SUMMARY OF Ph.D. DISSERTATION

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Title

Adaptive Routings in Irregular Networks

Abstract

Network-based parallel processing using clusters of personal computers (PCs), which are interconnected by system area networks (SANs), has been researched as potential cost-effective parallel-computing environments.

SANs consist of switches connected with point-to-point links, uses wormhole routing (WH) or virtual cut-through switching (VCT) as its switching technique to provide low-latency and high-bandwidth communications like those of interconnection networks in massively parallel computers. Unlike the interconnection networks used in massively parallel computers, SANs usually accept arbitrary topologies so as to provide extensibility and dependability to cope with low-reliability commodity PCs. The interconnection adaptivity, however, makes it difficult to establish paths that are free of deadlocks. A deadlock-free routing algorithm is thus crucial for making efficient use of network resources, yet the current deadlock-free routing algorithms in massively parallel computers with regular topologies cannot be directly employed in most cases. Thus, traditional routing algorithms usually employ connectivity and acyclicity of mapped spanning-tree to ensure deadlock-freedom and connectivity in their target topologies.

Up*/Down* routing is the most popular spanning-tree based deadlock-free adaptive routing algorithm. Up*/Down* routing guarantees deadlock-freedom by using one-dimensional (up/down) turn model approach, and does not require additional hardware such as virtual channels or buffers. However, Up*/Down* routing tends to generates unbalanced traffic because the one-dimensional turn model always generate unbalanced prohibited turns, and thus it leads to poor throughput.

This thesis introduces the systematic approach for designing deadlock-free adaptive routing algorithms called ``left-up first turn (L-turn) routings'' and ``right-down last turn (R-turn) routings''. The L-turn routings and the R-turn routings are based on a two-dimensional turn model to guarantee deadlock-freedom and make the paths as uniformly distributed as possible by selecting well-distributed prohibited turns. The extended two-dimensional directed graph, called H/V graph, provides the extra degree of freedom for the selection of prohibited turns. The L-turn routings and the R-turn routings can be applied to any networks in which Up*/Down* routing is used because they do not require additional hardware. A flit-level interconnection network simulator written in C++ was used for evaluating Up*/Down* routing and the proposed routings by probabilistic simulation model. Results of simulations show that the L-turn routings achieved the highest and up to 80% improvement on throughput. On the other hand, the throughputs of R-turn routings were the lowest. Although the L-turn routings and the R-turn routings achieve almost the same degree of uniformity about the distribution of prohibited turns, there is difference in an approximate tendency in which the traffic is more likely to be distributed. The traffic would be distributed toward the leaf nodes when the L-turn routings are employed, and thus it leads to better traffic balance and throughput. However, the traffic would be distributed toward the root node when the R-turn routings are employed, and thus it leads to unbalanced traffic and poor throughput. Therefore, better throughput results from uniformly distributing the prohibited turns by which the traffic would be more distributed toward the leaf nodes, and the L-turn routings meet this condition.