Strategies for updating link states in QoS Routers

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ABSTRACT
A crucial aspect of QoS routing is the frequency with which the nodes have to exchange information about the availability of network resources. In this work we classify and compare several strategies for triggering the update process in the nodes. Simulating an actual wide area network as a test-bed, we show that the triggering must be based on the relative variations of the available bandwidth in the links, better than using the utilised bandwidth or considering an absolute threshold or a policy of periodical updates.

1. INTRODUCTION
Owing to the progressive integration of real time services on IP, traditionally supported on connection oriented networks such as telephonic networks or ISDN, Internet must face the challenge of providing QoS (Quality of Service) requirements on a connectionless infrastructure. QoS on IP will result from the concurrence of different controls at different levels: packet classification and scheduling, resource reservation, traffic shaping and policing, call admission control and QoS routing. Current IP routing protocols (e.g.: OSPF, BGP or RIP) perform the path selection exclusively in function of topology information, normally minimising the hop count. In contrast with these “best-effort” protocols, QoS routers must also consider the resource availability as well as the QoS requirements of the flows, in order to proceed to select a feasible path. This implies that nodes have to exchange information on the present link states. However, if the routing information is exchanged every time the value of the QoS metric change, it will cause a great burden for the network links and routers, consuming link bandwidth and routers’ CPU cycles. In this sense, it must be achieved a tradeoff between the need of providing updated link information and the cost of broadcasting and processing update messages.

In this work we propose, classify and compare different strategies to trigger the update process in QoS routers. The comparison is performed in a realistic environment in terms of the provisioned QoS and the update rate that the different methods offer.

2. STRATEGIES FOR UPDATING LINK STATES
In QoS routing schemes, the metric that imposes the cost of a link, is normally chosen to be the available bandwidth, as it is strongly related to the rest of QoS parameters [1]. Moreover, using packet scheduling techniques such as Weighted Fair Queuing, delays and loss constraints are guaranteed by means of a bandwidth reservation.
In order to determine the exact moment in which QoS routers must broadcast the present link state to the rest of the network nodes, we consider three general methods:
1. Periodical Update: according to this simple strategy, which is very common in the literature [1], the actualisation of the available bandwidth is periodically performed regardless of possible changes in the resource availability. The router just has to implement a temporisation of fixed period $T$.
2. Update based on a fixed threshold [2]: A simple way to limit the range of non updated changes, is to establish a fixed threshold for the absolute variations of a state parameter with respect to the last notification. If this threshold is surpassed, the update process is triggered. For the case of available bandwidth, this policy guarantees in any moment that parameters are bounded within the range: $B^i_{ij} - \Delta B \leq B_{ij} \leq B^j_{ij} + \Delta B$, where $B^i_{ij}$ is the present available bandwidth of the link between the nodes $i$ and $j$, $B^j_{ij}$ is the last notified value and $\Delta B$ is the triggering threshold.
3. Update based on a relative threshold: in this case, it is considered the relative variation of the available resource [2]. Thus, the changes of $B_{ij}$ are notified when $B_{ij}$ varies more than a percentage
since the last notified value $B^*_ij$. This assures that until a new notification the value of $B_{ij}$ is limited in the interval: 

$$B^*_ij \cdot (1 - Th/100) \leq B_{ij} \leq B^*_ij \cdot (1 + Th/100)$$

A variation of the previous strategies can employ, as the parameter for triggering updates, the utilised bandwidth $UB_{ij}$, which is obviously defined as: $UB_{ij} = C_{ij} - B_{ij}$, being $C_{ij}$ the link capacity between the nodes $i$ and $j$.

3. SIMULATION AND RESULTS

For comparison purposes, the commercial network of MCI internet provider was simulated. This network consists of 19 nodes and 77 OC-3 (155 Mbps) and T3 (45 Mbps) links. Similar results were been obtained for other actual topologies. We considered CBR (Constant Bit Rate) traffic sources whose bandwidth was randomly chosen between 1 and 5 Mbps according to a uniform distribution. The call holding time was exponentially distributed with a mean of 1200 s. The traffic load was uniformly distributed among the nodes and was kept stable for each simulation (about $5 \cdot 10^5$ simulated seconds). For each path decision in the routers, it was considered that the cost of each link linearly depends on the available bandwidth, although similar tendencies were observed if other cost functions are utilised [3]. To compare the different strategies for updating, we measured the bandwidth loss probability ($Pr$), defined as the ratio between the rejected bandwidth and the global bandwidth that the sources demand to the network. As an estimation of the overhead introduced by each strategy, we also estimated the update rate, considered as the global number of actualisation messages per second.

Figure 1 shows the results of $Pr$ for the diverse strategies, considering different update periods ($T=60$ and 240 s), absolute ($\Delta B=5$ and 10 Mbps) and relative thresholds ($Th=40$ and 80%) for triggering the update. The figure shows that the best performance corresponds to the strategy which employs a relative threshold ($Th$) of 40%. On the other hand, the other strategies (periodical updating and actualisation with an absolute threshold) only can slightly improve the behaviour of the strategy of the relative threshold, but at the cost of using lower thresholds ($\Delta BW=5$ Mbps) and, as a consequence, heavily increasing the update rate (see Figure 2). It can be observed from Figures 1 and 2 that if a similar update rate is considered, the use of a relative threshold allows to reach losses rate three times inferior to those offered by the other methods. This difference is more notable for lower traffic loads, in the normal range of loss tolerance of commercial networks (below 2%).

The utilisation of a relative threshold for the available bandwidth make the network be especially sensitive to the changes in saturated links, which are determinant for the network throughput. This allows the routers to predict the bottlenecks in a more accurate way, which enables a better balance of the overall traffic.

These conclusions are corroborated if the changes in the utilised bandwidth, instead of the available bandwidth, are considered to be the metric for triggering the updates. In that case only the idle links will broadcast the changes while the nodes will not be notified of small relative changes in the utilised bandwidth of the saturated links, which are actually the main cause of losses. Figure 3 proves that losses increase almost up to an order of magnitude when using this new metric.

4. CONCLUSIONS

In this work we have compared several strategies for triggering the update process of the link states in QoS routers. Using an actual network as a test-bed, we prove that QoS routers are especially sensitive to the relative variations of the available bandwidth in the links. In particular, the best results correspond to a simple scheme which broadcasts the changes just when the available resources varies more than a fixed percentage since the last notification. The benefits of this solution are proved in terms of the routing performance (minimising the probability of call losses) as well as in terms of overhead (reducing the update rate).

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REFERENCES


FIGURE CAPTIONS

**Figure 1.** Bandwidth Loss Probability as a function of the call rate for the different strategies for updating

**Figure 2.** Update Rate as a function of the call rate for the different strategies for updating

**Figure 3.** Bandwidth Loss Probability as a function of the call rate for two different metrics: utilised and available bandwidth.
Figure 1.
Figure 2.
Figure 3.