Dynamics of Continuous, Discrete and Impulsive Systems
Series **B:** *Applications & Algorithms* **9 (2002)** 507-524

DYNAMIC MODELS FOR COMPUTER COMMUNICATION NETWOKS AND THEIR MATHEMATICAL ANALYSIS

N.U.Ahmed[1] and K.L.Teo[2]

[1]School of Information Technology and Engineering
and Department of Mathematics, University of Ottawa, Ottawa,Canada
[2]Department of Applied Mathematics, Polytechnic University of Hong Kong, Hong Kong

Abstract. In this paper we develop several continuous time dynamic models for computer communication net works. This is based on the token bucket control mechanism: a traffic shaping mechanism used at the network access point. The first set of models is based on the assumption that there is no buffer used before the traffic is processed by the token bucket. The second second set of models allow buffering. Here there are two types: buffers followed by token buckets and buffers preceded by token buckets. The third set of models include priorities. Incoming traffic is split into two streams one with high priority and one lower priority. The mathematical model turns out to be a system of nonlinear differential equations with discontinuous right hand side. We model this as differential inclusions and prove the existence of solutions and viability of the admissible domain of operation. This is a class of nonstandard systems. We prove the existence and regularity properties of solutions for these systems and discuss control and optimization.
Keywords. Mathematical Models, Computer Communication Network, Token Buckets, Buffers, Multiplexor, Channel Capacity. Differential Inclusions, Invariance.
AMS (MOS) subject classification: 34A36,34A60,49J24,93C10.

1 Introduction

The global computer communication network is a large scale system. Here every media (voice, video, data) is packetized by the user's system before it is transmitted to the local node which serves multiple users from the (geographical) area. In addition to carrying user data, the packets are furnished with headers (or additional bits) indicating the points of their origin and destination. The function of the node is to regulate the flow of the incoming packets before they are launched into the outgoing channel which has always finite bandwidth or capacity. This channel is linked with the global network. The node regulates the flow by use of token bucket algorithm which is designed to accept a packet only if it has a token (or a number of tokens for each packet) and reject otherwise. The accepted packets from all the users are queued up in the buffer of the multiplexor according to the order of their arrival (first come first served basis) depending on the availability of space. If