Simulation and Modelling of Communication Systems

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Abstract

Modern communication systems are very reliable due to advances in computer and telecommunications systems. The loss (and error) rate is usually in the region of 10^{-6} to 10^{-10} (one loss/error per million to one loss/error per ten billion). To simulate the communication system so that a few errors would occur, requires days or weeks of computer time.

This concise paper looks at methods of simulating the communication systems without very prolonged simulation runs. It discusses how simulation can be speed-up artificially and discusses how the results could be adjusted for this artificial change.

Introduction

The operation of communication networks are usually investigated using simulation techniques which, unlike analytical methods, use less assumptions and behave more like real systems. The direct stochastic simulation technique can be used to analyse networks with the loss probabilities higher than 10^{-5}. The required loss probability in modern networks (such as ATM networks) is very low, in the order of 10^{-6} to 10^{-10}, depending on the type of service. It would be very costly and would take a long time to use the direct stochastic simulation method for such applications. One can expect that the number of observations needed is at least ten times the inverse of the probability of loss/error in order to obtain results with reasonable confidence (Frost, 1994). This means that at least 10^{7} to 10^{11} statistically independent observations must be simulated in order to obtain a reliable estimate of the required probability of loss/error.

However, we can use a much smaller sample size and still get the result we require by using Rare Event Simulation techniques. These methods have been used previously for buffer dimensioning, calculating the low bit error rate (BER) of communication networks, MTBF (mean time between failure) of some equipments with very low failure rate, in radar systems, and in simulation of multihop links in digital satellites [Hahn, 1987].

Principles of RARE EVENT SIMULATINS

The general idea behind *rare event simulation* is to make the rare event under investigation occur more frequently (Kleijnen, 1975). That is to say, instead of simulating system S we simulate another system S* such that Event A* is more frequent in S* than event A in S. There is a connection between P(A) and P*(A*) where P*(A*) is the probability of event A* in system S*. To make the rare event simulation easier to understand, lets look at a M/M/K queuing system. If arrival rate is less than service rate, the queue does not fill up to get a loss. For M/M/K queue the best solution is to change arrival and service rate, so that it leads quickly to the required buffer overflow. If we increase the load (r=l/m) from r to r* so that r < r* , the queue gets full over and over again without getting emptied over a long period of time.

The result needs to be adjusted for this change by the same load adjustment factor to get the correct simulation results (Devetsikiotis, 1993). The detailed discussion is beyond a concise paper and the reader is to contact the write or the references for more information.

Conclusion

Modern networks have very low error/loss rates. To simulate the events that do rarely occur in communications systems, we could simulate a new system that the event occurs more often. The results need to be adjusted to cater for this change.

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