EE-789: Mini Project
4x4 Switch

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1 Problem Statement

Design and Test an 4x4 switch, which can handle packets with a maximum size of 256 bytes (ie. 64 words). Validate and characterize above switch for the following kinds of traffic

- Data comes in from a single port and goes out to a single port
- Data comes in from both ports and goes out to the same destination port
- Data comes in from both ports and is distributed across the destination ports (incoming packet is equally likely to go to any of the destination ports).

2 Introduction

An NxM switch transfers the data from one of the N input ports to one of the M outputs. Input packets arrives at the switch. The packet length (in bytes) is a multiple of 4-byte quantities (words). The first word in the packet is called the header, and its has basic information about packet (destination - 8bit, data length - 16bit, sequence id - 8bit).

2.1 Block diagram

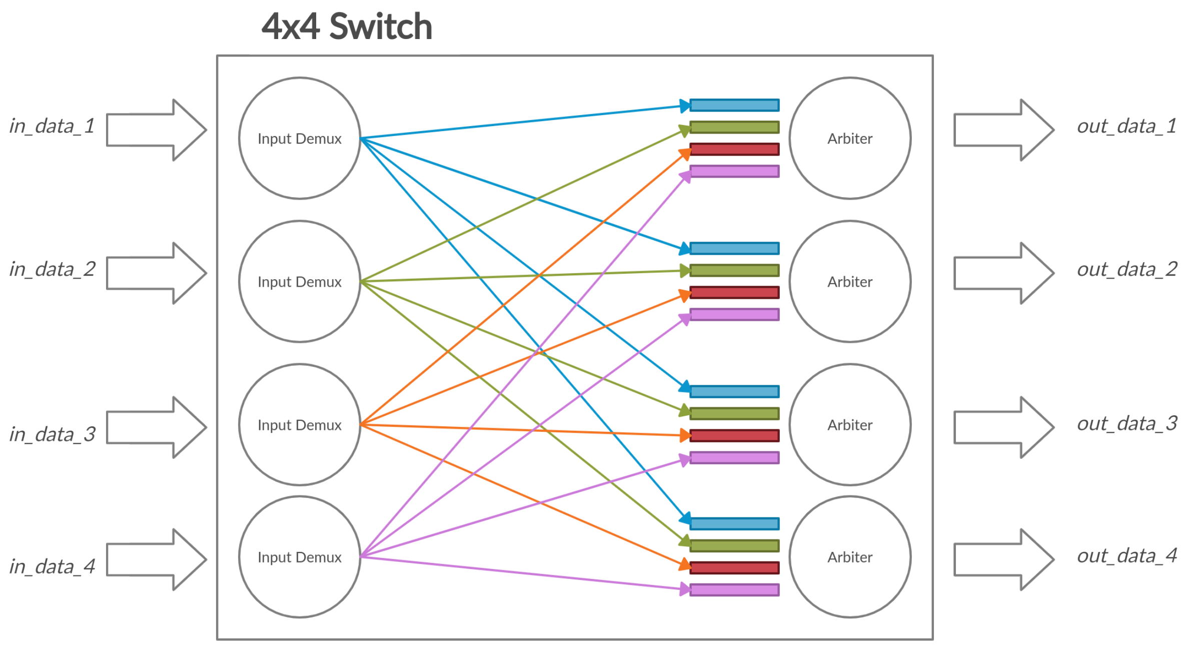


Figure 1: 4x4 Switch

3 Design decisions

Instead of monolithic design we will be using modular design strategy. We need to implement four identical input demuxes and four identical output arbiter. We would be designing one input demux and one output arbiter and copy that module to generate other input and output ports.
Design has following entities

- **2 input pipe** - 2 words depth
- **2 output pipe** - 2 words depth
- **16 non-blocking buffer queues** - 2*64 blocks of 33 bits

4 Implementation

4.1 Input demux

Input demux has pipeline running continuously and accepting input at each loopback. if *count_down* is '0' then new packet is accepted and recognised as a header. Header is decoded and splits into destination, packet length in words (4-byte) and sequence id with bit lengths of 8, 16 and 8 respectively. '1' is appended to the input to identify it as a valid packet. Then it is sent to the corresponding queue according to destination.

