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An adaptive congestion-aware routing algorithm based on network load for wireless routers in wireless network-on-chip

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Abstract

Wireless Network-on-Chip (WiNoC) is regarded as one of the promising alternative approaches for sorting out the issues of latency and power consumption in the conventional Network-on-Chip (NoC). Despite the additional bandwidth of wireless channels on a chip, wireless routers (WRs) are prone to congestion in WiNoC due to the limited number of wireless channels on a chip and the shared use of these channels among all the cores. In this paper, an adaptive congestion-aware routing algorithm consistent with traffic load is proposed for solving the congestion problem of WRs. The proposed algorithm selects source-destination pairs with the longest wired hop distance for using wireless channels. The number of selected packets is determined based on the wireless channel bandwidth and the network traffic load. Simulation results show up to 65% latency improvement, 16% wired/wireless link utilization improvement and a saturation throughput increase of approximately 11%.

Keywords:
Wireless Network-on-Chip, Adaptive routing algorithm, Congestion control, On-chip interconnection network, Hybrid NoC

1. Introduction

NoC is considered as a communication infrastructure for many-core architectures [1]. As the number of processors increases and integrated circuits (ICs) become more complicated and, also, due to the multi-hop nature of communications among processing elements (PEs), the conventional NoC deals with problems such as high latency and power consumption. As a result, other approaches such as photonic NoC, RF-I and WiNoC have been introduced to reduce the number of hops in the conventional NoC. Although on-chip photonic interconnection [2] has notable merits such as high throughput and low transmission loss [3], it has several challenges such as manufacturing cost, temperature sensitivity of the photonic components and design complexity [4]. Furthermore, although RF-interconnects (RF-I) [5] can be built using existing techniques such as the complementary metal-oxide semiconductor (CMOS), they require long on-chip transmission lines which lead to routing difficulty and large area overhead [3].

Wireless interconnects can reduce the number of hops among long-distance (LD) PEs; accordingly, they reduce latency and power consumption. Moreover, they provide high-bandwidth communications [6]. Wireless interconnects have unique features such as high energy efficiency for LD communication, reduced complexity in comparison with wave-guides or wired systems and compatibility with wireless CMOS technologies [7]. Thus, using unique features of wireless channels on a chip and through a combination of wired and wireless links, WiNoC provides promising solutions for solving the issues of the conventional NoC. Wireless channels do not completely replace wired communications in WiNoC; rather, they are regarded as a supplement to them [8]. However, since WRs are shared among all PEs, WiNoC is even more prone to congestion than the conventional NoC [9]. This issue can remarkably impact on system performance, especially in non-uniform traffic patterns where some network nodes have to dispatch much more packets than others [1]. In other words, although wireless links result in further useful bandwidth to reduce latency in WiNoC, they are shared among all the cores [10]; hence, they are prone to congestion and the excessive transmission of packets towards WRs leads to the reduction in throughput and high latency. In addition, the number of wireless channels on the chip is limited and efficient use of these valuable resources is essential. Until now, different methods have been proposed to prevent the congestion of WRs. Some of these methods try to sort out the congestion problem by increasing hardware resources of a system such as buffers. Some other methods try to solve this problem by presenting congestion-aware routing algorithms. Those congestion-aware routing algorithms used along with WR placement or application mapping techniques can notably reduce latency in WiNoC.

In this paper, an adaptive congestion-aware routing algorithm is proposed which can control WRs congestion and improve system performance regardless of using WRs placement, application mapping or increasing hardware resources of the system. This method selects a certain number of LD packets with the longest wired hop count at a given time interval and passes them through WRs. The number of packets which can

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