

Priority based addressing method for the components of on chip communication

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Abstract: In this paper we propose a priority based addressing method for Network-on-Chip applications. This method will facilitate a user to transmit a lesser number of overhead bits while transmitting a message to some other user. The number of overhead bits required will be dependent on the distance (in terms of number of routing nodes or routers) from source IP to destination IP. We also define a channel utility factor and show how the overall utilization of the channel increases with this method.

Keywords: System on Chip (SOC) , Network on Chip (NOC), Virtual Channels, wormhole routing, IP, channel capacity, Table-lookup routing

I. Introduction

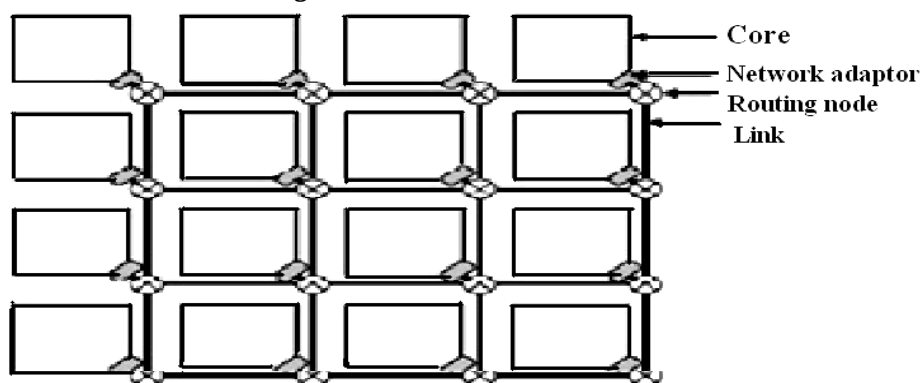
Network on Chip (NOC) is a new paradigm to make the interconnections inside a System on Chip (SOC) system. In traditional solutions interconnections are realized using a bus structure. While integration increases the bus structure does not meet the needs of the new technology. Bus starts to be narrow and in the worst case it begins to block traffic.

In NOC technology the bus structure is replaced with a network which is a lot similar to the Internet. Segments communicate with each other by sending packetized data over this network. Just like a computer network, a NOC network consists of devices that use the network, routers that direct the traffic between devices and wires that connect devices to routers and routers to other routers. In the network design of the NOC the most essential things are a network topology and a routing algorithm.

Fig. 1 shows the pictorial representation of a 4x4 NOC. A Network adapter is an interface between an IP and a router. Routing node represents a router and link is the physical channel for the communication between two routers.

These routers are generally wormhole routers, which employ virtual channels for the flow control. Router route the packets based on the algorithm that they use. Network throughput can be increased by dividing the buffer storage associated with each physical channel into several virtual channels. Authors in proposed a virtual channel flow control mechanism for wormhole routers.

Figure 1: 4*4 NOC



A single wormhole switch (Fig. 2) of mesh topology of Network on Chip (Fig. 1) is implemented in VHDL. In our implementation, we have taken four input and four output physical channels for the neighboring nodes and one output and input channel for the IP connected to the switch. Switch provides the greater bandwidth utilization because of virtual channels [2]. The bandwidth of each physical channel is divided into four virtual channels. Now, suppose two or more

virtual channels want to put their data on the any physical channel, an arbitration policy should be there to resolve the issue of access conflict. In case any conflict occurs due to two or more simultaneous requests for the channel there must be an arbitration scheme to resolve the conflict. These arbitration schemes can be given as:

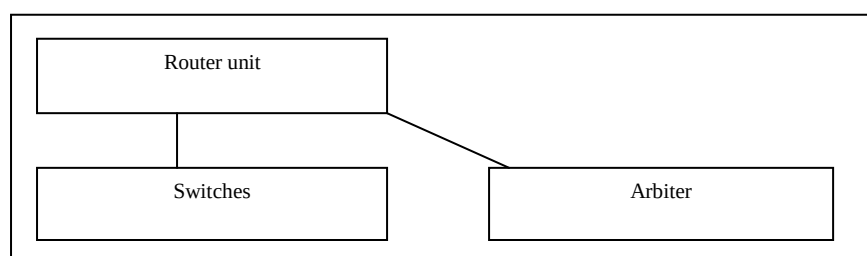
Fixed Priority: In this type of arbitration scheme a level of priorities for each contestant is assigned. A contestant, with higher priority will access the channel every time.

Rotating Priority: After serving the request, priority is changed to lowest.

Round Robin: Each contestant has its own turn to transmit the data. And this turn obeys the circular sequence.

Random arbitration: In random arbitration, grant is provided to a contestant in a random fashion.

