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Routing and Control of Congestion in Telecommunication Networks

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Abstract

A telecommunication network is composed of a set auto-switches and of a router which are connected by telecommunication circuits which ensure the network transmission function. We will first study the problem that all networks, whether of telecommunication or not, are confronted with. This problem is the congestion. Secondly, we will treat another problem that the solution can help us to solve the problem of congestion. This problem is called routing. To clarify our problematic, we suppose that we have a well-defined connection, so :

– What can we offer as solution to congestion problem in the network ?
– Which routing technique one should use to optimize information transmission ?
– What are performances of studied system ?

Key words : Telecommunication network, congestion, routing, performances.

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The routing problem is defined to be the responsibility of deciding on which output line a packet should be redirected. Once the route is defined many routing processes are proposed, the best process is the one which gives : simplicity, robustness and accuracy. The congestion is defined as a traffic jam observed at a node of the network, as a result of a burst of information packets arrivals.

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To solve these two problems, we will start by defining a variant of the congestion problem. This variant is defined by a basic principle which consists in placing a breakthrough bucket ahead of every emission source. The breakthrough bucket can be represented by a queue with a limited capacity, and which functions according to a FIFO (First In, First Out) discipline. When the source emits information packets randomly, the role of the breakthrough bucket consists in regulating the burst arrival flow, and let it pass with a constant rate. This method presents a drawback, which is that the breakthrough bucket can not allow a constant service rate to pass if it is greater than the one given by queue capacity. To face this problem, we have thought about using another variant more efficient and which has for mission to regulate the burst of arrivals, as well as to transmit them to destinations. We have applied this variant on the network that we will give.

The variant of token breakthrough bucket was modelled as shown in the next figure :

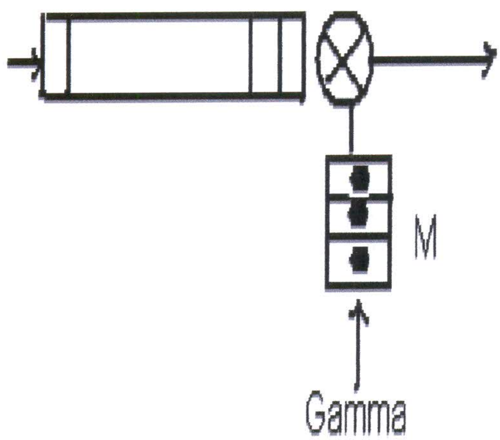

FIG. 1 – Token Bucket

We have two queues. The breakthrough bucket one, in which the arriving information packets will be put. The second queue is a pool of tokens of size

M, with a token arrival rate of gamma. Functioning principle is divided into two cases : firstly, if we have clients in the breakthrough bucket queue, and no tokens in the pool, then the arriving clients will be put in the first queue and wait tokens arrival. Secondly, if we have tokens and no arriving clients, then arriving tokens will be stored in their pool if the capacity M is not already reached. The only case, in which we can have information packets at the output, is when there are, at once, at least a client and at least a token. In this case, the first client in the breakthrough queue take a token and pass to the router, this one will send it to its destination. This principle allow to a burst of data to pass to the router queue, to join the destination network.

We will now try to find the optimal parameters of the break through bucket (M,gamma) which ensure an optimal control of congestion. Determining the optimal parameters, will allow us to reach wanted QoS (Quality of Service).

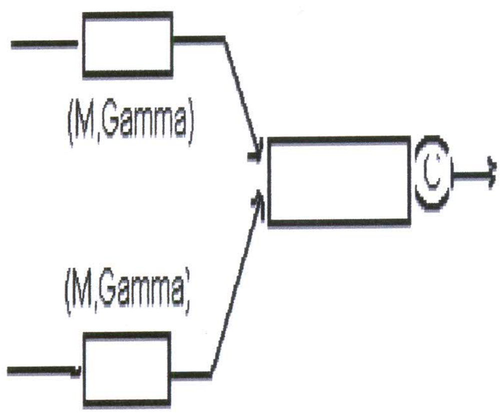

FIG. 2 – Connection with N token buckets

Modelling this system has given the following non linear mathematical problem :

$$\begin{cases} Min \sum_{i=1}^{n} \gamma_i, & \\ e^{-\theta_i M_i} \leq \zeta, & ; \\ M_1 + M_2 + \ldots + M_n = B, & ; \\ m_i \leq \gamma_i \leq r_i, & ; \\ \theta_i = \frac{r_i(\theta_i - m_i)a_i}{(r_i - \gamma_i)(r_i - m_i)\gamma_i}, & \text{i=1...N.} \end{cases}$$

Resolving this problem using the K-K-T theorem has given as results :

$$M^* = \frac{B}{K}$$

$$\gamma^* = \frac{-a_2 + \sqrt{a_2^2 - 4a_1a_3}}{2a_2}$$

with

$$a_1 = r - m$$

$$a_2 = \frac{\alpha r B}{-K\zeta} - r(r - m)$$

$$a_3 = (m\alpha B r)/K log(\zeta)$$

Results of the variant we have chosen, were obtained by applying it to a test network, this network is shown by the figure below :

