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Adaptive Routing for Recursive Interconnection Networks

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1 Introduction

Parallel computers are one of the torchbearers for computational power. Parallel computers contain processing elements(PEs) and interconnection networks.

Interconnection networks are used to pass massages containing data and synchronization information between the nodes of concurrent computers. The use of adaptive routing in a interconnection networks improves network performance by making use of same available paths and provides fault-tolerance by allowing massages to be routed around failed channels and node.

2 Interconnection Networks and Routing

A massively parallel computer requires interconnection networks with excellent features of a small diameter, a small number of links, expendability and fault-tolerance. Interconnection networks consisting of recursively-structured mesh or torus (Recursive interconnection networks) present a small number of links and a small diameter.

RDT is recursive interconnection networks based on Torus networks, that is proposed by Yang and Amano. RDT has fixed number of links per node and a special quality for communications. Inoguchi and Horiguchi proposed Shifted Recursive Torus (SRT). SRT consists of torus networks, which are shifted recursively. SRT has the advantage of that the number of links a node is fixed and the diameter is relatively small. More, network performance of SRT is the same of RDT. More, routing of recursive interconnection

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networks (Recursive Routing) is near-optimal method. However, recursive routing does not ensure for deadlock-free and dose not has adaptability and fault-tolerance. Dally has proposed a methodology to design static routing algorithm under general assumption. He defines a channel dependency graph and establishes a total order among channels. Routing is restricted to visit channels in decreasing or increasing order to eliminate cycle in the dependency graph. This methodlogy is able to apply for any interconnection networks. Hence, Dolly's method is applicable to recursive interconnection networks. Also, adaptive routing algorithm with deadlock-avoidance or deadlock-recovery techniques have been proposed for some topologies. Usually, adaptive routing algorithm is very effective and outperforming static strategies.

Duato proposed the theorem for deadlock-free adaptive routing with virtual channels. However, this method can not apply to recursive interconnection networks directly. Because, Duato's theorem is in need of deadlock-free routing algorithm. More, in Duato's method, messages has to go along the minimal path on the network. Generally, it is hard to pass through the minimal path in recursive interconnection networks.

Glass and Ni have proposed turn model that is a deadlock-free nonminimal adaptive routing. In turn model, a message is able to change of direction that is obedient to rule for deadlock-avoidance. However, turn model can not apply to 1D recursive interconnection networks. It is a reason that turn model prohibit 180-degree and 0-degree turns. In this paper, we give a method of deadlock-free adaptive routing on 1D and 2D recursive interconnection networks.

3 Adaptive Routing for 1D Recursive Interconnection Networks

In section III, we show that monotonic order routing can be applied to recursive interconnection networks for deadlock-avoidance and propose the same-dimensional detour routingwhich is an deadlock-free adaptive routing on a 1D recursive interconnection networks without additional virtual channels. In proposed theorem, condition that messages can turn of 180-degree which prohibits in turn model is shown. This adaptive routing allows a detour routing on the same dimension that is not allowed in turn model. In short massages forward once over a destination and return to a destination. For that reason a message can select several directions when the next node that recursive routing decide deterministic is congested and faulted. More, the same-dimensional detour routinghas been proved as a deadlock-free adaptive routing and performances are evaluated by computer simulation. As the result of our simulation, the latency of the same-dimensional detour routingis more improved from deterministic recursive routing algorithm. And the latency of the same-dimensional detour routingis smaller than mesh and TESH.

4 Adaptive Routing for 2D Recursive Interconnection Networks

In section IV, we propose dimension reversal routingwhich is deadlock-free adaptive routing algorithm on 2D recursive interconnection networks. We show conditions that messages can forward to direction that oppose dimension order. Dimension reversal routingdoes not have to add several virtual channels as well. Proposed method is able to forward messages different dimension partially, as well as dimension order routing is performed. Consequently, it can exploit higher flexibility than deterministic recursive routing and the same-dimensional detour routingsince it can use direction in the another dimension. Moreover, dimension reversal routingcan perform along with the same-dimensional detour routingand recursive routing. Result it is possible to select above three strategy. It's seen that the proposed dimension reversal routingachieves much better dynamic communication performance than a statistic recursive routing. And the performance of this method is excellent than mesh and almost same to Hypercube.

5 Fault Tolerance

In section V, we addresses fault tore-lance of proposed deadlock-free adaptive routing from two point of views. One point is the at theory. Another side discusses a dynamic communication performance include faulty links or PEs. From the theoretical view point we found that the same-dimensional detour routingand dimension reversal routingthat proposed methods are high flexible in route selection strategy. Degree of freedom in route selection is higher as a network scale is higher. In other words, proposed methods are able to apply massively networks. Recursive routing go down throughput drastically on networks included faulty channels or nodes. However, drastically decline in performance can avoid in proposed adaptive routing. As a result of simulation performance of two proposed routing algorithms are proportional faulty rates of physical channels.

6 Conclusion

The theoretical background for the development of deadlock-free adaptive routing algorithms,the same-dimensional detour routingand dimension reversal routing, has been proposed for recursive interconnection networks. Proposed routing method does not have to add some virtual channels. More over those adaptive routing algorithms has been evaluated by simulation on SRT, represent for recursive interconnection networks. From simulation results, it is shown that our routing algorithm improved the latency. It's seen the deadlock-free adaptive routing of SRT achieves much higher dynamic communication performance than mesh network, and the almost same performance of Hypercube. Then, we analyzed fault tolerance from two view points theory and simulation of network throughput. Result, adaptive routing algorithms have higher fault tolerance than deterministic recursive routing. Finally, it is shown that proposed deadlock-free adaptive routing algorithms for recursive interconnection networks have