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STABILITY FACTORS TO PROVIDE STABLE ROUTES FOR ADAPTIVE ROUTING ALGORITHM

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ABSTRACT

This paper shows how to prevent oscillation in adaptive routing algorithm. When a network implements load sensitive routing, traffic fluctuations are often observed which give rise to routing instability. This results in poor route selection and an overall degradation of network performance. In this paper we presented three different stability factors that can be used to provide stable routing by preventing oscillation in Adaptive Routing Algorithms. The performance is studied computationally for various networks with different number of nodes under static traffic model. In all the experiments the stability factor III shows better results in terms of iterations.

Keywords: Stability factor, Adaptive Routing, Oscillation.

1. INTRODUCTION

The problem of finding efficient routing algorithms has been a fundamental research area in the field of computer networks. Efficient routing results in smaller average packet delays; this means that the flow control algorithm can accept more traffic into the network. The routing algorithm provides the intelligence to compute a path from source(s) to destination(s) possibly subject to constraints and mostly optimizing a criterion.

In the static routing problem, a pair wise traffic function and link capacities are given. Thus the problem is to choose routes and assigns fractions of traffic to the links in order to minimize delay or maximize throughout [5]. In static routing, the selection of routes and the assignment of flows on the links are decided before the routing tables are downloaded into the network switches, and remain unchanged in time. In dynamic routing problem the routing decisions are changed continuously, according to the changes in traffic and congestion conditions in the network [2]. Earlier models of static and dynamic routing problems have been well studied by Gallager, Bertsekas, Segall [9]. These models mainly consider the shortest path routing problem to minimize expected delay. However, congestion and packet loss problems are not discussed.

In adaptive routing techniques such as hot-potato routing [4], deflection routing [4] and convergence routing [4] ensure no packet loss due to congestion inside the network. The adaptive routing combines, in a dynamic fashion, the on-line routing decision with the instant traffic load inside the network. Convergence routing [1] ensures that packets will reach their destinations without being routed on the same link twice. Thus it ensures a deterministic bound on the maximum route length in an arbitrary topology network [3].

In this paper we show that the performance of the adaptive routing algorithm depends on the stability factor used in the routing algorithm. We introduced three stability factors to prevent oscillation and to provide stable route between source and destination. In all the experiments the stability factor III shows better results in terms of iterations. Given a traffic load, optimization of an adaptive routing algorithm [7] requires new techniques since actual routes cannot be fixed, but altered, based on routing priorities and the actual traffic conditions The adaptive routing considered in this paper is Minimum Proximity algorithm (MIP). The stability and performance improvements are studied on various networks with different number of nodes and are discussed in section IV.

The rest of this paper is organized as follows. Section II shows the related work. Section III describes the oscillation problem and the proposed stability factors used to prevent oscillation. Implementation and the performance of the proposed stability factors are discussed in section IV. In section V, we summarize our findings.

2. RELATED WORK

The global Quality of Service (QOS) routing algorithm needs to provide up-to-date changes of all links at all times making them impractical [6]. An alternate to global QOS routing algorithms is eliminating typical link state advertisements [10]. It incurs large communication, processing overheads and affects QOS routing algorithm.

In "Virtual Node Algorithm for Data Networks" [8] they assumed that the physical layout of the network is a graph, and a ring is embedded using the above algorithm with thread links. The traversal ring on a graph is called graph embedded ring (GER).

In "Look -Ahead Approach to Minimize Congestion in Data Networks" [9] they considers the average of the current unbiased and all past biased utilization values and guarantees a smoother change of the utilization at each iteration.

3. OSCILLATION PROBLEM AND PROPOSED STABILITY FACTORS

The oscillation problem can be explained with the help of a given below example. Assume that in a network virtual node i has two outgoing links, (i, j) and (i, m). It uses the equation (4), to compute the utilization value of a link at a particular iteration of the routing algorithm. If the total flow on the link (i, j) is equal to Z, the maximum total flow over all of the links. Then according to equation (4) of the algorithm, $\rho_{ij} = 1$. The next step in the algorithm is to compute the routing probabilities using the recent utilization values. But according to equation (2) of the algorithm, $p_{ij}^{k} = 0$ and $p_{im}^{k} = 1$ for all k. Therefore, at the next step, all of the flow on link (i, j) will be moved to the link (i, m), leading to oscillation. In this case the algorithm will not converge. This situation is called as oscillation.

The utilization value of a link ρ_{ij} values computed at iteration n of the algorithm are used to compute the routing probabilities in iteration $(n + 1)$. Thus, the utilization values may cause changing the priority assignments on the links and routing probabilities. In turn, routing probabilities may change the link utilization. The oscillation can be avoided, depending on the way the link utilization values are updated. We proposed three stability factors to avoid the oscillation problem. Using any one of the stability factors the oscillation problem can be prevented.

3.1 Effect Oscillation on Network Performance

The oscillation problem can have the following adverse effect on the network performance.

