Cross-Line — A Globally Adaptive Control Method of Interconnection Network

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Abstract. An ordinal interconnection network is composed of many independent routers that can cooperate as a communication subsystem in a massively parallel system. Many routing algorithms are proposed in the past, however, they do scarcely utilize global network information. In this paper, we propose a new adaptive routing method, Cross-Line, that makes efficient use of global information over the network. The algorithm achieves global routing control efficiently by collecting just one-bit information of each virtual channel in the x- and y-directions. Analytical and simulation results reveal the effectiveness of the algorithm.

1 Introduction

An economical but effective interconnection network is strongly required for massively parallel systems. After a communication message is generated at a source node, it is relayed via multiple routers until its destination. Each router determines the proper direction for the message to go through. Routing function can only be acquired as a result of co-operative work of individual routers.

Many routing algorithms are presented in the past[1,2]. Many of them improve the communication performance, although, no one succeeds in globally optimal routing. This is an essential problem of interconnection networks. Routers are connected to each other by limited number of links. Thus a router can acquire quite localized information by itself and it can perform only locally optimal routing. We can expect performance improvement by introducing globally optimal control mechanisms.

This paper presents a practical and efficient routing method, called Cross-Line[3,4]. The method includes an efficient function for collecting global information of network status and a routing algorithm that uses the collected information. The method can be implemented as a simple extension of the ordinal adaptive routing method. Evaluation results reveal the effectiveness of the proposed method.
2 Basic Design for Global Adaptability

Network performance is extremely degraded in a badly congested situation\cite{1,2}. The source of the problem is a chain reaction of packet blocking. As a blocked packet is stopped at a packet buffer, the filled buffer blocks other packets. Thus the chain reaction spreads over the network. Our essential idea is to prevent chain reactions by introducing a globally optimal routing method. The method should be not only effective but also practical. We discuss the basic method in this section.

Here, we assume 2-dimensional torus networks for simplification. We define congestion as a situation in which packets are blocked among multiple neighboring routers. And we define a congested area as a congested portion of the network. If a router has global information of congestion, the router can properly guide packets in a less congested area.

Our basic idea is illustrated in Figure 1. A packet is routed in $x$- and $y$-directions. A router determines whether the packet should go straight or turn. We use a one-bit information per packet buffer, which represents ready/busy state of the buffer. The bit is transferred to the straight direction and forms a global congestion information. As the one-bit information is equivalent to virtual channel status, we call the collected information VCinfo.

Neighboring router’s status is directly reflected as a flow-control signal in the corresponding output port. The LSB of VCinfo represents the state. A router transfers its own VCinfo to the reverse direction. The neighboring router receives the information and stores it into its own VCinfo after shifting left one bit. A ready/busy signal in the corresponding output port is set to the LSB of the VCinfo. Thus $i$-th bit in VCinfo represents the corresponding buffer status. A router can determine appropriate routing direction by its own VCinfo. For example in Figure 1 curr.node has a packet destined for dst.node. VCinfo in $x+$ direction shows a congested area, while $y+$ VCinfo does not include congested area information. Thus the router can properly select $y+$ direction.