Performance Metrics for Communication Mechanisms

Three performance metrics are critical in any communication mechanism:

1. ***Communication bandwidth*** —Ideally the communication bandwidth is limited by processor, memory, and interconnection bandwidths, rather than by some aspect of the communication mechanism. The bisection bandwidth is determined by the interconnection network. The bandwidth in or out of a single node, which is often as important as bisection bandwidth, is affected both by the architecture within the node and by the communication mechanism. How does the communication mechanism affect the communication bandwidth of a node? When communication occurs, resources within the nodes involved in the communication are tied up or occupied, preventing other outgoing or incoming communication. When this occupancy is incurred for each word of a message, it sets an absolute limit on the communication bandwidth. This limit is often lower than what the network or memory system can provide. Occupancy may also have a component that is incurred for each communication event, such as an incoming or outgoing request. In the latter case, the occupancy limits the communication rate, and the impact of the occupancy on overall communication bandwidth depends on the size of the messages.

2. *Communication latency* —Ideally the latency is as low as possible. As communication latency = Sender overhead + Time of flight + Transmission time + Receiver overhead

Time of flight is fixed and transmission time is determined by the interconnection network. The software and hardware overheads in sending and receiving messages are largely determined by the communication mechanism and its implementation. Why is latency crucial? Latency affects both performance and how easy it is to program a multiprocessor. Unless latency is hidden, it directly affects performance either by tying up processor resources or by causing the processor to wait. Overhead and occupancy are closely related, since many forms of overhead also tie up some part of the node, incurring an occupancy cost, which in turn limits bandwidth. Key features of a communication mechanism may directly affect overhead and occupancy. When naming and protection mechanisms are provided by the processor, as in a shared address space, the additional overhead is small. Alternatively, if these mechanisms must be provided by the operating system for each communication, this increases the overhead and occupancy costs of communication, which in turn reduce bandwidth and increase latency.

3. *Communication latency hiding*— How well can the communication mechanism hide latency by overlapping communication with computation or

with other communication? Although measuring this is not as simple as measuring the first two metrics, it is an important characteristic that can be quantified by measuring the running time on multiprocessors with the same communication latency but different support for latency hiding. Although hiding latency is certainly a good idea, it poses an additional burden on the software system and ultimately on the programmer. Furthermore, the amount of latency that can be hidden is application dependent. Thus, it is usually best to reduce latency wherever possible.