An Efficient Arbitration Technique for NOC Using XY and VCT Routing

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***Abstract*- NOC has many advantages of traditional bus-based SOC. The bus structure in NOC technology is replaced with the network design for a better and enhanced communication. A large number of heterogeneous devices are integrated in a single chip. In the web representation of the NOC technology, the router algorithms and arbitration techniques are the essential things, between these communication devices. The common problem with arbitration technique is live lock and dead lock. It can be removed by proper routing algorithms. The combination of XY and VCT routing method used on proposed design routers for an improved and upgraded data transfer which increase the performance of the NOC. In this paper on proposed design routers an efficient arbitration technique is used that gives the developed routing output because the input data packets are allocated in priority wise.**

***Index terms*- Arbiter, Network on chip (NOC), Virtual cut through (VCT) router, HRRA (Hierarchical round robin arbitration), TDMA (time division multiple access) arbitration**

1. INTRODUCTION

A network-based subsystem for communications on an IC is called NOC. It improves the scalability of the soc source and power efficiency of complex socs design. To build a single chip or soc many computing resources are added to satisfy high performance and low power necessities. So the integrated circuits are becoming increasingly complex. Interconnecting between the resources is another challenging issue. On NOC, router algorithms, network topology and arbitration techniques are the essential things. By arbiter all the bus access should be serialized and using packet switching the scalable bandwidth constraint could be removed. Routers are used to forward the packets to the destination and also forward the packets to the other routers which connected to it.

1.1 NETWORK ON CHIP ROUTER

If the number of PE is increased, the scalability of the bus is reduced. To overcome this problem NOC is used. In fig.1. Conventional NOC architecture, which consist of PEs (processing elements), NIs (network interfaces), and R (router) are shown. In NOC architecture, NI is connecting PE to a local router. According to the router's decision packet transferred between sources PE to destination PE.

Fig.1. REGULAR NOC ARCHITECTURE

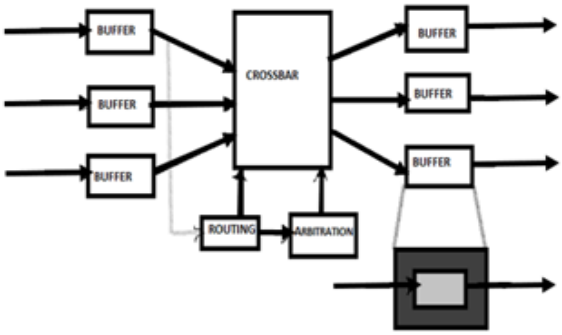

Fig.2. CONVENTIONAL NOC ROUTER

In Fig.2 the conventional router architecture is shown. On NOC, routers it controls and coordinates the data flow. In NOC router architecture,

1. Data-path -It is used for packet switching for a better transmission process that consists of input channels and output channels [1][2].
2. Control logics- Taking control decision and channel arbitration.
3. Input buffer-storing the packets in every router.

The crossbar is used to transfer the granted packets to the next router. This transmission process continued until the packets arrive at its destination. The design of the NOC structure should be simple otherwise it will increase the design complexity and implementation cost.

