

A New Token Allocation Algorithm for TCP Traffic in Diffserv Network

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Abstract

A new algorithm has been designed for providing optimal allocation of tokens for TCP traffic in DiffServ networks, which is aimed at minimizing the packet losses of the individual flows. The optimality in token allocation is achieved using optimization technique employing Genetic Algorithm (GA). The transient performance of the proposed algorithm has been evaluated through Matlab simulation. It has been observed from the simulation studies that the token allocations vary with respect to the incoming rate of the flows. A TCP friendly three color marker has also been proposed to minimize the spacing between the subsequent “IN” and “OUT” packets. The formulation of the objective function and the application of GA for the optimization process have been explained. The simulation results pertaining to the token allocation for two different cases are furnished.

Keywords: Optimization, Genetic Algorithm, Token Allocation, Packet Marking, DiffServ networks.

I. Introduction

The Differentiated Services (DiffServ) architecture has been proposed as a scalable solution for providing service differentiation among flows without any per-flow buffer management inside the core of the network [1]. The building blocks of the assured

service include a traffic marker that marks packets as “IN” and “OUT” depending upon the service level agreement (SLA) at the edge of the domain and an active queue management technique such as RIO (RED with IN / OUT) in the network interior [2],[3].

Previous works on markers provide good per-flow marking but do not consider fair token distribution between individual flows of the aggregate incoming traffic [4],[5]. The service goals promised by the DiffServ network are not likely to be achieved in many situations due to the TCP congestion control algorithm, which was developed for the best effort service and has no knowledge about the priorities of packets [6] - [8].

Ibanez et al. have used a token bucket marker for assured service and showed that it resulted in TCP not realizing the minimum assured service [9].

Feroz et al. have proposed a TCP friendly marker to minimize the spacing between the subsequent ‘IN’ packets to overcome the bursty nature of the traffic, which is the main cause for the packet losses in TCP. However, there is no fairness in allocation of tokens to short-lived TCP flows [10].

Renjish Kumar et al. have proposed two markers namely the Memory-based two

color marker and Memory- based three color marker for TCP friendly traffic based on the rate estimator [11]. The bursty nature is resolved by means of probabilistic marking. However, this marker is TSW-TC based.

II. Proposed Work

In the present paper, a novel technique is proposed to distribute the tokens optimally among the TCP flows employing TB-TC using genetic algorithm. A three colour packet marking algorithm is also presented. The proposed algorithm aims at optimal allocation of tokens to small window flows as well as for others based on the availability of the tokens. Hence a multi-objective function is required to be formulated for the optimization process.

The main feature of the proposed marker is to optimally allocate the available tokens such that flows of higher sending rate get more tokens than those of lower sending rate to minimize the packet losses of the individual flows. This requirement is met by using a weighting factor in formulating the objective function which is evaluated by an optimization process using GA. The output of the optimization process results in a token allocation vector X and the default spacing vector O of size 'f', where 'f' corresponds to the fraction of the total flows.

The objective function for the proposed work is formulated as:

$$\text{Minimize } F(x) = \sum_{i=1}^f w_i (p_i - x_i) \quad (1)$$

subject to the following constraints :

i) The total tokens allocated to 'f' flows should not exceed the available tokens. This requirement is met by the constraint g1 as follows:

$$g1 = \sum_{i=1}^f x_i \leq Tk$$

ii) The tokens allocated to any individual flow 'i', should not exceed their estimated sending rate in order to avoid wastage of tokens and at the same time not less than zero(negative value is not possible). This constraint g2 is enforced by the upper and the lower limits of the design parameter as

$$g2 = 0 \leq x_i \leq p_i$$

where

p_i = estimate of the number of packets corresponding to flow 'i'

x_i = number of tokens allocated to flow 'i'

n = total number of flows

f = number of small window flows or the remaining (i.e. it is a fraction of n)

Tk = number of tokens expressed as packets

w_i = weight factor for flow 'i', which is expressed as the fraction of the estimated packets of flow 'i' to the total estimated packets of 'f' flows

i.e.

$$w_i = \frac{p_i}{\sum_{i=1}^f p_i} \quad (2)$$

Token Allocation Algorithm

Step I: Identifying the flows and finding the total of the estimated packets

For each flow 'i',

if ($E_i < k$) then /*Increment Small windows and find the total of them */

Sw ++; find Σp_i ; $\forall i$ corresponding to Sw
/*Increment remaining flows and find the total of them */

else R ++; find Σp_i ; $\forall i$ corresponding to R

Step II : Distribution of the tokens among the flows

i) **If** ($Tk < \sum P_i ; \forall i$ of Sw) /* If no tokens left after protecting Sw flows */

