Abstract

Advances in parallel and distributed computing have made interconnection networks a potential networking alternative to meet growing demands of high-performance computing applications like computer communication networks, aerospace, industrial automation, artificial intelligence, and genetic engineering. These applications require parallel computing facility with multiple processors and memories. Obviously, connecting every processor to all memory modules through direct links is not an efficient solution therefore these are connected through multistage switching technologies.

As crossbars of large sizes are cost prohibitive, multi-stage interconnection networks (MIN) of lesser cost have been developed that can provide similar functioning at lesser cost. Multistage Interconnection Network (MINs) plays a vital role in providing fast and effective communication between high-capacity modules. As the technology is improving, modern systems are becoming large and complex, day-by-day. To accomplish excellent parallel processing, development of more proficient and cost-effective MINs is required. MINs development has been an area of great interest to researchers in the field of computers and communication industry.

Multistage Interconnection Network (MIN) is an interconnection system consisting of multiple interlinked switching elements layers arranged in a predefined topology. It allows processor and memory modules to communicate with each other and has been adopted in many fields, mainly in computer networking, telephone network and multiprocessor environment.

Initially this thesis presents an extensive survey on existing MIN topological aspects based on unexplored taxonomy of MIN performance metrics. Pitfalls and shortcomings are noted.

Keeping in view the shortcomings and the growth of the technological frontiers, there is always a need for the developing reliable, fault tolerant and cost- effective multistage interconnection networks (MINs), which are the critical metrics of any multi-processing system. New MIN designs have been proposed. Their performance is found promising and superior when compared with some of the existing MINs designs.

This thesis proposes new fault tolerant MIN layouts with highly adaptive reliable multipath dynamic routing behavior. These designs can withstand switch failures and provide more redundant paths dynamically to tackle failures, achieving higher fault tolerance and reliability. Proposed MINs provide higher terminal reliability and outperform other MINs; hence these make a good choice for practical interconnection networks.

Complexity of the networks is increasing day by day, which makes these networks prone to more failures. The performance of MINs depends upon the ability of a specified set of nodes being communicable. Therefore reliability computation becomes a necessity for analyzing these networks. Reliability of a MIN is defined as the probability that a MIN will be able to provide the required interconnection for a specified period of time under a given set of operating conditions. This is currently an interesting research area and its impact on ensuring cost effective and reliable communication has attracted researchers to work on reliability design of such networks.

Reliability values are computed in two steps. Initially redundant and disjoint paths for various MIN topologies are traced using existing simple and efficient path-set enumeration method. A path is a set of components (nodes and links) whose functioning ensures functioning network. Then reliability values are computed from these path sets by multiple-variable-inversion sum-of-disjoint product (MVI-SDP) approach. Thus MIN traditional reliability parameters (Two/ broadcast /all terminal reliability) are evaluated in efficient and compact manner.

With increasing number of input and output nodes in supercomputer environment, reliability evaluation of multi-cast nodes is found mandatory. In other words, a network has to transmit a signal or commodity between different pairs of nodes of a network simultaneously. Communication between multiple-sources multiple-destinations is needed to understand network behavior in practical sense where multiple nodes are communicating with each other. This analysis offers several advantages like increased performance, improved reliability and decreased costs through better resource sharing and identification of weak links in that design . Therefore, traditional reliability evaluation is extended to include a new reliability measure, multi- source multi-terminal reliability (MSMT) for MINs.

In short, present work is an attempt in the direction of developing designs of high faults tolerant and reliable MINs. It is hoped that this work serves as a useful tool for MINs reliability evaluation besides providing direction for future research in designing more reliable and fault tolerant MINs.

Keywords: Parallel Computing; Multistage Interconnection Network (MINs); Fault-tolerance; Reliability; Multicasting; Dynamic Routing