2 ROUTING AND ARBITRATION TECHNIQUES

2.1 ROUTING TECHNIQUES

In the router design, there are three main parts

1. FIFO
2. Arbiter
3. crossbar

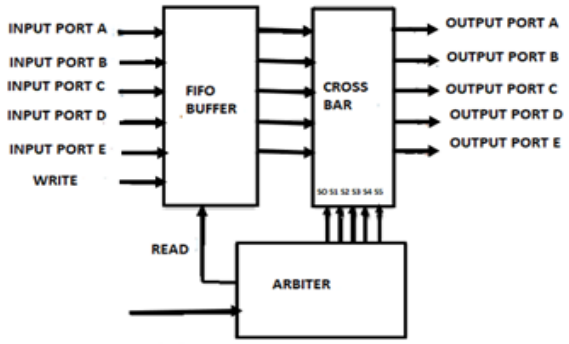

Fig .3. UNIDIRECTIONAL ON CHIP ROUTER

In fig.3.unidirectional on chip router is shown. Buffering is the most important thing in the NOC for congestion control and flow control. The best performance is received by calculating the proper size of buffer. The buffer depth is utilized to give the input buffering. The Arbiter is used to control the goals of the ports and takes care of the disputed issues. It refreshes the status of the considerable number of ports and knows whether the ports are free or communicating with one another. It is answerable for finishing the needs among the many input demands. The crossbar is a switch interfacing the various contributions to multiple yields in a matrix way. In a reconfigurable crossbar switch, connection matrix, decoder and preheader analyzer are used. In this paper two different routing techniques is used,

1. XY ROUTING
2. VCT ROUTING

In XY routing it is determined by their address. In x dimension (source) message travels horizontally. After determination of x dimension, y dimension is determined vertically. In XY routing East-south, west-south, east-north and west-north direction pairs are possible. This concept of routing is easy to implement with deadlock free.

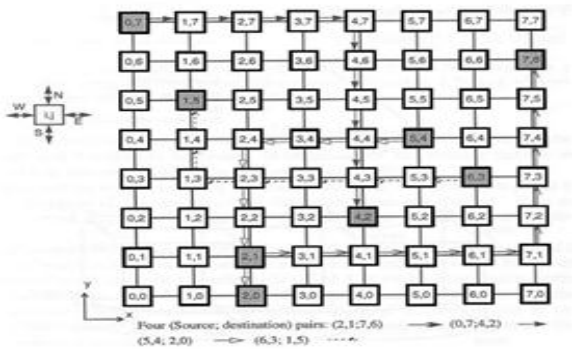

Fig.4. XY ROUTING CONCEPT

The XY directing ideas as appeared in Fig.4. In VCT routing it makes a virtual channel to pass the data packets that are permitted by the mediator. The message comes from the intermediate node [2] and it is similar to message switching with a difference. It's choosing the free channel for departing and messages sent outed. The message is not allowed, when it has busy output. In VCT routing, it has intermediate node.

2.2 ARBITRATION TECHNIQUES

On NOC numerous assertion methods are there in particular fixed priority, round robin, token-ring, lottery-based arbitration and so on The availability between the input and output ports are upgraded by the arbiter and determine the execution succession of the routing paths. In arbitration, various problems are experienced,

1. Congestion
2. Starvation
3. Deadlock
4. Live lock
5. Head of line blocking

Deadlock happened when output port can't be gotten to by an output port since it is looking out for other input port to discharge the assets [10]. Live lock: The data packets from the yield port are moving, yet it doesn't arrive at the ideal output port [10]. By breaking down the different arbitration performances,

High throughput and low idleness are satisfied with ring arbitration, the performance expanded by HRRA, the starvation issue decreased by the RRA. So HRRA, RRA, modified RRA, TDMA and ring arbitration are proficient assertion methods in the NOC.

2.2.1 ROUND ROBIN ARBITRATION TECHNIQUE

It gives a high level of fairness by treating each input port similarly among the operators and it gives an equivalent opportunity to get to the yield port. In this plan token is passing the needs change at each move. In the event that the master with the most noteworthy need doesn't have to get to the slave, the token is given to the master with the following most noteworthy need [6]. The issue with this procedure is a smidgen time consuming activity and expanded multifaceted nature of the need handling in round need request

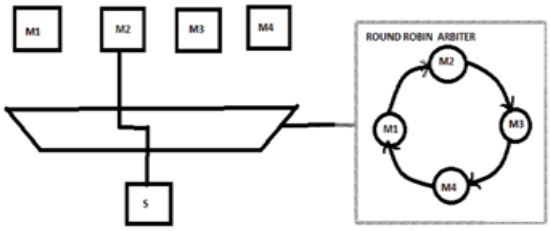

Fig.5. ROUND ROBIN ARBITER

The ring counter is used to generate the tokens, using the round robin algorithm, this concept as shown in Fig.5.

