Comparison of 2D MESH Routing Algorithm in NOC

Pan Hao[1],Hong Qi[12]*,Du Jiaqin[1],Pan Pan[1]
[1]School of Electronics and Information Engineering，Anhui University，Hefei 230011,China
[2] State Key Lab of ASIC, Fudan University, Shanghai,201203,China
* Email:hongqi@fudan.edu.cn

AbstractThe purpose of NOC is to solve the choke point in communication and the clock problem from architecture. Each route in NOC includes some routers，and it takes a few clock periods by passing a router. When the network is in congestion，the package transmission will produce much more time delay. So adopting a appropriate routing algorithm to get the balance between the time delay and throughput rate becomes the key problem. In this paper，we have done some research on XY and OE algorithms based on the 4×4 mesh topology by using NIRGAM emulator. The result shows that the ratio of throughput rate and package time delay is 2.5358 in OE routing algorithm，which is larger than 2.1126 in XY routing algorithm，and it proves that the OE routing algorithm is better to Mesh topology than OE routing algorithm.

Key Words NOC; 2D Mesh; XY routing algorithm; OE routing algorithm; NIRGAM simulator

1. Introduction

With the progress of integrated circuit technology, soc is no longer able to meet the requirements of increasing function and performance indicators, thus people put forward network on chip architecture. Its core idea is to transplant computer network technology into the chip design, so as to solve the problems caused by the bus architecture through the system architecture.

NOC mainly consists of some function modules processor core、IP core memory units etc)，the router and the link between their composition. Figure 1 gives a 4×4 2D Mesh topology[1]. Each router is connected with an IP core. Except the outside edge node, each node is connected with four nodes around.

Responsed by Open Fund of State Key Lab of ASIC(No.10KF014)and Emphasis Project of Anhui Province Education Department

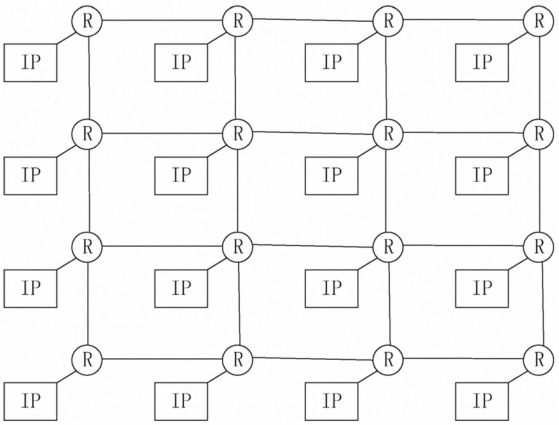

Figure 1. 4×4 of the 2D-Mesh topology

For determining NOC topology structure[2],The means of communication between IP cores will greatly impact network performance. Therefore, the choice of routing algorithm is the key factor affecting NOC network communication. Routing algorithm[3] has different classifying standards. It can be grouped into deterministic routing algorithm and adaptive routing algorithm. Deterministic routing algorithm ,also known as static routing algorithm, which defines a unique path between the original node and the destination node, such as XY routing algorithm. This algorithm is simple and easy to implement. OE routing algorithm gives limits on the possible shift position of packets to avoid the happening of deadlock.

2. 2 Routing algorithm

(1) XY routing algorithm

XY routing algorithm is a kind of deterministic routing algorithm. The path from node A to node B is a fixed transmission path, regardless of the state of the network. When the network has no congestion, it has a high reliability and low delay, and the hardware design and implementation are simple. For a two-dimensional Mesh topology, we can use（x,y）coordinates to identify each node. The source and destination addresses are

978-1-61284-193-9/11/$26.00 ©2011 IEEE

represented as（C_{x0}，C_{y0}）、（D_{x0}，D_{y0}）Only when the source address and destination address are equal, will the packets be sent to local node. When the source address and destination address are not equal, the value of C_{x0} and D_{x0} should be compared first.When $C_{x0} > D_{x0}$,the packets are sent to W channel; when $C_{x0} < D_{x0}$, the packets are sent to E channel; when $C_{x0} = D_{x0}$, compare the value of C_{y0} and D_{y0}.When $C_{y0} < D_{y0}$, the packets are sent to S channel; when $C_{y0} > D_{y0}$, the packets are sent to N channel. When the port is busy, the packet will be blocked. The packet will not be sent until the port is idle. Here are the contents of XY routing algorithm:

Current node（C_{x0}，C_{y0}）,destination node（D_{x0}，D_{y0}）

```
begin
if（Cx0 > Dx0）
return W;
else if（Cx0 < Dx0）
return  E;
else If（）
{  if（）
return  S;
else if（）
return  N;
else  return C;
}
End
```

(2) OE routing algorithm

OE routing algorithm[4] is applied to NOC of Mesh structure. By making agreements to the position of possible occurrence turns, it can avoid the occurrence of deadlocks without using virtual channels. Take 2D-Mesh for example, if the X-dimensional coordinate of a node is odd , it is called the odd column. If the X-dimensional coordinate of a node is even, it is called the even column. Using S、W、N、E to represent the south、west、north and east directions.The algorithm contains eight kinds of turns, respectively WS、WN、NS、NE、ES、EN、SE、SW. For example, WS identifies the turn from west to south. In the odd-even turn model, such turns are prohibited: (1)in even column nodes, EN, ES are prohibited;(2) in even column nodes, NW, SW are prohibited;(3) 180°turn is prohibited.