Figure 2: Basic Routing Block

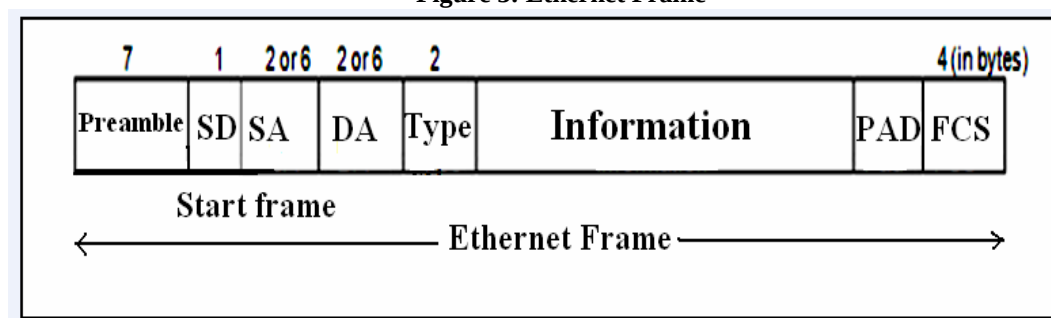


This paper is organized in the following way: section II describes the addressing methods which are being used in computer networks. Section III explores the proposed method for NOC applications and section IV explains channel utility factor and the effect of proposed method on the overall channel utilization. Finally, section V concludes the paper and elaborates the future aspects.

II. Addressing in computer network

Message is transmitted in form of packets or frames over the network link. Each packet, then, individually has to travel over the transmission link following some routing directives. Hence each packet or frame carries routing and addressing information along with the message bits. For Examples, in a LAN an Ethernet packet/frame has the structure given in Fig.2 Being generalized, every packet in computer network (whether it belongs to any set of protocols), belongs to any pair of source and destination some overhead (including SA,DA and other pre-info and post-info bits). Suppose a message of N bits which is broken into p packets. The number of bits in a packet can be given by $N_m = N/p$ bits. When these N_m bits are transmitted over the link some addressing information N_a and overhead N_o must be added to it. This overhead includes the bits for synchronization, SOF (start of frame), EOF (End of frame) and other fields' information in it. Now the packet that has to travel over the link consists of $N_p = N_a + N_o + N_m$ bits. The number of bits N_a and N_o generally remain constant for a given set of rules or protocols. So, every time, when a packet is transmitted it carries some constant overhead additional to information bits.

Figure 3: Ethernet Frame



III. Proposed method

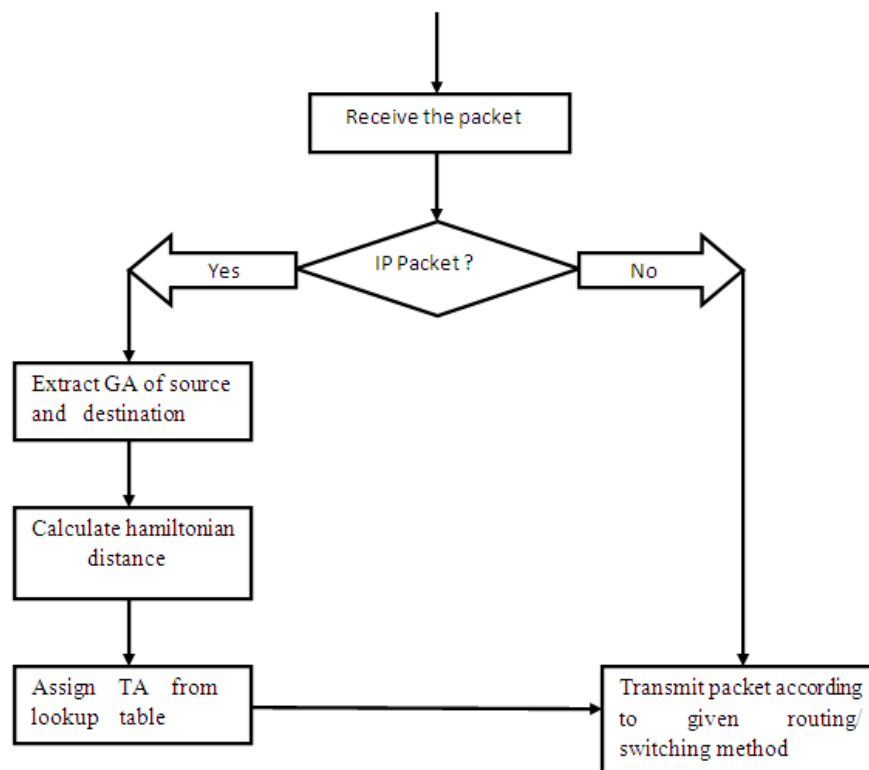
Every IP connected to routers in NOC (mesh topology) is assigned a global address in such a way that the global

addresses of two directly connected IPs must have only single bit difference. It means the number bit changes in the global addresses of two IPs will indicate the distance between them. For a NOC with mesh topology, the number of routers between two IPs situated at d distance to each other can be given by $n = (d+1)$. If b number of bits required to resolve the internal port addresses of a single router, then to address the complete path, travelling address will contain $TA = n \times b = (d+1).b$ bits. same for the possible shortest path exist for the given source destination pair in a mesh topology.