2.2.2 HIERARCHICAL ROUND ROBIN ARBITRATION TECHNIQUE

Inside one clock cycle the arbitration is required to be finished, so as to get a fast and region effective RRA. This procedure is called HRRA. In this method light weight and elite RRA is utilized for the best execution of arbitration. In HRRA approach, the quantity of sources of inputs is expanded in RRA. K sets of a n input demand RRAs are called SRRA (sub-RRA). The SRRA design utilized in the phases of HRRA. All the SRRAs fills in as basic and it rearranges the activity with non-circular need setting. It is a basic mechanism which includes smooth progress of the dynamic state starting with one SRRA then onto the next SRRA. The HRRA can reach out to various stages [11]. It builds the clock frequency as high, decline in area and power utilization separately.

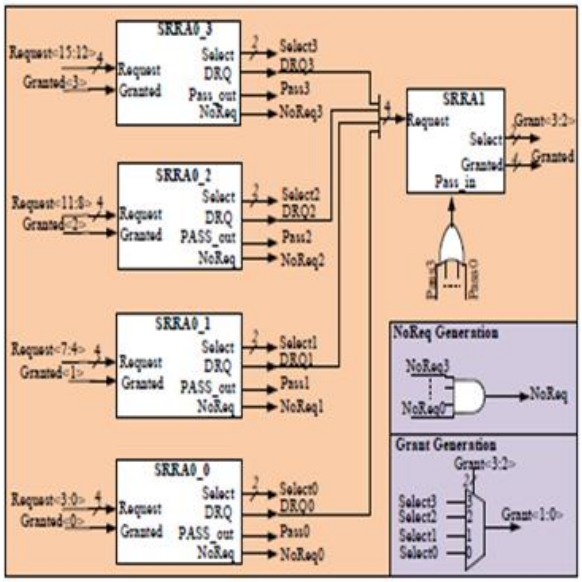

Fig.6. 16 -input HRRA

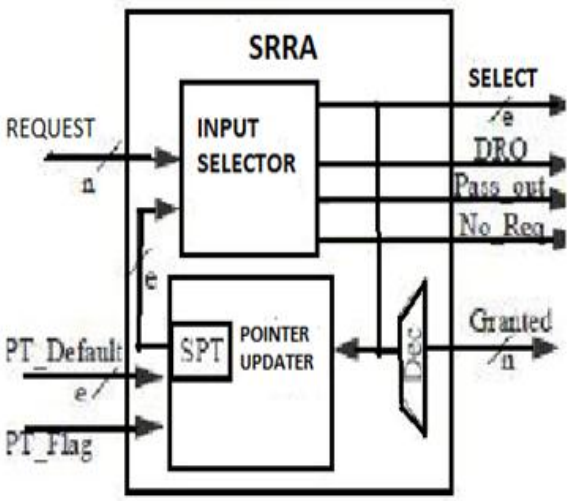

Fig.7. SRRA DESIGN

In fig.7 the architecture of SRRA for all the stages of HRRA as shown.

2.2.3 MODIFIED ROUND ROBIN ARBITRATION TECHNIQUE

It is an advanced technique of RRA. In modified RRA priority logic is used which has a combination of priority encoder and decoder for accessing the bus when it gets request [2]. Based on the enable pin, bus grant signal will be proceeded. In this arbitration, the computation will be reduced. The logic diagram of modified round robin algorithm as shown in fig.8.