4.2 Output arbiter

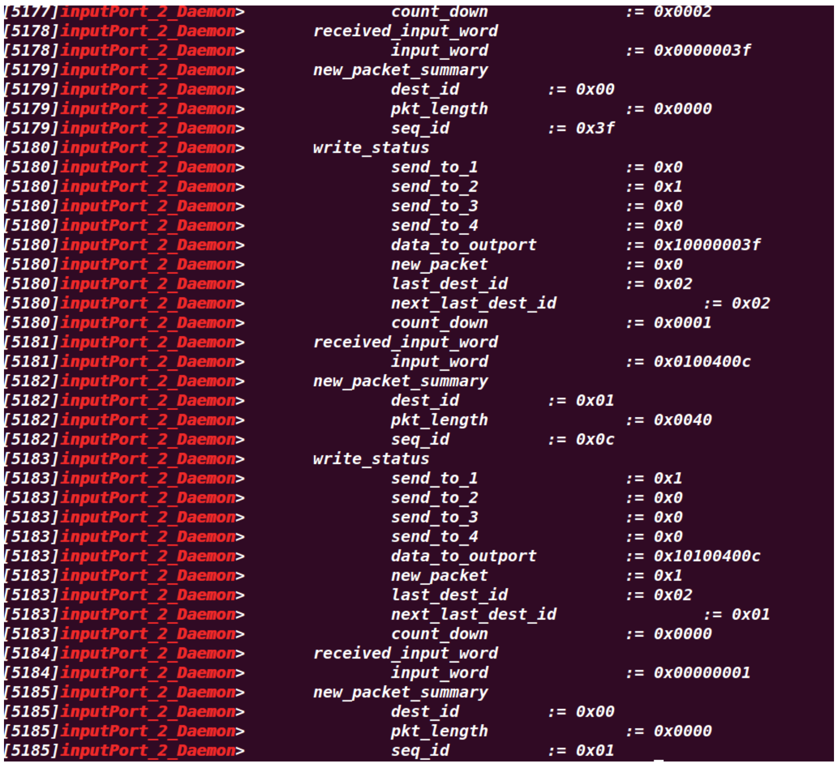
Output arbiter accepts 33 bits from all queues corresponding to 4 input demuxes if corresponding *read_from_* is true. Active packet refers to the current queue from which packet is being sent out currently. *priority_queue* is a 3-bit variable which stores the priority for next active packet.
We check the valid packets from four queues and whether there is any valid packet to send or not. We then apply priority select logic which is explained in next section. We get the next active packet and next priority packet as a output from priority select logic. Next active packet decides which packet needs to be sent out.

4.3 Priority Select

Priority select implements **Round-robin scheduling** method to decide priority. Priority changes from 0—1, 1—2, 2—3, 3—4, 4—1. *priority_queue* is 3-bit variable and stores the queue index which is at current priority.

