Bandwidth as a dominant metric in localized QoS algorithm

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Abstract— **most of the QoS routing mechanisms involve periodic exchange of global state information which causes communication overheads. Therefore, localized routing is the method to avoid this problem. The network in this technique is inferred by the source nodes using statistics which are collected locally. This paper presents new localized algorithm Highest Minimum Bandwidth routing algorithm (HMB). The new algorithm is compared to the existing localized Credit Based Routing (CBR) and the global WSP routing algorithm. The selection of disjoint paths and recalculation of the set of candidate paths were also introduced. There also was shown positive effect of dynamic path selection method on the performance of localized routing algorithm.**

Keywords- *Localized Routing, Quality of Service.*

I. Introduction

Periodic exchanging of global QoS state information and keeping it in a database of network routers is one of the problems in the global state routing. Several routing schemes [1-4] that have been introduced in the QoS routing need the exchange of the link state information among the routers in the whole network. It leads to flapping of routers and high communication overheads. Localized QoS routing is considered an alternative method which reduces the mentioned above problems. Flow blocking statistics, that are collected locally and provided to the network QoS state by the source nodes, minimize the communication overhead and eliminate the need for the routers to update and keep a database of QoS state[5]. Highest Minimum Bandwidth routing (HMB) is offered in this paper. Effective methods, such as the selection of disjoint paths and recalculation of the set of candidate paths, have been applied in our work to improve the presented algorithms. To further illustrate the effectiveness of latter, we conducted the simulation demonstrated superior performance of our proposed algorithm. It produced significantly better results in a number of cases, even when prior approaches failed to do so. Candidate paths selection plays a part in localized QoS routing. Various methods of selecting the preferred path have been proposed in [6, 7]. A set of candidate paths between sources and destinations are chosen based on different schemes, e. g. an algorithm of the shortest path Dijkstra's, where the flow is routed along these paths. Effective methods applied in our work to improve the selection of candidate paths.

II. Related Work

The CBR is the most relevant work to our algorithms. It was compared to Widest-Shortest-Path (WSP) and localized algorithm PSR [3, 5, 8].

In CBR each source node needs to set a number of candidate path sets *R*, based on minimum hop path R^{min} and an alternative path R^{alt} which refers to the paths with minimum hop and minimum hop plus one respectively, where $R = R^{min} \cup R^{alt}$. CBR assigns a maximum credit for each path *P.credits= max_credits*, and selects the path with the highest credit from both sets to direct the flow. Test message is sent along the chosen path and each node in this link behaves as a router to test the outgoing link, if it has sufficient residual bandwidth for the flow. In case, if the residual bandwidth is not sufficient to satisfy the QoS, failure message is sent back informing the source about the path failure and the path credit is decremented by its blocking probability. In the successful case the bandwidth of the message is reserved from the residual bandwidth. Then message is forwarded till it reaches its destination and the path credit will be increased by (1- the path blocking probability). CBR algorithm uses both Φ and *max_credits* as system parameters, where Φ controls the usage of alternative paths and where max*_credits* verify the maximum credit for each path.

CBR routes the flow based on crediting scheme that rewards a successful path and penalizes the failed ones. Blocking probability statistics are calculated in CBR within each 20 flows. The credit is given for each path based on the average number of rewarded points and penalized ones during these periods.

In spite of CBR performing at a more enhanced level than PSR, the metric employed for path selection relies on crediting scheme and therefore does not show the quality of the path. It has to be estimated directly on the basis of QoS characteristic, e. g. bandwidth or delay. In addition, it is not a quite logical approach to use manipulation by blocking probability as a gradient variable.