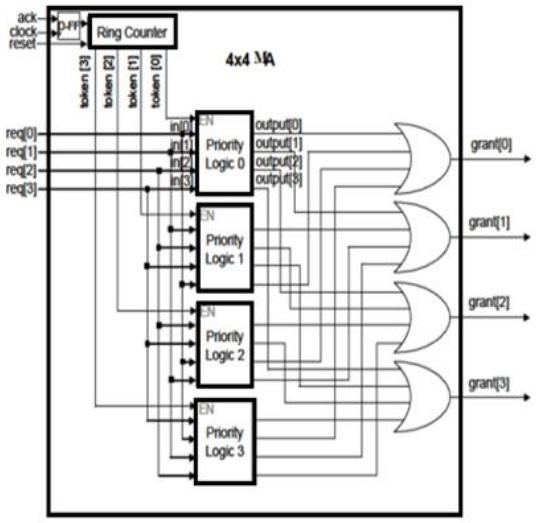

Fig.8. MODIFIED ROUND ROBIN LOGIC IMPLEMENTATION

2.2.4 RING ARBITRATION TECHNIQUE

The Ring arbiters depend on the token ring idea. The idea of the ring arbiter is creating a lock signal by a token and the signal ought to have the attributes of the non-return to zero flagging. A heavy work load condition high throughput and low idleness are accomplished. For a light burden condition, the lazy ring convention is exceptionally liked. At the point when the signal NO REQ is 1, there is no development of token. The token traveled through the ring when the signal NOREQ is 0. The revolution of a token is steady throughout the ring in ring arbiters. The nonattendance of priorities from the token ring makes the level of reasonableness in the lazy ring arbiters is exceptionally high [13].

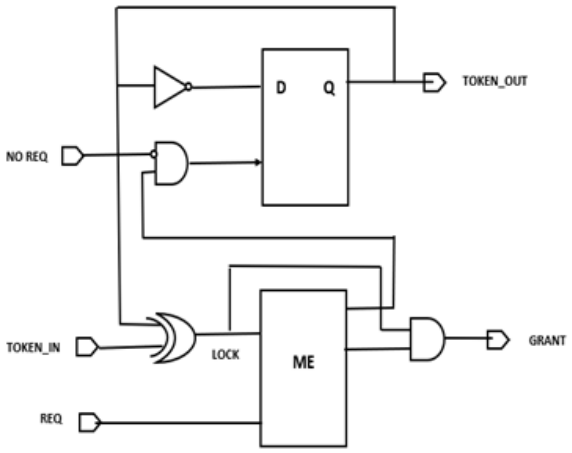

Fig.9. RING ARBITRATION MODULE

The ring arbitration module as shown in Fig.9.

2.2.5 TIME DIVISION MULTIPLE ACCESS ARBITRATION TECHNIQUE

During TDMA arbitration, for a transfer fixed time frames are given to the masters. When masters need more bandwidth, it provides longer time frames. For the critical masters higher bandwidth allocation are ensured [8]. In TDMA arbitration fixed bandwidths are guaranteed for all the masters. And it is properly designed. Even with unpredictable (or) changing traffic for a critical master it gives high performance.

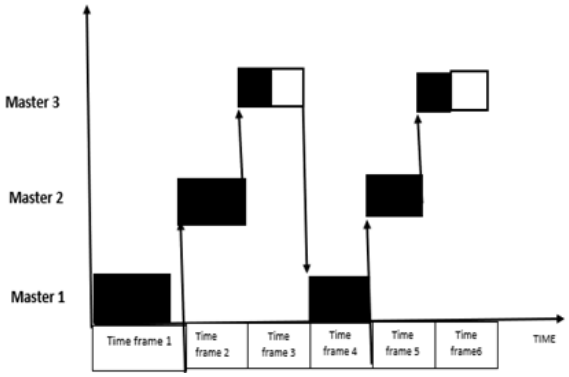

Fig.10. TDMA ARBITRATION MODULE

The darkest areas of the diagram are the actual used transfer times. Making decision of the time frames for ensuring higher bandwidth allocation on the lengths is crucial.

3 PROPOSED ROUTER DESIGN

The mix of XY and VCT directing is utilized in proposing a router switch. The input data packets are sent to the arbiter with priority. The dynamic yield is given to the VCT router which finds the most limited way of the transport. Furthermore, after VCT routing, XY switch is utilized to send the packets a similar way which found by VCT switch.

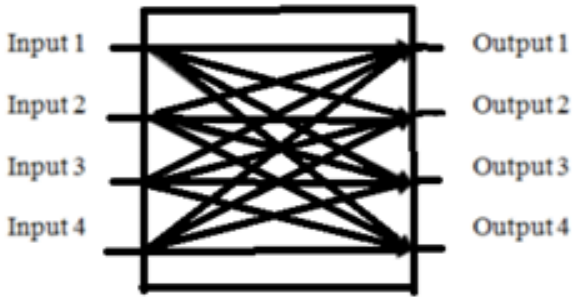

Fig.11. CROSSBAR SWITCH

In Fig.11 the crossbar of the proposed router architecture is shown.