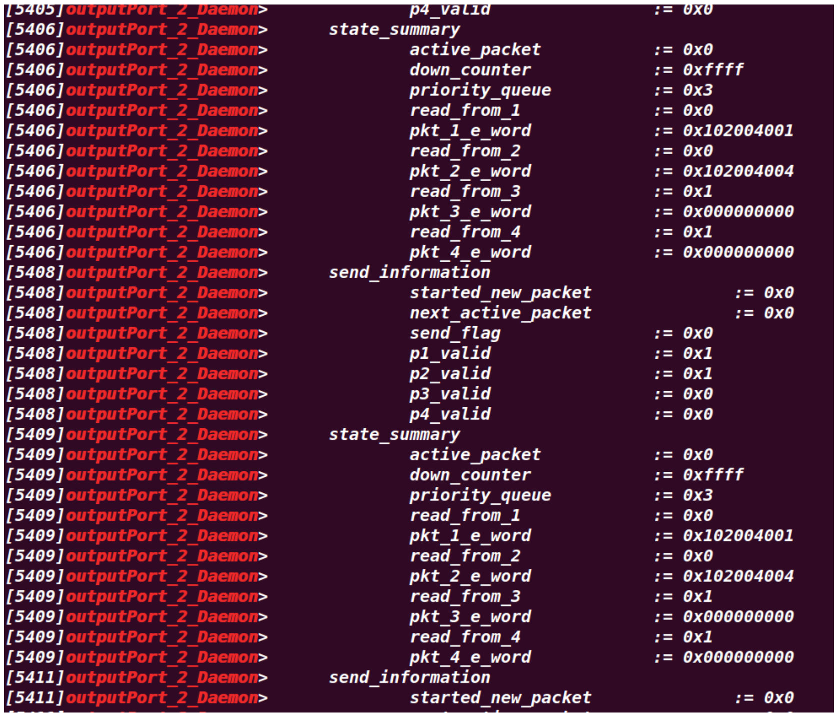
5 Design verification

Design is verified by the testbench in C. Report statements were added to debug the code and see intermediate states. In testbench all input ports are active and destination is randomly selected.



```
[5177]inputPort_2_Daemon>               count_down              := 0x0002
[5178]inputPort_2_Daemon>       received_input_word
[5178]inputPort_2_Daemon>               input_word              := 0x0000003f
[5179]inputPort_2_Daemon>       new_packet_summary
[5179]inputPort_2_Daemon>               dest_id         := 0x00
[5179]inputPort_2_Daemon>               pkt_length              := 0x0000
[5179]inputPort_2_Daemon>               seq_id          := 0x3f
[5180]inputPort_2_Daemon>       write_status
[5180]inputPort_2_Daemon>               send_to_1               := 0x0
[5180]inputPort_2_Daemon>               send_to_2               := 0x1
[5180]inputPort_2_Daemon>               send_to_3               := 0x0
[5180]inputPort_2_Daemon>               send_to_4               := 0x0
[5180]inputPort_2_Daemon>               data_to_outport         := 0x10000003f
[5180]inputPort_2_Daemon>               new_packet              := 0x0
[5180]inputPort_2_Daemon>               last_dest_id            := 0x02
[5180]inputPort_2_Daemon>               next_last_dest_id               := 0x02
[5180]inputPort_2_Daemon>               count_down              := 0x0001
[5181]inputPort_2_Daemon>       received_input_word
[5181]inputPort_2_Daemon>               input_word              := 0x0100400c
[5182]inputPort_2_Daemon>       new_packet_summary
[5182]inputPort_2_Daemon>               dest_id         := 0x01
[5182]inputPort_2_Daemon>               pkt_length              := 0x0040
[5182]inputPort_2_Daemon>               seq_id          := 0x0c
[5183]inputPort_2_Daemon>       write_status
[5183]inputPort_2_Daemon>               send_to_1               := 0x1
[5183]inputPort_2_Daemon>               send_to_2               := 0x0
[5183]inputPort_2_Daemon>               send_to_3               := 0x0
[5183]inputPort_2_Daemon>               send_to_4               := 0x0
[5183]inputPort_2_Daemon>               data_to_outport         := 0x10100400c
[5183]inputPort_2_Daemon>               new_packet              := 0x1
[5183]inputPort_2_Daemon>               last_dest_id            := 0x02
[5183]inputPort_2_Daemon>               next_last_dest_id               := 0x01
[5183]inputPort_2_Daemon>               count_down              := 0x0000
[5184]inputPort_2_Daemon>       received_input_word
[5184]inputPort_2_Daemon>               input_word              := 0x00000001
[5185]inputPort_2_Daemon>       new_packet_summary
[5185]inputPort_2_Daemon>               dest_id         := 0x00
[5185]inputPort_2_Daemon>               pkt_length              := 0x0000
[5185]inputPort_2_Daemon>               seq_id          := 0x01
```

