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A Linearly Scalable Family of Swapped Networks

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Abstract : A supercomputer can be constructed from identical building blocks which are small parallel processors connected by a network referred to as the local network. The routers have unused ports which are used to interconnect the building blocks. These connections are referred to as the global network. The address space has a global and a local component (g, l). The conventional way to connect the building blocks is to connect (g, l) to (g',l). If there are K blocks, this requires K global ports in each router. If a block is of size M, the result is a machine with KM routers having diameter two. To increase the size of the machine to 2K blocks, each router connects to only half of the other blocks. The result is a larger machine but also one with greater diameter. This is a crude description of how the network of the CRAY XC® is designed. In this paper, a family of interconnection networks using routers with K global and M local ports is defined. Coordinates are (c,d, p) and the global connections are (c,d,p)↔(c',p,d) which swaps p and d. The network is denoted D3(K,M) and is called a Swapped Dragonfly. D3(K,M) has KM2 routers and has diameter three, regardless of the size of K. To produce a network of size KM2 conventionally, diameter would be an increasing function of K. The family of Swapped Dragonflies has other desirable properties: 1) D3(K,M) scales linearly in K and quadratically in M. 2) If L < K, D3(K,M) contains many copies of D3(L,M). 3) If L < M, D3(K,M) contains many copies of D3(K,L). 4) D3(K,M) can perform an all-to-all exchange in KM2+KM time which is only slightly more than the time to do a one-to-all. This paper makes several contributions. It is the first time that a swap has been used to define a linearly scalable family of networks. Structural properties of this new family of networks are thoroughly examined. A synchronizing packet header is introduced. It specifies the path to be followed and it makes it possible to define highly parallel communication algorithm on the network. Among these is an all-to-all exchange in time KM2+KM. To demonstrate the effectiveness of the swap properties of the network of the CRAY XC® and D3(K,16) are compared.

Keywords : all-to-all exchange, CRAY XC®, Dragonfly, interconnection network, packet switching, swapped network, topology
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