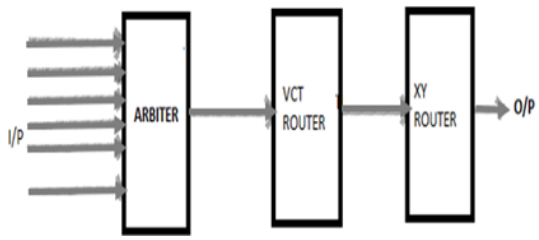

Fig.12. PROPOSED ROUTER TECHNIQUE

The combination of the XY and VCT routing techniques are shown in Fig.12.

4 SIMULATION RESULT COMPARISONS

In this paper, the simulation result has been taken using the XILINX 14.7 software and the performance analysis is taken from MICROWIND 13.2 software. The time related report, delay, performance, throughput, the total energy utilized by the router are tabulated for the various efficient arbitration techniques.

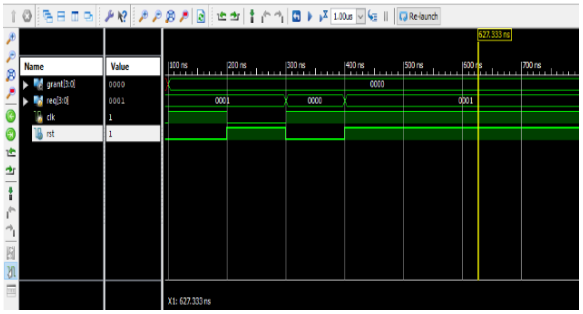

Fig.13.ROUND ROBIN ARBITRATION

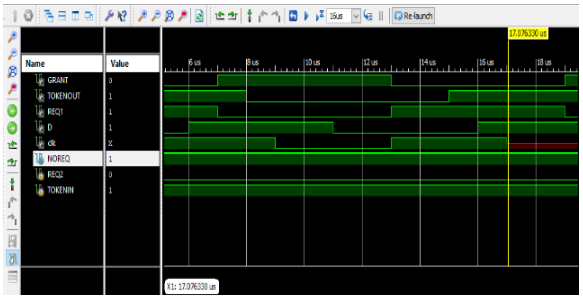

Fig.14.RING ARBITRATION OUTPUT

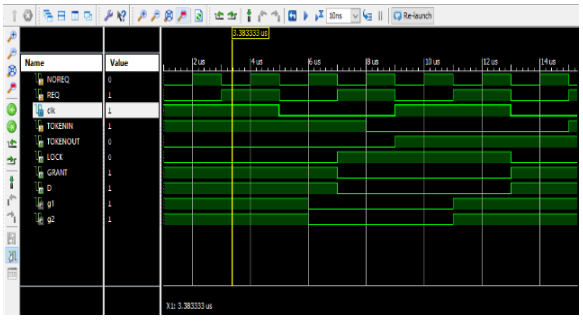

Fig.15. HRRA OUTPUT

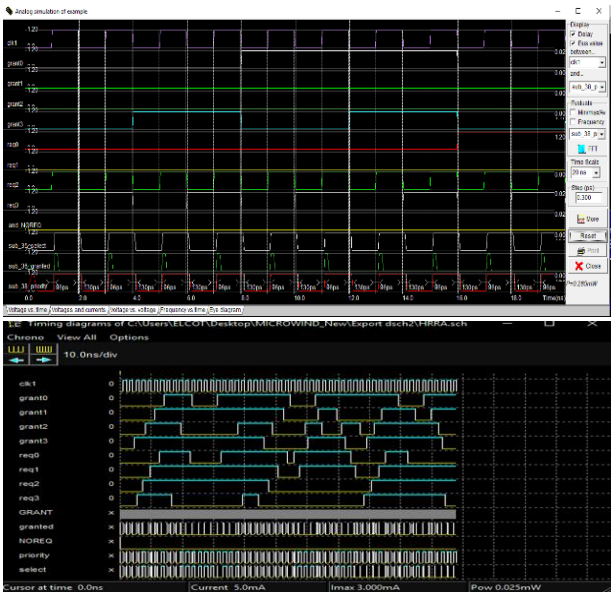

Fig.16. MODIFIED RRA OUTPUT

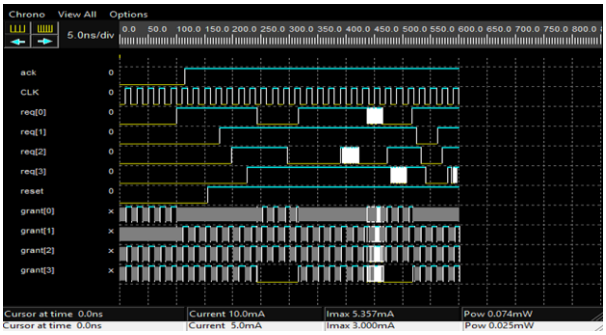

Fig.17.TDMA OUTPUT

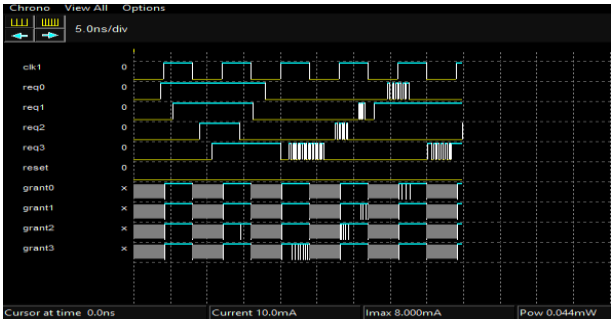

Fig.18. RING ARBITRATION LAYOUT