When any IP sends the packet to its router, every packet by IP to its router consists of constant No, global address of source and destination and information. At routing node global addresses of Source and destination are extracted out from the packet and thus the distance and number of routing nodes between the given source and destination can be found out. Now router will assign a travelling address from its look-up table for given source and destination. In case of wormhole routing header flit contain only the travelling address not the source and destination global addresses. Here as the simplest case a flit size is supposed to be equal to a packet size. At destination port destination router will find the global address of the source IP by reversely traversing the travelling address in its look-up table. By doing so, we are transmitting more no. of message information in a packet.

Flow chart in Fig. 4 elaborates the mechanism that takes place at a routing node when a packet from its IP arrives to it. It is clear from Fig.1 that only one IP is directly connected to a routing node (via network adapter).

Fig 4: Flow chart



IV Channel utilization

We define a channel utility factor which measures the amount of true information transferred over the link of capacity C bits/sec.

$$U_{ch} = Nm / Np \quad (1)$$

$$Np = Na + No + Nm \quad (2)$$

$$= 1 - ((d+1).b + No) / Np$$

Where , $0 < U_{ch} < 1$.

$$U_{ch} = [N_p - (N_a + N_o)] / N_p$$

$$U_{ch} = 1 - (N_a + N_o) / N_p \quad (3)$$

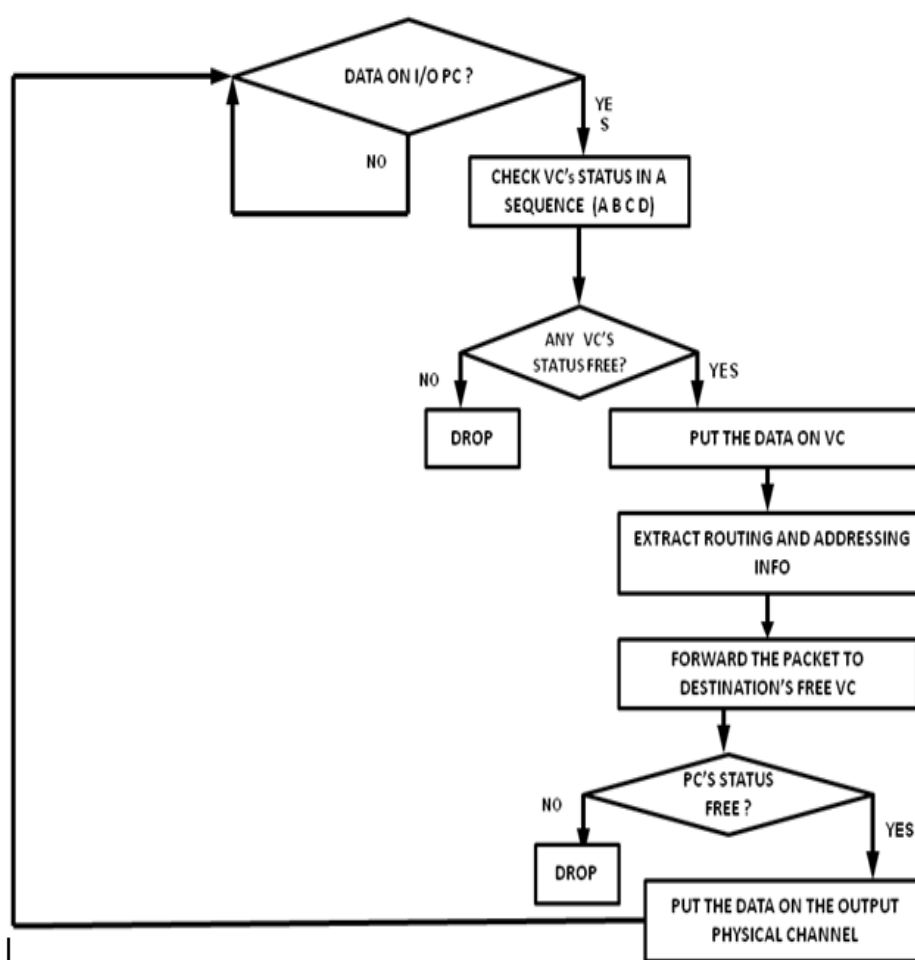
For a fix N_a and N_o , U_{ch} will remain constant. But if N_a is replaced by the travelling address TA .

$$U_{ch} = 1 - (TA + N_o) / N_p \quad (4)$$

Now utilized channel capacity (which indicates flow of true information over the channel of given capacity C

$$C_u = U_{ch} \cdot C \quad (5)$$

Fig. 5: Flow chart



For $N_p = 64$ bits and d ranges 1 to 6 , various curves as Total overhead bits ($N_a + N_o$) Vs distance , Channel utility Factor Vs Distance and No. of Message bits Vs Channel utility Factor are plotted in Fig. 6, Fig.7 and Fig. 8 respectively.

