among flows based on these weights. This ensures that heavier (or more important) flows get more bandwidth while lighter flows still receive a fair share.
2. Even in cases of non-uniform or bursty traffic, WFQ ensures that each flow receives its weighted share of resources, making it highly fair.

Round Robin: Offers equal service to all flows but does not consider traffic load, which can lead to inefficiencies, especially with non-uniform traffic. Hence, it does not ensure fairness when traffic demands differ.

Priority Scheduling: Prioritizes high-priority traffic but starves lower-priority flows, making it unfair for lower-priority traffic.

iSLIP: Provides fairness in switch arbitration but is less focused on weighted bandwidth allocation than WFQ.

Thus, **WFQ** provides the highest fairness by ensuring all flows are served according to their weight and traffic demand.

iSLIP

The **iSLIP algorithm** is an enhanced version of Round Robin, primarily used in switch scheduling (e.g., in crossbar switches) for high-speed routers and networks.

iSLIP is designed for input-queued switches, where multiple inputs contend for the same output port. It uses an iterative matching process to match input-output pairs and efficiently allocate resources.iSLIP operates in iterations where it selects input-output pairs that can be served. It balances fairness with efficient matching by giving each input-output pair a chance to be served in subsequent iterations.

It improves upon traditional Round Robin methods in several ways:

1. In Round Robin, contention between multiple inputs for the same output port can lead to inefficient resource use. This can result in packet delays due to port contention. iSLIP improves by resolving contention more effectively through an iterative matching process. Each input and output maintains a pointer, which rotates, allowing the algorithm to gradually adjust to demand and resolve conflicts efficiently.
2. Simple round-robin techniques only serve one input-output pair at a time in a cyclical order. When multiple inputs request the same output, some inputs may have to wait until the next round, causing delays. iSLIP uses multiple iterations to allow multiple matches in a single cycle. This results in better utilization of the switch resources and reduces packet delay due to contention.
3. In Round Robin, the service order is fixed, meaning once an input or output is served, the pointer moves to the next in a fixed order. iSLIP adjusts pointers dynamically. Once an input-output pair is matched, iSLIP advances the pointer to give other inputs and outputs a chance to be served in future iterations. This ensures fairness while still allowing efficient resource matching.
4. iSLIP achieves higher throughput than traditional Round Robin methods by making better use of available resources. With traditional Round Robin, some output ports may remain idle due to conflicts, leading to lower throughput.
5. Round Robin can lead to increased delays, especially when certain inputs are heavily loaded and have to wait for multiple cycles to be served. iSLIP minimizes packet delay by quickly resolving contentions and matching inputs to outputs more effectively.

Best Scheduling Algorithm for high throughput router switch fabrics:

Based on the evaluation of fairness, delay, contention resolution, and throughput, **iSLIP** is the best scheduling algorithm for use in high-throughput router switch fabrics because:

1. In high-throughput routers, multiple input ports often contend for the same output port. iSLIP handles this efficiently through its iterative matching process, resolving contention and allowing multiple inputs to be matched with outputs in a single cycle.
2. By optimizing resource allocation and minimizing idle time on output ports, iSLIP ensures higher throughput than Round Robin. It maximizes the number of packets transmitted in each cycle, making it ideal for high-speed switch fabrics that require maximum utilization of bandwidth.
3. iSLIP minimizes packet delay, especially in scenarios involving contention, which is common in high-throughput networks. By using multiple iterations per scheduling cycle, it reduces the time packets spend waiting to be transmitted, improving overall performance.
4. While iSLIP focuses on high throughput, it also provides a good level of fairness by dynamically adjusting its pointers to ensure that all inputs get a fair chance to be matched with outputs over time.