Here are the contents of the OE routing algorithm:

Source router（S_X，S_Y），destination router（D_X，D_Y），current router（C_X，C_Y）.

```
begin
dimention_set=empty;
Ex = Dx -;
if（Ex==0&&Ey==0）
return C;
if(Ex==0)
{ if(Ey<0)
add N to dimention_set;
else
add S to dimention_set;
}
Else
{if(Ex>0)
  If(Ey==0)
{ add E to dimention_set;
}
Else
{if (Cx%2 !=0 or Cx==Sx )
If (Ey<0)
add N to dimention_set;
```

else
add S to dimention_set;

if (D_X %2 !=0 or E_X !=1)

{ add E to dimention_set;}}}

else

{ add W to dimention_set;

If (C_X %2==0)

If(E_Y <0)

add S to dimention_set;

add N to dimention_set;}}

Without additional virtual channels[4] and physical channel, OE routing algorithm makes a balance of routers' number between source node and destination node .

3. The simulation results of the two algorithm and analysis

NIRGAM[5] is a modular extensible simulation which based on systemc, and enables NOC researchers to use different data to test various applications and routing algorithm. It provides parameters for users to select in each stage of NOC design. In the simulation, XY and OE routing algorithm use the same application mapping, transport conditions and simulation control conditions. All resource nodes are associated with CBR , so we need allocating transmission parameters of resource node. using the packet size is 8 and fixed destination node. The following should also be ensured: 100% of the maximum bandwidth is available; the interval of successive flits is 2 clock cycles; the simulation run 1000 clock cycle and clock frequency is 1GHz.

Routing algorithm tests each channel's [6] performance parameters. The main parts are packet average delay and channel average throughput. Figure 2 and figure 3 show the simulation results of packet average delay and network average throughput which use XY routing algorithm based on 2D-Mesh topology. Figure 4 and figure 5 are the simulation results of packet average delay and network average throughput using OE routing algorithm .

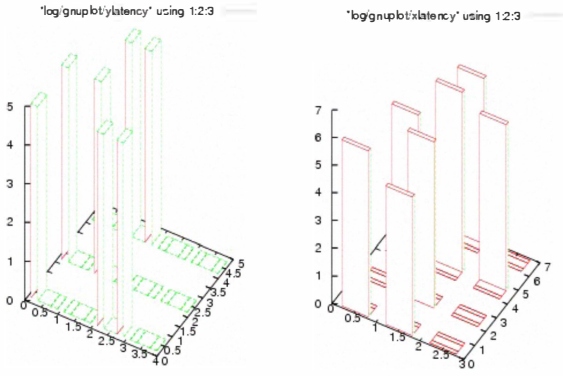

Figure 2. The packet average delay of XY routing algorithm

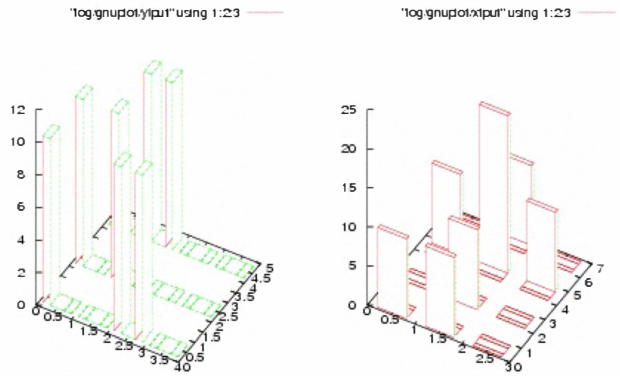

Figure 3. Average throughput of XY routing algorithm

It can be seen from figure 2 and figure 3 that for XY routing algorithm, packet delay of X-dimensional direction is greater than packet delay that of Y-dimensional direction. Average throughput of X-dimensional direction is greater than average throughput that of Y-dimensional direction.

