



International Conference on Computer Science and Computational Intelligence (ICCSCI 2015)

## Uniform Traffic Patterns using Virtual Cut-Through Flow Control on VMMN

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### Abstract

The previous study of static network performance of a Vertical Midimew connected Mesh Network (VMMN) was shown to be good. However, its dynamic communication performance has not been evaluated yet, we have proposed a deadlock free dimension order routing algorithm using 4 virtual channels. In this paper, The TOPAZ simulator is used to evaluate the dynamic communication performance of a VMMN with virtual cut-through flow control under uniform traffic pattern. We found that the VMMN dynamic communication performance is better than that of the hierarchical TESH network and its counter rival MMN.

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Peer-review under responsibility of organizing committee of the International Conference on Computer Science and Computational Intelligence (ICCSCI 2015)

*Keywords:* TOPAZ Simulator; Virtual Cut Through; VMMN; Uniform Traffic Pattern; Dynamic Communication Performance.

### 1. Introduction

Parallel computers provide computationally efficient techniques for the solution of large and difficult problem in a reasonable time<sup>1</sup>. To resolve the issue of demand for maximizing of computing power in various fields, for example new medicines development, new sources of energy and materials development, disaster mitigation and prevention strategies development, weather forecasting, and Cosmo studies (origins of matter and the universe), we require massively parallel computer (MPC) systems consisting up to millions of node, that meet the voracious

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demand of computing power. In the upcoming years, the world requires MPC with tens of thousands or even millions of nodes<sup>2</sup> to accomplish this high level of performance that computing at the exaflops level. It is expected that the parallel systems of the next decade will contain up to 100 million of nodes<sup>3,4</sup>.

One significant stage of developing such MPC systems is to decide the topology of the network to connect the nodes, because the overall performance is considerably influenced by the topology<sup>5,7</sup>. Hierarchical interconnection network is a conceivable alternative in which several topologies are interconnected together. Among the numerous HINs, there is no ultimate winner in all aspect of performance. Is it possible to find an optimal HIN, which will yield good performance in almost all aspect?

A Tori connected mESHes (TESH) network is a k-ary k-cube based HIN, containing several 2D-MESH networks called basic modules (BMs) that are interconnected hierarchically to form upper level networks using 2D-torus networks<sup>8,9</sup>. However, the main demerit of the proposed TESH network is that it has lower dynamic communication performance (DCP) compare to other conventional networks such as torus network, especially in terms of network throughput. Midimew network has the lowest diameter and average distance among the direct symmetric network of degree 4<sup>10</sup>. With this motivation, the 2D-torus network of the TESH network was replaced by Midimew network and analogous to the TESH network it is called Midimew connected Mesh Network (MMN). The MMN is a HIN constituting of multiple BMs whereby the BM are 2D-mesh network and they are interconnected hierarchically by 2D Midimew fashion<sup>11</sup>. In thrust of optimal static network performance, it was assigned the free links at the contours of the BM in different way. And vertical Midimew connected mesh network (VMMN) yields the best static network performance. In the VMMN, the diagonal links are connected in the vertical direction and the wrap-around links are connected in the horizontal direction<sup>12</sup>.

The evaluation of the performance of the static network of the type of VMMN has been done previously and revealed better performance than that of mesh, torus, and TESH network<sup>12</sup>. However, the performance of dynamic version of the VMMN is not evaluated yet. The main objective of this paper is to study the dynamic communication performance of the VMMN using dimension order routing (DOR) which is deadlock free, under uniform traffic pattern and virtual cut-through flow control. The cycle-accurate modeling of TOPAZ (open source) simulator<sup>13</sup> is used for dynamic communication performance evaluation.

The remainder of the paper is organized as follows. In Section 2, we briefly describe the architecture of the VMMN. Routing of messages is discussed in Section 3. The dynamic communication performance of the VMMN is discussed in Section 4. Finally, in Section 5, we conclude this paper.

## 2. Vertical Midimew Connected Mesh Network

A Vertical Midimew Connected Mesh Network (VMMN) is a derivative of MMN and it results good static network performance<sup>12</sup>. The VMMN is a proposed HIN consisting of several Basic Modules (BM) that are interconnected hierarchically to create a higher level network.

### 2.1. Basic Module (BM)

The basic Module of a VMMN is a 2D-mesh network of size  $(2^m \times 2^m)$ . BM consists of  $2^{2m}$  nodes with  $2^m$  node rows and  $2^m$  node columns, where  $m$  is a greater than or equal zero. Bearing in mind  $m = 2$ , a BM of size  $(4 \times 4)$  is presented in Figure 1. Each BM contains  $2^{(m+2)}$  free ports to connect to higher level interconnection. All ports of the internal nodes are used for intra-BM connections; whereas all free ports of the external nodes, either one or two, are used for inter-BM connections to create higher level networks. In this paper, BM refers to a Level-1 network.

### 2.2. Higher Level Network

The Midimew network connects in two directions horizontal and vertical, one direction use diagonally wrap-around connection and other direction is symmetric tori connection. Consecutively the higher level networks can be built by recursively interconnecting immediately lower level sub networks as a  $(2^m \times 2^m)$  Midimew network. We have assigned the vertical free links of the BM for diagonal wrap-around connection and horizontal free links are

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