- Limiting throughput can occur. This is due to shifting of traffic from forward link having utilization value 1 to another forward link whose utilization value is less than 1.
- The algorithm will not converge. So its computation time also increases.
- Due to oscillation the traffic at a link can be shifted to another link suddenly. As a result the congestion can be increased.

3.2 Stability Factor

Stability factor is the new utilization value assigned to a forward link. By assigning a new utilization value to the link, the algorithm becomes stable and prevents oscillation. This new utilization value is called stability factor. Using the above second method, three stability factors are proposed to prevent the oscillation and to improve the network performance.

3.2.1 Stability Factor I

The oscillation problem can be avoided by shifting the entire traffic in one forward link to other forward links uniformly. Stability factor I is proposed based on the above technique. In order to shift the traffic to other forward links, the utilization value of the current iteration $\rho'_{ij}(t)$ is divided by the number of available forward nodes nik. While doing so all forward links have the same utilization value ρ_{ij}. Now the probability of selecting a link to route the packet can also be changed.

i.e. $$\rho_{ij} = \rho'_{ij}(t) / \text{nik}$$

$$\rho_{ij} = 1 / \text{nik}$$

Here, the condition for oscillation is broken and the traffic is distributed uniformly in the two forward links without the oscillation problem. The Minimum Proximity (MIP) [15] algorithm then computes the minimum proximity value for each forward link. Based on the minimum proximity value it assigns priority for each forward links. The forward link with the highest priority will be selected to route the packets to the destination. The stability factor I can be written as follows

$$\rho_{ij}(t) = \begin{cases} 1/\text{nik} & \rho'_{ij}(t) = 1 \\ \rho'_{ij}(t) & \text{Otherwise} \end{cases} \quad (3.1)$$

3.2.2 Stability Factor II

The second approach to avoid oscillation problem is by taking the average of the utilization values ρ_{ij} of the forward links over a few iterations. Stability Factor II is proposed based on the above principle. In our implementation, we take the average of the utilization values of current iteration $\rho'_{ij}(t)$ and the last two iterations i.e. $(t - 1)$ and $(t - 2)$ respectively. In this stability factor the new utilization value can be assigned as 0.5 for the first two iterations.

Stability Factor II is written as follows:

$$\rho_{ij}(t) = \frac{1}{3}\left[\rho'_{ij}(t) + \rho'_{ij}(t-1) + \rho'_{ij}(t-2)\right] \quad (3.2)$$

3.2.3 Stability Factor III

Oscillation problem can also be avoided by taking the average of the utilization values of the links over a large number of iterations. In Stability Factor III the average of utilization values of all the previous iterations is taken. While taking the average of all previous iterations the new utilization value can be changed smoothly. Since it considers the long term average utilization value, the packets can be shifted to various forward links depending upon its priority. The new utilization value is assigned as 0.5, when the number of iterations is less than 3. Otherwise the Stability Factor III is given by the following equation

$$\rho_{ij}(t) = \frac{1}{t-1}\left[\sum_{l=1}^{t-1} \rho_{ij}(l)\right] \tag{3.3}$$

4. IMPLEMENTATION AND PERFORMANCE ANALYSIS OF THE STABILITY FACTORS

The proposed stability factors are implemented in MIP algorithm [9]. We show that the performance of the network depends on the stability factor used in the routing algorithm. The performance is studied computationally for various networks with different number of nodes under static traffic model. Table 1 show the convergence rate of various networks for various stability factors and is represented in Fig. 1.

Table 1
Convergence Rate for Various Stability Factors

`	*ITERATION*		
NODE	*SF I*	*SF II*	*SF III*
6	12	10	7
8	12	10	9
9	10	9	8
10	11	10	7
12	11	9	7
14	10	8	6
15	12	10	8
16	11	9	6
18	12	10	8
20	12	9	7
22	9	7	5
26	10	7	6
30	10	8	7

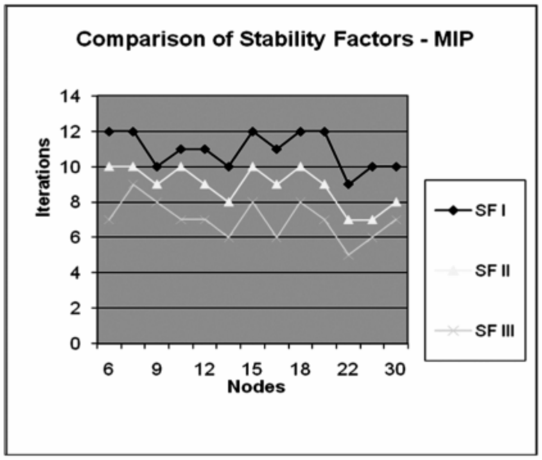

Figure 1: Convergence Rate for Various Stability Factors

5. CONCLUSION

Generally the Minimum Proximity (MIP) routing algorithms have oscillation problem. The oscillation can be avoided, depending on the way the link utilization values are updated. We proposed three stability factors to prevent the oscillation problem. Using any one of the stability factors the oscillation problem can be prevented. A series of experiments were performed for various network topologies and in all the experiments the stability factor III performs better in terms of iterations.

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