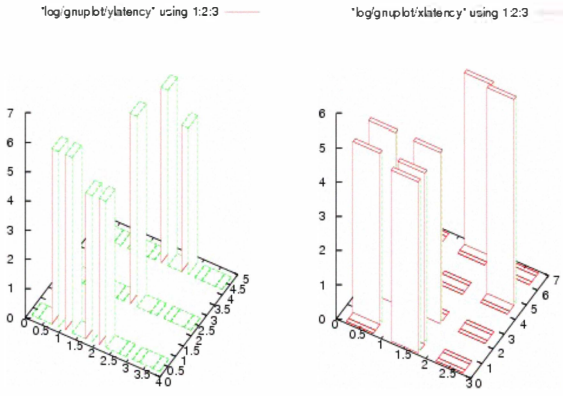

Figure 4. The packet average delay of OE routing algorithm

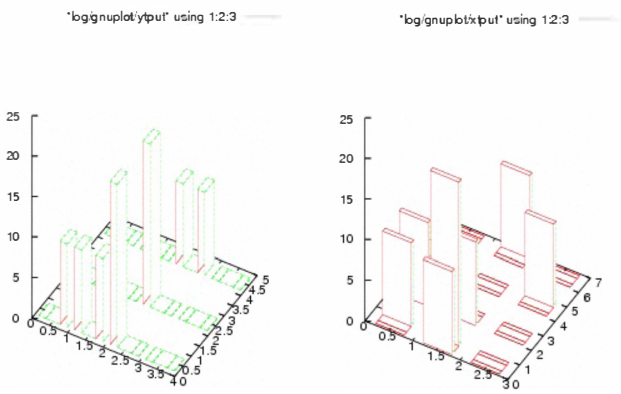

Figure5. Average throughput of XY routing algorithm

It can be seen from figure 4 and figure 5 that for OE routing algorithm, packet delay of X-dimensional direction is less than packet delay that of Y-dimensional direction. Average throughput of X-dimensional direction is almost equal average throughput to that of Y-dimensional direction.

Table 1.comparison of the main simulation performance parameters between XY and OE routing algorithm

		A maximum value of through channels	A minimum value of through channels	Network average value of XY routing algorithm	Network average value of OE routing algorithm
XY and OE	Packet delay (clock cycle)	6.5	5	5.4667	5.4118
	Flits delay (clock cycle)	2.1667	1.6667	1.8222	1.8039
	Throughput (Gbps)	20.1342	10.2041	11.549	13.7230

It can be seen from table I that in 4×4 Mesh topology, as when source node sends packets to fixed destination node, these two kinds of algorithms[7] are the same for maximum and minimum delay of packet and maximum and minimum value of average throughput. However, when we calculate the network average value, we find that network average delay of OE routing algorithm is smaller and throughput is larger. We define a parameter P [8] to show the average performance of network: P=average throughput of network/average delay of packet, the greater P value is, the better performancealgorithmhas.P(XY)=11.549/5.4667≈2.112，P(OE)= 13.7232/5.4118≈2.5358.So OErouting algorithm is more suitable than XY routing algorithm in the Mesh topology.

4. Conclusion

Routing algorithm is the contents of network layer[9] in the design of NOC. It is the key factor impacting NOC network communications. This paper is based on the two dimensional 2D-Mesh of 4×4 topology. We use XY routing algorithm and OE routing algorithm respectively on NIRGAM simulation, comparing packet delay and throughput of the two algorithm. The results show that for XY routing algorithm, packet delay of X-dimensional direction is greater than that of Y-dimensional direction, and average throughput of X-dimensional direction is greater than that of Y-dimensional direction. For OE routing algorithm, packet delay of X-dimensional direction is less than that of Y-dimensional direction, and average throughput of X-dimensional direction is nearly equal to that of Y-dimensional direction. We use the ratio of average throughput and average packet delay to show whether the algorithm is good or bad. The larger the ratio, the better the performance. The results show that the ratio of OE routing algorithm is 2.5358, and the ratio of XY routing algorithm is 2.1126. Therefore, the performance of OE routing algorithm is better in the two-dimensional Mesh topology.

References

[1]Dong Shaozhou. The Design and Research of NOC Routing Algorithm and Simulation Model [D].Hefei: Hefei University of Technology,2009

[2]Liu Youyao. The Research of NOC Topology and Communication Methods[D].Xian: Xian Electronics Science and Technology University,2009

[3]Jiang Yongnan. The Research about NOC Routing Algorithm and Application[D]. Chengdu: University of Electronic Science and Technology,2008

[4] Majid Janidarmian,vahhab Samadi Bokharaie,Ahmad Khademzadeh etc.Sorena:New On-Chip Network Topology Featuring Efficient Mapping and Simple

Deadlock Free Routing Algorithm[C].2010 10th IEEE International Conference on Computer and information technology. Oakland:IEEE computer society,2010:2290-2299

[5]A Simulator for NOC Interconnect Routing and Application Modeling[Z].University of Southanpton UK: Lavina Jain,2007

[6]Yusuke Fukushima,Masaru Fukushi,Susumu Horiguchi.Fault-Tolerant Routing Algorithm for Network on Chip without Virtual Channels[C].2009 24th IEEE International Symposium on Defect and Fault Tolerance in VLSI Systems.Oakland:IEEE computer society ,2009:313-321

[7]Ou Yang Yiming , Dong Shaozhou, Liang Huaguo. The Design and Simulation of NOC Routing Algorithm based on 2D Mesh[J]. Computer Engineering, 2009,35(22):227-235

[8]Wang Zhang,Ligang Hou, Jinhui Wang etc. Comparison Research between XY and Odd-Even Routing Algorithm of a 2-Dimension3×3Mesh Topology Network-on-Chip[C] .Global Congress on Intelligent Systems. Oakland: IEEE computer society,2009:329-333

[9]Hoi-Jun Yoo,Kangmin Lee,Jun Kyoung Kim. Low-Power NoC for High-Performance SoC Design.[M] . Boca Raton :CRC Press,2008