Bufferless Routing Algorithms: A survey

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Abstract

Network on chip (NoC) reduces the communication delay among processors in a multi core chip. But it consumes more spaces and more power to do this. Hence it was proposed to design NoC without buffers to save the packets. These are called bufferless NoC. Though bufferless NoC consumes less power and area than the conventional NoC the performance is drastically reduced due to deflection routing. Research is being done to improve the performance of bufferless NoC. In this survey, we discuss the available bufferless routing algorithms.

Keywords: Network on chip, Bufferless, Routing algorithms.

Introduction

System on chip (SoC) contains multiple chips to decrease the computation delay. These processors usually have communication among them. The communication is done through bus medium. This bus medium becomes the bottleneck for the whole performance. To reduce this problem the concept of network among processors is introduced [1]. In this all processors are connected to a router and the routers are connected to the routers which are adjacent to them in four cardinal directions as shown in fig. 1. This architecture is called Network on Chip (NoC). These routers are called 5 port routers due to the nature of the availability of at most five ports. When two or more packets from different input ports compete for the same output port a winner is chosen based on some algorithm and is assigned to the port. The other packets should be saved to send in the future or they should be lost or they should be assigned to some other ports. To minimize the path delay saving the packets is preferred. For that the routers have buffers.

It was shown in [2] that the buffers significantly increase the power consumption. To reduce the power consumption by buffers methods such as dynamic buffer [3], centralized buffer [4] are suggested. Though these methods reduce power, they have some buffer and have power consumption due to buffer. When power consumption is the major cost, reduce it by removing buffers completely is necessary. These NoC are called bufferless NoC. Since the packets cannot be saved in the routers, they have to be either discarded or assigned to any one of the free ports in bufferless NoC. The first one is not at all a solution. Invariably the second solution is used in all bufferless NoC. This routing technique is called ‘hot potato routing’ or ‘deflection routing’. This routing leads to a serious problem called ‘live lock’. In live lock the packets are moving in the network but they would not reach the destination. Hence care should be taken to avoid live lock in bufferless NoC. In bufferless NoC many packets are forced to avoid minimal path due to the lack of buffers. Hence the throughput reduces sharply. Bufferless routing algorithms should try to increase the performance. In this survey paper we discuss some bufferless routing algorithms to meet the above two objectives. We consider not only true bufferless algorithms but also some minimal buffer algorithms. In this survey router network with mesh topology has been considered.

Bufferless Routing Algorithms

BLESS: BLESS [5] is the first bufferless NoC. In this one hot-potato routing is used. The packet is injected by local processor only if one or more input links are free. The packets from input link are directed to any one of the output links. They are not saved in routers. The output link(s) which directs the packet towards its destination are called productive link(s). The output links which put the packet away from the required destination are called non-productive links. A packet may have either one or two productive links in a mesh network. A packet may have two or three non productive links in a mesh network. When competition arises for a particular output link, only one packet is assigned to productive link and other packets are assigned to non-productive links.

All packets have a field to record the number of deflections. This field is initialized to zero when the packet is injected to the network. Whenever the packet is assigned to a non-profitable port the count is incremented. The count remains same when profitable link is assigned to the packet. The packet with highest deflection count wins during competition for an output link. The winner is chosen randomly when two or more packets with same deflection count compete. It eliminates the live lock problem.
**Chipper:**

Bit field for deflection count is the main draw back in the BLESS [5] router. It increases the packet size. The deflection count is more than half of the diameter of the network. To increase the data ratio in packets CHIPPER [6] suggests a synchronous algorithmic approach. The deflection count field is removed in CHIPPER [6]. All routers are agreed to consider a packet as “gold packet” for a particular time period. This time period is called “golden epoch”. In a golden epoch only one packet is considered as a gold packet. One golden epoch lasts for the circuit diameter number of clock pulses. The number of clock pulses for a golden epoch is known to all routers. It is equal to the worst case time of delivering a packet to the destination. Hence if a packet is considered as “gold packet” and it is always assigned to the profitable port during a golden epoch, then the delivery of gold packet is guaranteed within one golden epoch. This inspiration is exploited in CHIPPER [6]. All routers synchronously begin and end a golden epoch. In a golden epoch all routers synchronously and independently know the gold packet. For this they use a tuple (source number, packet number). These are initialized to first source number, first packet number in the first golden epoch. Invariably, this will be (0, 0). From the next golden epoch onwards the source number is incremented till all source number are covered. In the next golden epoch the packet number is incremented with the very first source number. Usually now the golden packet will be (0, 1). These iterations will go until the entire communication is over. Since the source number and packet number are available in the header field of all packets, it can be easily identified. Priority is given to this packet. In this strategy all packets becomes golden certainly. So, live lock is eliminated.

**Minimum deflection:**

When two packets compete for the same output link in CHIPPER[6] method, one packet is chosen as winner arbitrarily. Minimum deflection (MD) router [7] chose the one which is going straight instead of deflected router. For example, when north and west links compete for east and south links then west is assigned to the east and north is assigned to the south output link. Similarly if these links are non-profitable for north and west links and have to be deflected then again north is deflected to south and west is deflected to east. Since this ensures least deflection, this algorithm is called minimum deflection. This increases the throughput while keeping the complexity and worst case delivery time as equal as to CHIPPER [6].

**Minimum buffer:**

CHIPPER [6] is slightly modified in this algorithm. All routers have a very small amount of buffers. These buffers are utilized only when the next router is the destination for the incoming flit which has a competition with golden flit. In the conventional CHIPPER [6], this packet has to be deflected which reduces the probability of reaching destination quickly. In this MINBUF [8] method, this and only this packet is saved in the router buffer. Once the golden packet is out of competition, this packet is sent to the destination and is consumed. This technique is in between traditional buffer NoC and bufferless NoC. But due to the nature of a very limited amount of buffer, in this survey the authors consider this very similar to bufferless NoC.

**Simulation Results**

The following figure shows the comparison results of BLESS[5], CHIPPER[6] and MD[7] of three important factors namely throughput, latency and hop count.

**Figure 2(a): Injection rate Vs Throughput**

**Figure 2(b): Injection rate Vs Average Latency**

**Figure 2(c): Injection rate Vs Average hop count**
Throughput gives the number of packets per unit time. Average latency is the time delay between inserting the packet into network and ejected from network. Finally average hop count indicates the average number of nodes crossed by the packet before reaching the destination. Clearly the throughput has to be high and the other two parameters have to be low for an ideal network. Figure (2) results show that MD performance surpass the other two.

Conclusion
In this paper a survey of three important bufferless routers of NoC is presented. A minimum buffer router is also presented. BLESS is the first bufferless router. It has more overhead in packets to avoid live lock. CHIPPER eliminates this overhead considerably. MD reduces the unnecessary deflections in CHIPPER.

References