▪ **For small window flows**

Divide Tk among the Sw flows optimally

$$F(X) = \sum_{i=1}^{Sw} w_i(P_i - x_i)$$

/* The vector X is obtained for Sw flows using GA */

subject to the constraints

$$O_i = [p_i/x_i] - 1;$$

▪ **For all other flows**

$$x_i = 0$$

ii) **Else if** ($Tk \geq \sum p_i ; \forall i$ of Sw)

/* To protect small window flows all the tokens are assigned to SW flows */

▪ **For small window flows**

All packets are assigned tokens

$$x_i = p_i$$

$$O_i = 0$$

▪ **For all other flows**

/* If tokens are left after protecting Sw flows */

Divide the remaining tokens among the other flows optimally

$$F(x) = \sum_{i=1}^R w_i(p_i - x_i)$$

/* The vector X is obtained for other flows using GA */

subject to the constraints

$$O_i = [p_i/x_i] - 1$$

/* The spacing vector O is obtained for other flow */

It is to be noted that the allocation of tokens is done once in every T seconds. Thus by the above algorithm, the token allocation vector X and the packet interleaving vector O (i.e. default spacing) for all the 'n' flows

are obtained. The packets are marked based on the vectors X and O. In the marking interval of T secs., the spacing is updated dynamically depending on the incoming rate. The marking algorithm proposed is aimed at providing three different levels of marking, namely green, yellow and red as explained in the packet marking algorithm furnished below.

Packet marking Algorithm

count_i = count of number of packets of flow 'i'

i) Save the spacing variable for each flow 'i' in a temporary variable.

$$Ds_i = O_i$$

ii) For every packet that comes in, identify its flow 'i'.

iii) For flow 'i', check if "IN" tokens are available

i.e. if ($x_i > 0$)

iv) If true then mark as follows :

if (count_i ≥ O_i) /*packet count is larger than the spacing*/

mark as "green"

$$O_i = (Ds_i - (count_i - O_i))$$

Reset count_i

decrement x_i

else

if ((count_i < O_i) and (count_i ≥ Ds_i))

mark as "yellow "

Reset count_i

else

Mark as "red "

v). Else Mark as "red"

III. Optimization using GA

The lower and the upper limits of the allocation vector X corresponding to the individual flows 'i' are initialized to 0 and p_i respectively. Starting from the specification of the population size, number of generations, cross-over and mutation probability, the optimization process is initiated. In general, GA maximizes the given function whereas in the present case,

the aim is to minimize the objective function (eqn.1). So, the function is written as $fitval = 1 / (1 + objval)$, where $objval$ is the objective function value and $fitval$ is the fitness function value. The detailed steps for obtaining the convergence of the objective

function are shown in flow chart of Fig. 1. As a result of this optimization, the token allocation and the default spacing for all the 'f' flows are obtained in a vector X and O respectively.