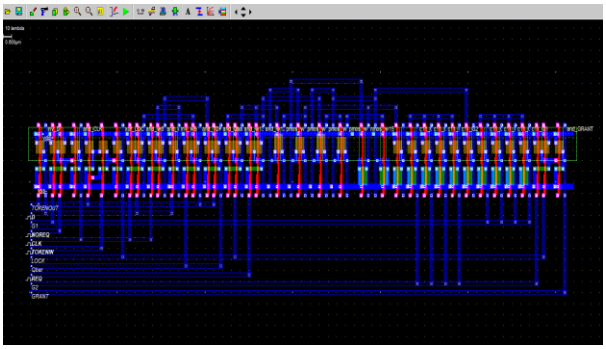

Fig.19.HRRA LAYOUT

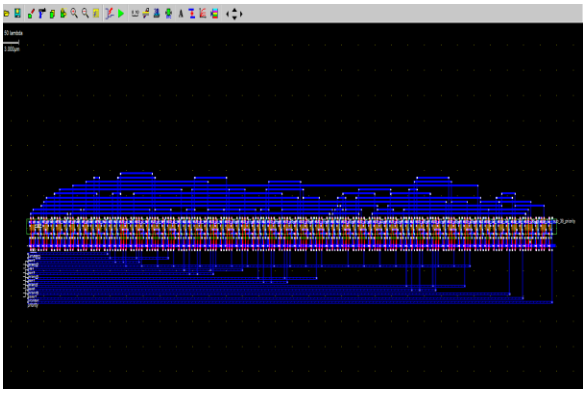

TABLE.1. PERFORMANCE ANALYSIS OF ARBITRATION TECHNIQUES

ARBITRATION	RRA	MODIFIED RRA	HRRA	TDMA	RING ARBITRATION
DELAY (ns)	11.798 ns	10.00 ns	10.010 ns	20.00 ns	13.13 ns with 2.3 latency
GAIN(GHZ)	1.000	1.059	1.010	0.776	0.924
FREQUENCY	0.489	1.075	0.500	0.247	0.250
POWER (mW)	0.599	0.650	0.399	1.165	0.123
POWER DELAY	20.22ns	18.617ns	17.511ns	23.13ns	15.145ns
ENERGY (PJ)	-	-	0.359	-	2.12
AREA	220		1248		600
PEAK MEMORY USAGE	4486	4346	4548	-	4203
PERFORMANCE	MODERATE	HIGH	HIGH	MODERATE	HIGH
ARCHITECTURE	All bus masters have equal bandwidth			All the bus masters Require high and fixed bandwidth	

From the tabulation TABLE.1, the high performance and low latency being provided by ring arbitration, HRRA and modified RRA. The layout design of HRRA and ring arbitration showing the less computational complexity with less propagation delay.