Figure 2: Terminal screenshot

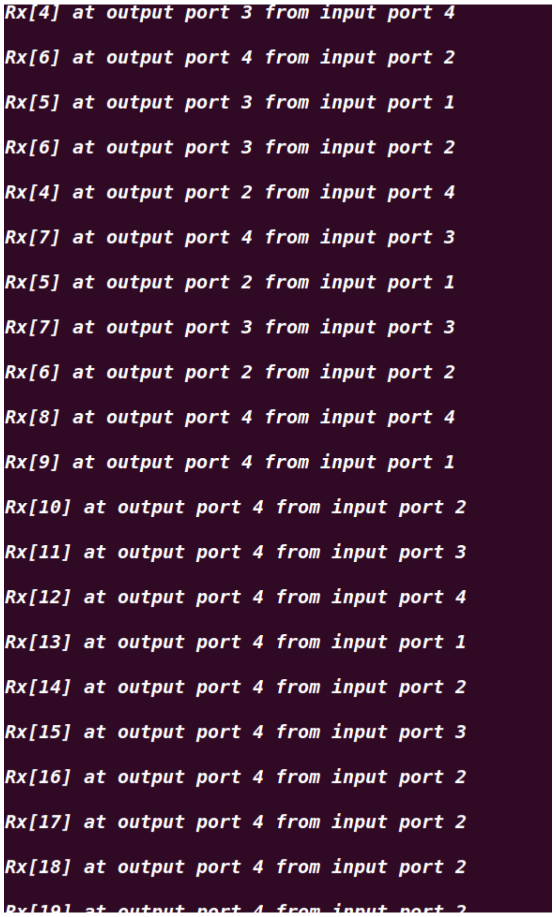


```
[5405]outputPort_2_Daemon>          p4_valid                := 0x0
[5406]outputPort_2_Daemon>      state_summary
[5406]outputPort_2_Daemon>          active_packet           := 0x0
[5406]outputPort_2_Daemon>          down_counter            := 0xffff
[5406]outputPort_2_Daemon>          priority_queue          := 0x3
[5406]outputPort_2_Daemon>          read_from_1             := 0x0
[5406]outputPort_2_Daemon>          pkt_1_e_word            := 0x102004001
[5406]outputPort_2_Daemon>          read_from_2             := 0x0
[5406]outputPort_2_Daemon>          pkt_2_e_word            := 0x102004004
[5406]outputPort_2_Daemon>          read_from_3             := 0x1
[5406]outputPort_2_Daemon>          pkt_3_e_word            := 0x000000000
[5406]outputPort_2_Daemon>          read_from_4             := 0x1
[5406]outputPort_2_Daemon>          pkt_4_e_word            := 0x000000000
[5408]outputPort_2_Daemon>      send_information
[5408]outputPort_2_Daemon>          started_new_packet              := 0x0
[5408]outputPort_2_Daemon>          next_active_packet              := 0x0
[5408]outputPort_2_Daemon>          send_flag               := 0x0
[5408]outputPort_2_Daemon>          p1_valid                := 0x1
[5408]outputPort_2_Daemon>          p2_valid                := 0x1
[5408]outputPort_2_Daemon>          p3_valid                := 0x0
[5408]outputPort_2_Daemon>          p4_valid                := 0x0
[5409]outputPort_2_Daemon>      state_summary
[5409]outputPort_2_Daemon>          active_packet           := 0x0
[5409]outputPort_2_Daemon>          down_counter            := 0xffff
[5409]outputPort_2_Daemon>          priority_queue          := 0x3
[5409]outputPort_2_Daemon>          read_from_1             := 0x0
[5409]outputPort_2_Daemon>          pkt_1_e_word            := 0x102004001
[5409]outputPort_2_Daemon>          read_from_2             := 0x0
[5409]outputPort_2_Daemon>          pkt_2_e_word            := 0x102004004
[5409]outputPort_2_Daemon>          read_from_3             := 0x1
[5409]outputPort_2_Daemon>          pkt_3_e_word            := 0x000000000
[5409]outputPort_2_Daemon>          read_from_4             := 0x1
[5409]outputPort_2_Daemon>          pkt_4_e_word            := 0x000000000
[5411]outputPort_2_Daemon>      send_information
[5411]outputPort_2_Daemon>          started_new_packet              := 0x0
```

Figure 3: Terminal screenshot

6 Results

Current implementation till now works for all combinations of input and output ports.



```
Rx[4] at output port 3 from input port 4

Rx[6] at output port 4 from input port 2

Rx[5] at output port 3 from input port 1

Rx[6] at output port 3 from input port 2

Rx[4] at output port 2 from input port 4

Rx[7] at output port 4 from input port 3

Rx[5] at output port 2 from input port 1

Rx[7] at output port 3 from input port 3

Rx[6] at output port 2 from input port 2

Rx[8] at output port 4 from input port 4

Rx[9] at output port 4 from input port 1

Rx[10] at output port 4 from input port 2

Rx[11] at output port 4 from input port 3

Rx[12] at output port 4 from input port 4

Rx[13] at output port 4 from input port 1

Rx[14] at output port 4 from input port 2

Rx[15] at output port 4 from input port 3

Rx[16] at output port 4 from input port 2

Rx[17] at output port 4 from input port 2

Rx[18] at output port 4 from input port 2

Rx[19] at output port 4 from input port 2
```

Figure 4: Terminal screenshot

7 Conclusion

4x4 Switch is created successfully.