THE SUMMARY OF Ph.D. DISSERTATION

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Title

Routing Techniques in System Area Networks

Abstract

System area network (SAN or server area network), which connects personal computers (PCs) of PC clusters, high-performance storage systems and I/O systems, is one of the crucial components of modern high-performance parallel and distributed systems. SAN is a switch-based network using point-to-point links, and unlike local area network (LAN), virtual cut-through (VCT) or wormhole routing (WH) is used for low latency direct-communication in switching technique. In such networks, a high-performance deadlock-free routing is required. However, unlike interconnection networks used in parallel machines, SAN accepts irregular topologies, and it introduces difficulty on guarantee of connectivity and deadlock-free packet transfer. In traditional systems, spanning tree based routings which use the connectivity and acyclicity of spanning tree are used as practical solutions. However, they have common problems: (1) they must accept non-minimal routes, and (2) they tend to generate unbalanced traffic.

This thesis addresses these problems from various aspects of routing techniques, and aims to develop efficient routing techniques for SAN.

First, ``left-up first turn (L-turn) routings" and ``right-down last turn (R-turn) routings" are proposed for avoiding traffic unbalance. The L-turn routings and the R-turn routings are adaptive algorithms, which can select a route of packet dynamically, and they use a special directed graph. This graph introduces two dimensions and four directions instead of traditional one dimension and two directions. The L-turn routings and the R-turn routings try to set routing restrictions considering traffic balance on this graph. The L-turn routings and the R-turn routings have the advantage of requiring no additional virtual channels, which use a physical channel by time-sharing, and they can be applied to any topology. Results of simulations show that the L-turn routings achieve up to 80% improvement on throughput under using no virtual channels.

Secondly, I focus on output selection functions (OSFs). An adaptive routing, which can select a route of packet dynamically, consists of routing function and selection function. In routing function, an adaptive algorithm provides a set of suitable (deadlock-free) outgoing channels. Then, in selection function, one of outgoing provided channels is selected by the OSF. Thus, the fundamental technique of the OSF as well as that of the adaptive algorithm is needed to improve the performance of adaptive routing. Here, I propose ``load-dependent selection function (LDSF)", ``LRU selection function", and ``minimal multiplexed and least recently used (MMLRU) selection function", which dynamically consider traffic balance. In the three proposed ones, each switch locally grasps the congestion information by the utilization ratio of its own physical and virtual channels. Results of simulations show that the three proposed OSFs are advantageous and achieve stable performance.

Finally, ``descending layers (DL) routing" is proposed for using virtual channels to guarantee deadlock-free and improve the throughput. The DL routing is a deterministic routing, which statically determines a route, and it is based on dividing the network into the layers of similar sub-networks. Through switching sub-networks, the DL routing reduces the path hops, and can consider traffic balance. Results of simulations show that the DL routing decreases the routing hops and achieves up to 266% improvement on throughput under using virtual channels.