C. INFORMATION FLOW IN LARGE COMMUNICATION NETS

The purpose of this investigation is to consider the problems associated with information flow in large communication nets. The nets considered consist of nodes that receive, sort, store, and transmit messages entering and leaving by way of the links (one-way channels that connect the nodes together).

Very little effort has been devoted to these problems in published works, although there is a clear practical need for an understanding of these nets. Jackson (1) has considered a class of related problems dealing with a system of departments in which messages travel between the departments according to a probability measure assigned to each link (including sources and sinks). His results show that it is possible to break the system down into independent elementary departments.

In the present investigation, a number of results have been obtained for systems that are similar to Jackson's, but altered enough to represent a communication net. In particular, it can be shown that it is not possible, in general, to assign an arbitrary probability measure on the use of the channels (as Jackson assumed for his departments), although a fair approximation to this situation can be developed. Moreover, there has been added, as a constraint on the communication net, the necessity for a message to leave the system upon delivery at its final destination (a constraint not included by Jackson). With this additional constraint, it has been shown that for one class of systems investigated, the solution takes on a form that is almost identical to Jackson's, and insures the independence of the nodes.

It has also been shown that for a general class of systems, all traffic leaving nodes in the net is Poisson in nature (that is, the inter-departure times of messages are independent, and obey an exponential distribution).

Another general result involves the definition of p, the utilization factor, of a one-input, N-output node, where the input traffic is Poisson, with mean rate λ, the message lengths are exponentially distributed with mean length $1/\mu$, and the routing and queueing discipline is completely arbitrary. The capacity assigned to each output channel is arbitrary, subject to the condition that the total capacity on all channels must sum to C.

Let

P_n = Pr [n messages in a node in the steady state]

$\overline{C_n}$ = Expected value of the unused capacity, given n messages in the node,

$p = \lambda/\mu C$ = utilization factor (a common definition)

Then, it can be shown that

$$p = 1 - \sum_{n=0}^{\infty} (\overline{C_n}/C)P_n$$

provided that the steady state is achieved.

L. Kleinrock

References

1. J. R. Jackson, Networks of waiting lines, Operations Res. 5, 518 (1957).