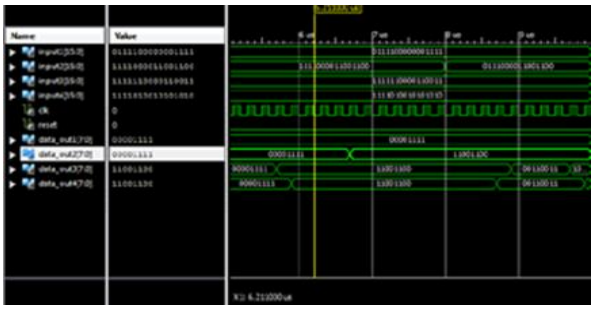

Fig .20. COMBINATION OF XY AND VCT ROUTING for ring arbiter

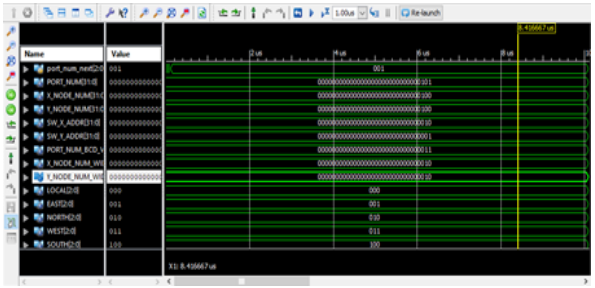

Fig .21. COMBINATION OF XY AND VCT ROUTING for HRRA arbiter

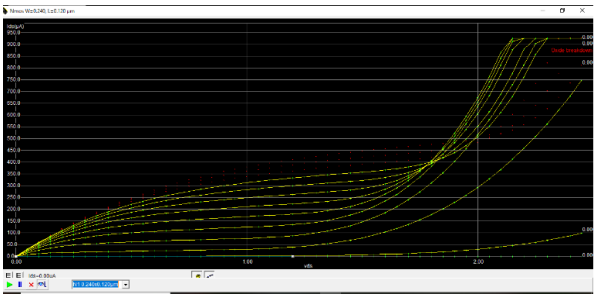

Fig .22.LAYOUT SIMULATION OF HRRA TECHNIQUE WITH THE COMBINATION OF ROUTING

TABLE.2. TABLE OF THE RESULTS OF XY AND VCT ROUTING

PARAMETERS	XY	VCT	VCT&XY
NO OF SLICES	123	148	2405
NO OF SLICES OF FF	53	52	329
LATENCY	20.341ns	5.642 ns USED (26.714 ns)	
NO OF INPUT LUT'S	230	267	4574

From Table.2. It's clear that Unmistakably XY switch results are better than VCT switch. But with the combination of XY and VCT routing, It provides high performance with reduced delay.

5 CONCLUSION

From Table.1 it's shows the comparison result of dynamic arbitration techniques for the routing purpose. The objective of the paper is to implement these efficient arbitration algorithms in the network on chip router design using the combination of XY and VCT routing. All the arbitration techniques are simple to design and has less delay. The Round robin arbitration can handle more than one request from the bus master but HRRA, ring arbitration and modified RRA is more dynamic in terms of high speed, high throughput and less delay. The performance of NOC is improved when reduces the arbitration problems. Better and optimized data transfer is provided by the VCT and XY routing. Because path selected by XY router and To send the packets, virtual channel is selected. For VCT routing it has better switching speed and less area requirement. The combination of XY and VCT routing is efficient for the NOC with a dynamic arbitration technique.

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