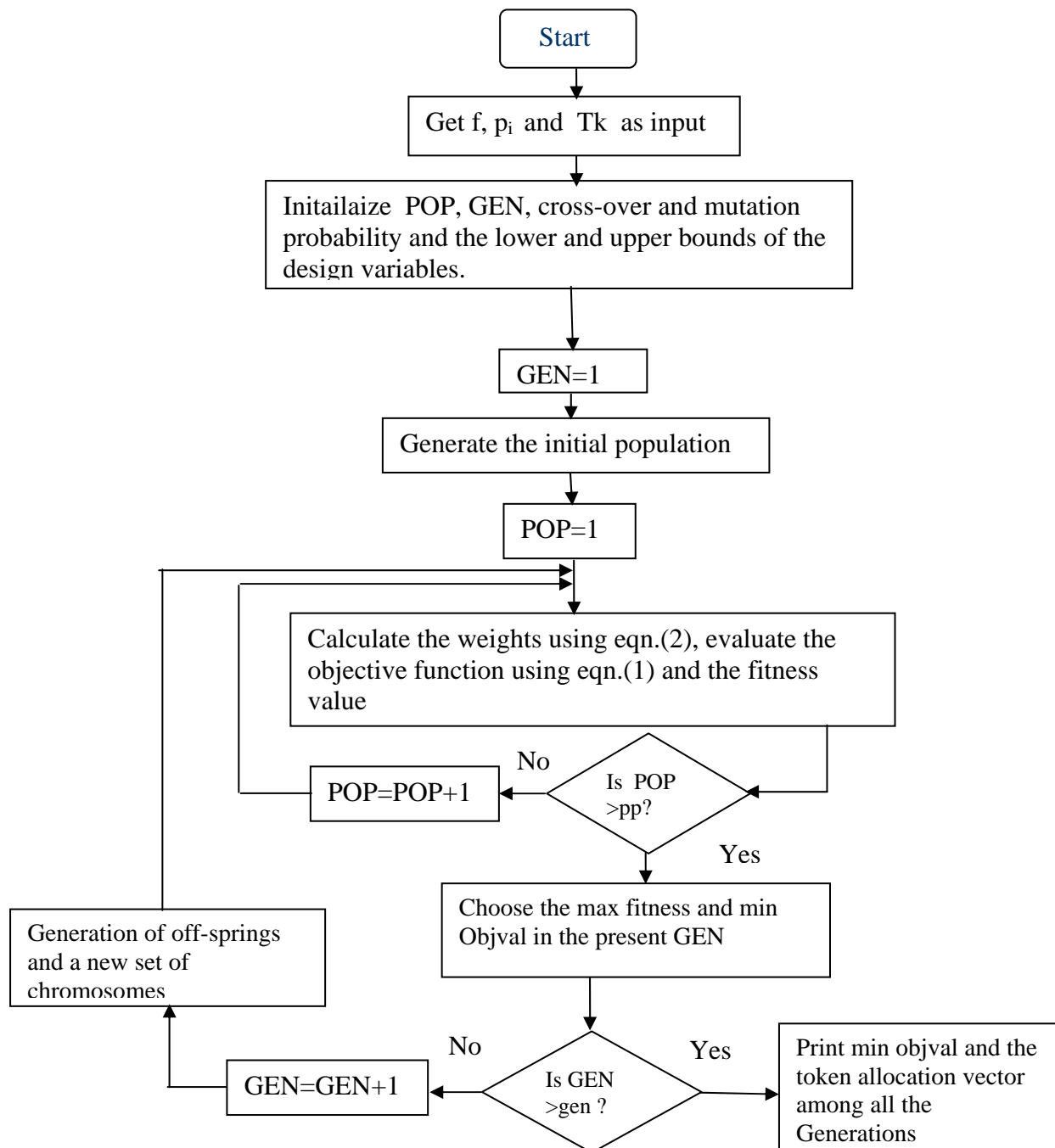


Fig. 1 Flowchart for the optimization process.
 GEN : generation count POP : population count

IV. Simulation Results

The following values have been chosen for simulation in the optimization process:

Number of generations, $gen = 50$; population size, $pp = 30$; mutation probability = 0.002; cross-over probability = 0.96

The simulation was carried out for 10 flows of which the first five were assumed as small window flows. The estimation of the number of packets corresponding to each flow 'i' was generated randomly. The random generator follows a uniform distribution in the range [0, 1]. To have the effect of a real network, the estimates were scaled up to higher values. The simulations have been carried out for two cases namely i) when the network load is high and ii) when the network load is low. In the first case, the small window flows are protected by optimally allocating the available tokens only to them. In the second case, after protecting small window flows, the remaining tokens are optimally allocated to

the other flows. The number of tokens was suitably initialized in both the cases.

The simulation scenario considers the network topology shown in Fig. 2 where there is a bottleneck link. The results of the simulation are plotted in the form of graphs shown in Fig. 3. The token allocation of the individual flows by the proposed algorithm is compared with that of the TCP friendly marker suggested by [10]. From the plots, it is observed that the token allocation varies with the estimation of the number of packets, thus providing an optimal allocation of tokens.

The suggested packet marking algorithm minimizes the spacing between the two subsequent 'IN' (green) as well as "OUT" packets. The OUT packets are further categorized as yellow and red which will be treated differently in the network interior. The colors green, yellow and red represent drop precedences 0, 1, 2 respectively of a single AF class.