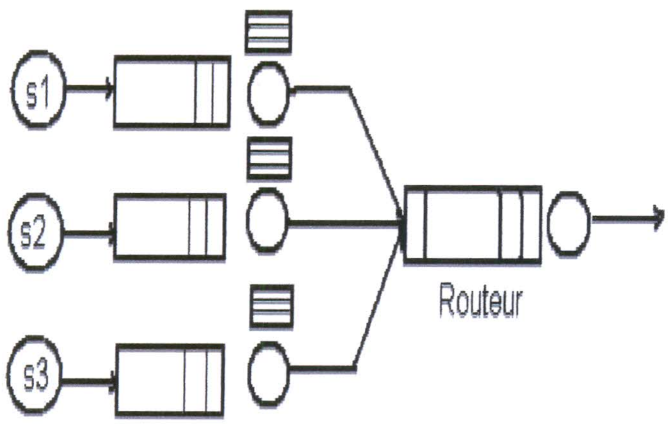

FIG. 3 – Networks Test

Emission sources S1, S2 and S3 are supposed :

- S1 emits information packets with an exponential mode ;
- S2 emits information packets periodically ;
- S3 is considered of type ON / OFF.

To visualize our results we have conceived a software that we called SIMTOK , that can show results of a simulation (see fig 4 and 5).

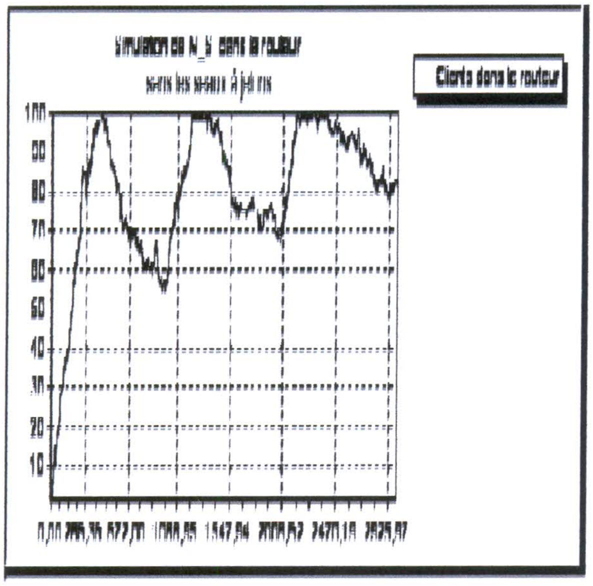

FIG. 4 –

The part reserved for routing using the distance vector in our software, allows us to give procedures used to update routing tables if need be. We will suppose that at a given moment, an update request is issued by a node of the network, or by the entire network, the network status at this moment is given by the next figure :

So, we obtain the following results : Every line of the matrix 1 and 2 represents a distance vector of the node given by the line index. Every box [i,j] of the matrix 1 gives the first node in the shortest path between node i and node j. As for matrix 2, every box [i,j] gives the cost of this path.

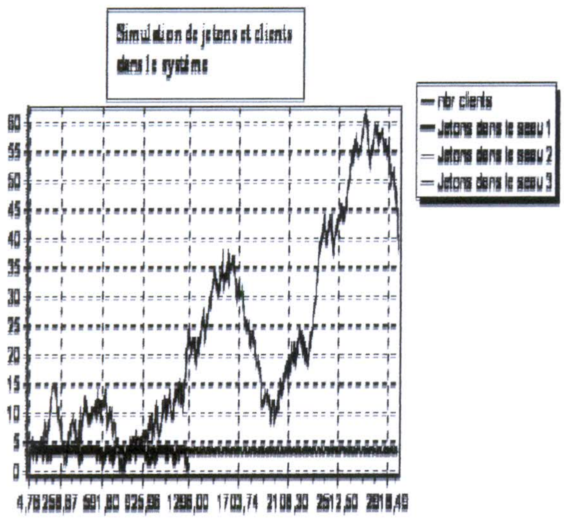

FIG. 5 =

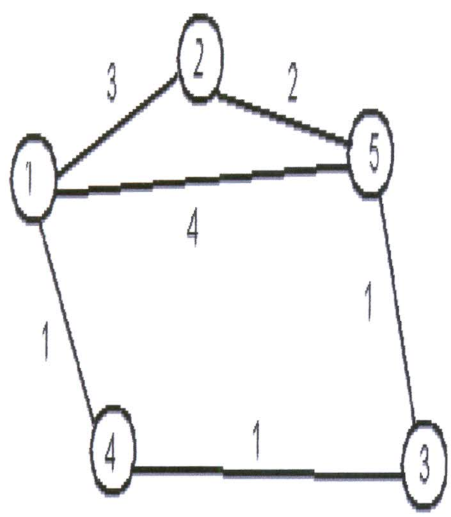

FIG. 6 = Network Test

	1	2	3	4	5
1	0	2	4	4	4
2	1	0	5	1	5
3	4	5	0	4	5
4	1	1	3	0	3
5	3	2	3	3	0

TAB. 1 – Matrix 1

	1	2	3	4	5
1	0	3	2	1	3
2	3	0	3	4	2
3	2	3	0	1	1
4	1	4	1	0	2
5	3	2	1	2	0

TAB. 2 – Matrix 2