Buffer Management in Cellular IP Networks Using Evolutionary Algorithms

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ABSTRACT

Real-time traffic in Cellular IP network is considered to be important and therefore given priority over non-real-time. Buffer is an important but scarce resource and to optimize Quality of Service by managing buffers of the network is an important and complex problem. Evolutionary Algorithms are quite useful in solving such complex optimization problems, and in this regard, a two-tier model for buffer, Gateway and Base Station, management in Cellular IP network has been proposed. The first tier applies a prioritization algorithm for prioritizing real-time packets in the buffer of the gateway with a specified threshold. Packets which couldn’t be served, after the threshold, is given to the nearest cells of the network to be dealt with in the second tier, where Evolutionary Algorithm (EA) based procedures are applied in order to optimally store these packets in the buffer of the base stations. Experiments have been conducted to observe the performance of the proposed models and a comparative study of the models, GA based and PSO based, has been carried out to depict the advantage and disadvantage of the proposed models.

Keywords: Buffer Management, Dropped Packets, Genetic Algorithm, Particle Swarm Optimization, Prioritization, Quality of Service (QoS)

INTRODUCTION

Cellular IP protocol is a solution for mobility management at micro level. Being designed for micro level of mobility, Cellular IP supports frequently moving mobile hosts. It can also efficiently serve rarely moving or even stationary mobile hosts. A Cellular IP network consists of interconnected nodes. These nodes accomplice the tasks to route IP packets inside the Cellular IP network and also communicate with the mobile hosts via wireless interface. Components of Cellular IP network are Cellular IP Base Station which controls and is responsible for the nodes in a cell, Cellular IP Gateway that connects Cellular IP network to Internet and stores the packets intended to be sent through Internet in its buffer, and the Cellular IP Mobile Node which implements the Cellular IP protocol (Valkó, Gomez, Kim, & Campabell, 1999). Many operations such as routing, paging, and handoff etc. take place in Cellular IP network. Quality of Service (QoS)
in Cellular IP network depends on number of factors and is insured according to the availability of the resources in the network. Buffer, an important resource should be managed and utilized in an effective manner to achieve better performance in the Cellular IP network.

In wireless communications packets are prone to be dropped, lost, or delayed which results in connection disturbance. Buffer space is a resource which is often in short supply and if handled properly may improve the performance of the network drastically. For the real-time and non real-time traffic there should be good schemes for buffer management that guarantee least packets drop/loss. Also the schemes for buffer management, especially in Cellular IP networks, must be as robust as possible that produce good results in terms of QoS.

In Cellular IP networks, when a packet is sent from a base station to the Gateway connecting the network with Internet, it will be queued for onward transmission to the corresponding node (network). If there is no available buffer space to put the packet in, the packet has to be discarded. To offer good quality of service, buffers can be reserved for real-time flow of packets so that this flow doesn’t have to compete for buffers with other flows. In Cellular IP networks, due to data packet buffering at the air interface of the Gateway, the end-to-end bottleneck is a potential problem. Therefore buffer management is essential to support end-to-end QoS provision. Buffer reservation or buffer management must be done by giving the priority to real-time traffic over non real-time traffic and improve the QoS in the network. QoS can be achieved by increasing the Connection Completion Probability (CCP).

Evolutionary Algorithms (EAs) are often used to solve optimization problems that have no straightforward solutions. EAs maintain a population of structures (usually randomly generated initially) that evolves according to the rules of selection, cross-over, mutation etc. All individuals are evaluated against a fitness function. The fittest individuals are likely to be selected to generate new population in the next generation (Jain, Palade, & Srinivasan, 2007).

Buffer management is an important issue to improve QoS in wireless networks especially in Cellular IP networks. With the increase in the number of flows this problem has become a complex one and involves a big search space. EAs can be applied successfully to solve this problem.

A two tier model is being proposed, in this work, for the buffer management. In the first tier, the real-time packets are prioritized and arranged in the front portion of the Gateway buffer. The packets are served from the front of the buffer till a specified threshold. Rest of the packets will be transferred back to the Cellular IP network rather than being dropped. In the second tier of the model, the returned packets are stored in the buffer of the network and for that an EA based procedure is applied in order to find a good solution. The model applies both GA and PSO based procedure in the second tier to observe the performance benefit of the buffer management with both the procedures. Eventually, the packets will be transferred to the Gateway buffer with higher priority. Most of the returned packets to the swarm (considered here as a group of cells) are normally (most probably) the non real-time packets. It is so because the real-time packets are given more priority for their service by putting them in the front of the buffer. Often the non real-time packets, considered less important, are further treated rather than discarding them straightforward. This is an important difference from few other similar models in which packets related to a non real-time application may be discarded that eventually may result in the application termination and disturbance in the service. Treatment of these packets will save the application though it may be delayed, thus make the system more reliable.

The rest of the paper is organized presenting models that have been described, and both the EAs used in the model PSO and GA are explained. Next, insight of buffers in Cellular IP networks are given while elaborating on the proposed model. The results along with the comparative study will be mentioned, followed by observations and a conclusion.
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