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A SIMULATION STUDY OF A MULTI-NODAL COMMUNICATIONS NETWORK WITH CONTENTION

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We consider a communication network in which one set of nodes receive messages which are transmitted to another set of nodes. The simulation attempts to examine the growth of congestion due to conflicts, the impact of contention on several system performance measures and the effects of the contention resolution procedures on these measures.

1. MODEL

We consider a network which consists of a set of origins each of which has a path to one of several destinations. The origins are called sending nodes and the destinations are called receiving nodes. These nodes are further divided into small groups. We assume that the arrival to each sending node form a Bernoulli process whose parameter depends on the group to which the node belongs. When a message arrives at the head of a sending node, its destination is determined by a Routing Probability Matrix, which governs the selection of the receiving group and a receiving node in that group is chosen at random.

The service time of a message depends on the sending and receiving groups and is chosen from the given set of distributions. When the destinations of several sending nodes are chosen, it is likely that they are the same for many of them. Since only one message can be processed by any receiving node at any given time, this gives rise to the phenomenon of contention. The study is an attempt, using the simulation methodology, to identify and interpret the presence of contention, to analyze the influence of the model parameters on the performance of the network and compare the strategies for the resolution of contention. This model is related to the interleaved memory design of multiprocessors and discussions on these designs can be found in Burnett and Coffman(1975) and Chang, Kuck and Lawrie(1977) and the references thereof.

2. THE SIMULATION PROCEDURE

For the simulation procedure,the model parameters which describe the design of the network are initialized outside the main simulation routine. The simulation parameters which control the manner in which the simulation is carried out are supplied during the execution of the main program.

The simulation is carried out by introducing registers or arrays that record the state of the network at each time point. These registers must be few in number and at the same time should be capable of capturing the dynamics of the network. Moreover, these registers must also facilitate data collection for the purposes of analyses.

There are three main registers that provide a complete description of the state of the nodes of the network. These are the activity register, the queue length register and the register of residual service time. At each time point, the updating routine is called to update the counters. To generate the variates from the given discrete distributions, the alias method is utilized and

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while generating the variates from the service time distribution, the special structure of such distribution is used to evolve efficient algorithms.

The crux of the simulation procedure is the updating routine. It is called at each time point. The updating procedure is quite involved and details of it are given in Kumar(1983).

It is reasonable to require that the expected quanta of work that comes into each receiving node from all the sending nodes be less than the amount of work that can be performed by that node at a given time point, which is one unit. We call this expected quanta of work load the utilization factor and we require this factor to be less than one. The utilization factor is the same for all the nodes in a given group and can easily be calculated using the model parameters.

3 THE ANALYSIS

The basic parameters that we are interested in are the average number of busy channels, average number of idle channels, average queue length, the number of messages completed by each sending node and the proportion of time spent by each sending node contending for service and transmitting messages.

We use the batch means method to estimate these parameters (Law 1982) and more significantly use the graphical output to identify and interpret the nature of contention, the influence of various model parameters on contention and the effectiveness of the contention resolution procedures. Several procedures can be adopted to resolve conflicts. The sending nodes may be chosen at random from the group of contending nodes or the decision may be based on other characteristics such as the contention time, the number of messages completed, queue length, average message length, and the likelihood of being followed by another message which has the smallest chance of requesting the same receiving node. In the examples, we compare the first three procedures. The analysis indicate that these methods affect the system performance in different ways and hence the actual design of a resolution strategy depends on its effectiveness as well as the network objective and the relative ease with which the corresponding hardware can be included in the system.

It is shown that even for the networks in which the receiving nodes are not saturated with requests, contention forces a substantial number of sending nodes to become blocked. The dependence of the distribution of workload among the sending nodes and the total amount of work completed during the simulation run on the contention resolution procedure is brought out in the analysis.

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