Fig.6: Total Overhead Vs Distance

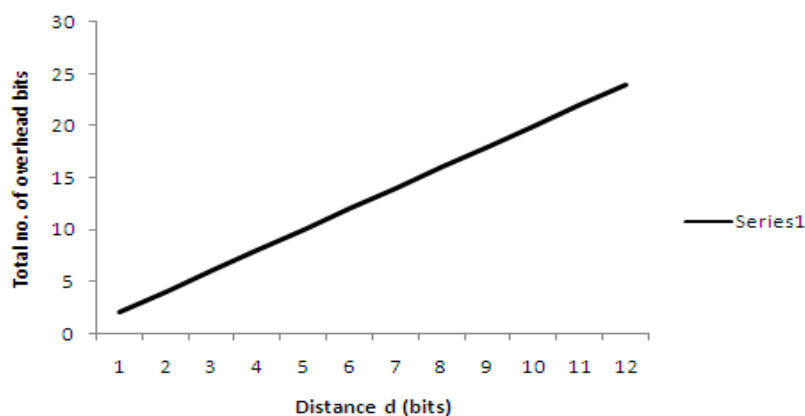


Fig.7: Channel Utility Factor Vs Distance

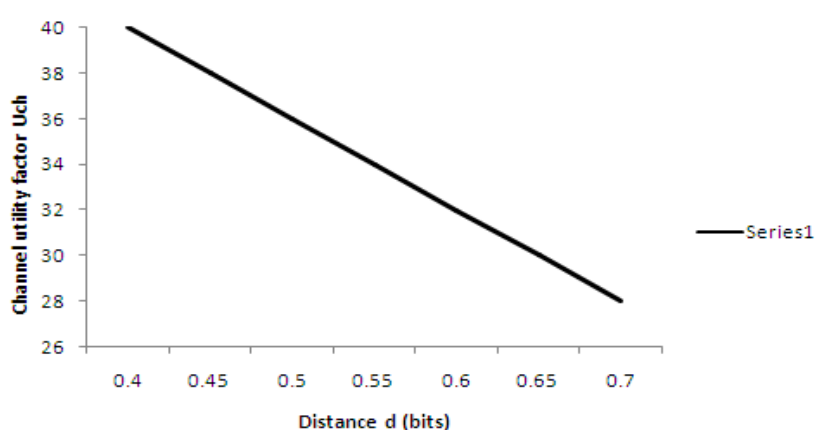
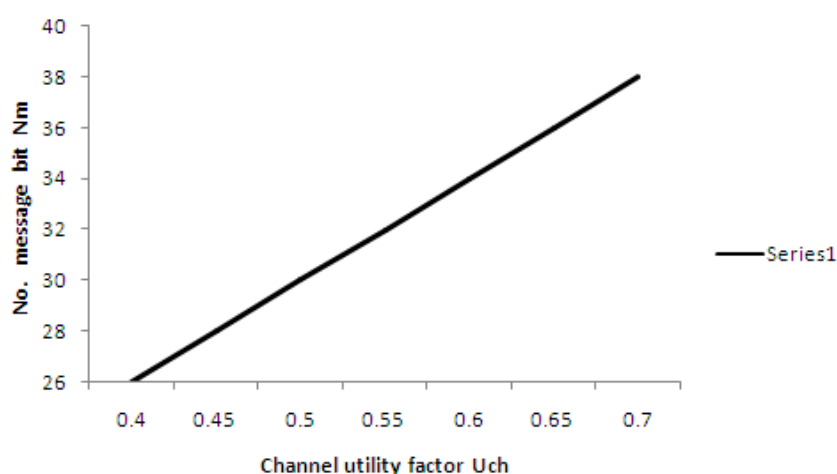


Fig.8: No. of Message bits Vs Channel utility Factor



V Conclusion

Though the obvious requirement for the proposed method is to place a look-up table at each node, and such an implementation is, however, not practical because the size of look-up table places an artificial upper bound on the network size, and the large table is inefficient in the use of chip area, the above method provides better channel utilisation by sending larger number of message bits in a lesser time for the available resources. As this method always provide a shortest path on the basis of bit change in global addresses of source and destinations, an obviously required flexibility can be introduced in the case when there is any congested link appears in

between the assigned travelling path. Furthermore the size of look-up table can be reduced to alleviate larger buffer size and chip area constraints.

VI References

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