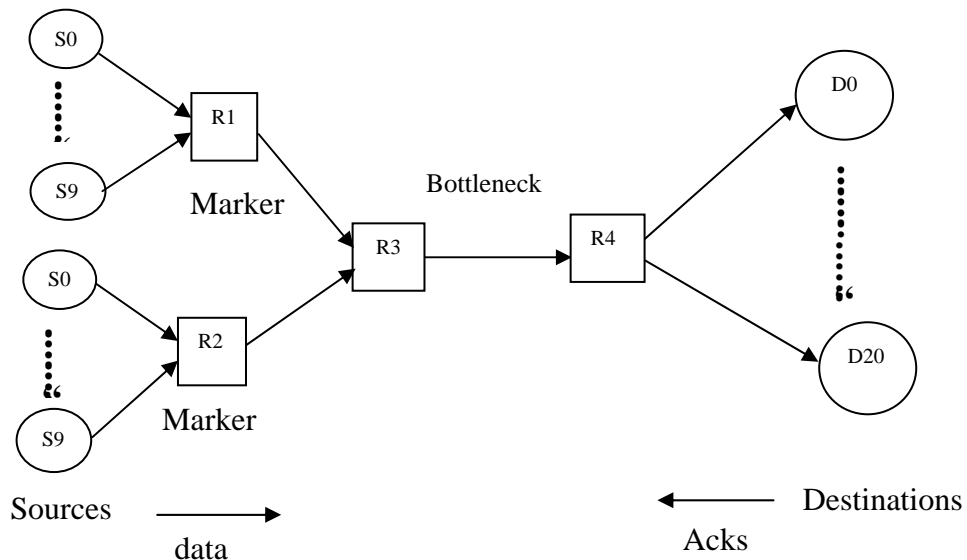
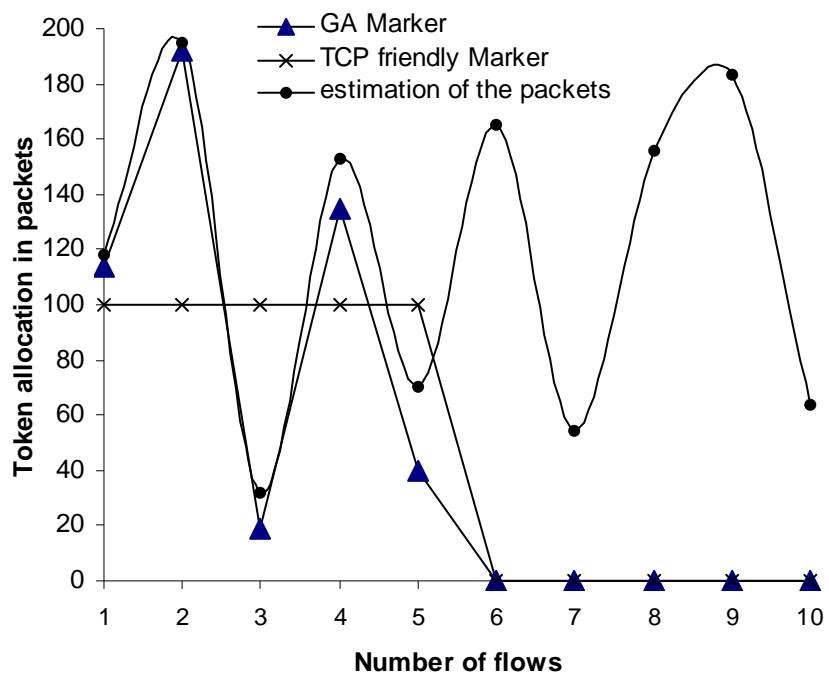
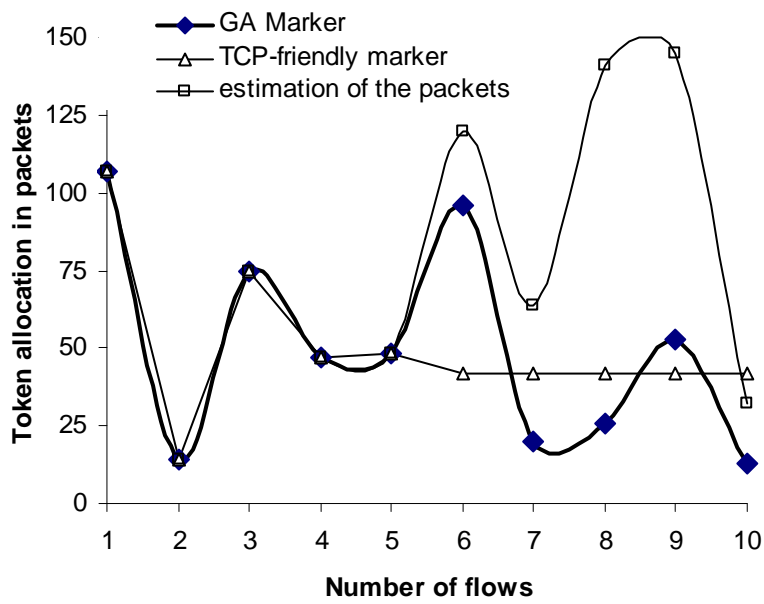


Fig. 2 Network topology



(a)



(b)

Fig. 3 Variation of token allocation with flows ($n=10$, $Sw=5$, $R=5$)
 (a) when network load is high
 (b) when network load is low

V. Conclusions and Future Work

In this paper, a new algorithm has been proposed for token allocation in a Diffserv network. The token allocation algorithm suggested provides an *optimal distribution* of tokens to the flows, when the network load is high or low. A judicious formulation of objective function combined with GA technique for optimization has resulted in an optimal token allocation vector for both small window flows and other flows. Further, a packet marking algorithm has also been proposed which marks the packets as green, yellow or red in order to minimize the spacing between the subsequent IN and OUT packets of these flows. It is expected that the packet losses may reduce by this algorithm and hence better performance can be achieved in terms of timeouts, goodput etc. However, this has to be substantiated by simulating it in NS-2.

As a further work, it is aimed to evaluate the proposed TCP friendly marker through simulations on NS-2 (Network Simulator).

VI. References

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