III. The Proposed Algorithms

Our QoS algorithm assumes that the network is enhanced by signalling and resource reservation mechanisms to make the path for the new flow. CBR and PSR use the statistic of blocking probability as a factor in selecting the routing paths. Differently, our proposed algorithm uses residual bandwidth as the direct QoS guideline to select routing paths. The HMB algorithm selects the highest minimum residual bandwidth among the candidate paths set. The HMB scenario starts when a setup message travels from source to destination along the outgoing links in the path. All the outgoing links in the single path are compared, to locate the link with the minimum residual bandwidth. Each selected link refers to a path in the candidate paths set. The HMB algorithm selects the best path by selecting the link that has the largest residual bandwidth among the selected links with the minimum residual bandwidth. Fig. 1 shows the flow chart of the HMB algorithm. The pseudo code for this algorithm is:

```
1.  set SelectedPath = P0
BEGIN
2.    P.MinResidualBW = min (L.ResidualBW, MinResidualBW),  ∀ L∈ P and ∀ P ∈ R
3.    if (SelectedPath.MinResidualBW <  P.MinResidualBW)
4.          set SelectedPath = P
END
5.   Route flow along  Selected Path.
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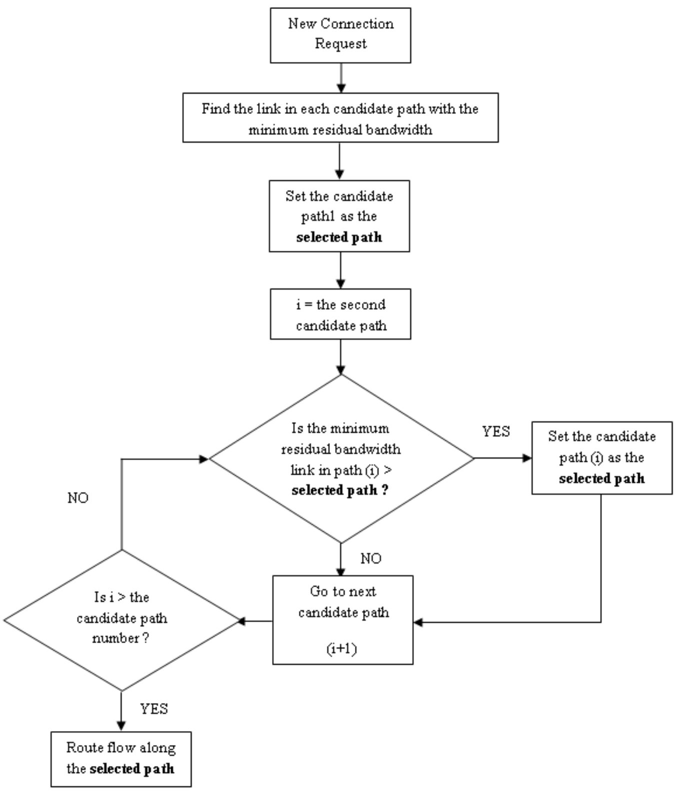


Figure 1. Flow chart of the HMB algorithm.

TABLE I. THE CHARACTERISTICS OF THE USED TOPOLOGIES

Topology	Nodes	Links	Node degree	Avg. path length
ISP	32	108	3.375	3.177
RAND45	45	172	3.822	2.692
RAND80	80	482	6.025	2.99

IV. METHODOLOGY

Our Localized QoS routing algorithms were programmed to operate at flow level. Resource reservation, admission control, and selecting of the preferred path are based on the algorithms (HMB and CBR), and simulated using the discrete-event simulator OMNeT++ [9]. All networks were implemented in OMNet ++ combined with C++. Table 1 shows the characteristics of the topologies used.

In all networks all simulated links are bidirectional and of the same capacity with C units of bandwidth in each direction (C =150 Mbps). The flow bandwidths are distributed uniformly within a range [0.1, 2 MB], whereas the arrival rate of flows reaches each source node according to a Poisson process with rate λ . Nodes in the networks can be either sources or destinations. The flow service time is exponentially distributed with mean 1/μ. The offered load of the network $\rho = \lambda N\overline{bh} / \mu LC$, where N is the number of nodes, b is the mean bandwidth per flow, h is the average hop count per flow and L is the number of links in the network. Various ranges of loads are used in our simulation. All paths between each source-destination pair having a maximum length, at most, of one hop more than the minimum number of hops, are chosen as the candidate paths [5]. QoS routing scheme is introduced to limit the blocking probability in the network by increasing the number of admitted flows. Therefore, QoS routing algorithms performance is estimated by determining the overall flow blocking probability. It is calculated as the ratio of the number of flows blocked and the total number of flows that arrived at the network.

V. SIMULATION RESULTS

In this section we first describe the path selection methods followed by the evaluation of the performance of the HMB algorithm. We weigh it against the CBR scheme. The comparison method considers the QoS blocking probabilities, and the fact, that the algorithm with lower blocking probability achieves better performance.

A. Path Selection Methods

We introduce some methods of candidate path selection to improve our offered mechanisms. Selection of the disjoint paths between each pair of source and destination shows progress in reducing the blocking probability. Recalculation of the set of candidate paths is the second method which aims to calculate the amount of blocking in all possible paths between each pair of source and destination nodes in the network. It modifies the set of candidate paths by replacing the path of higher blocking by the ones with lower blocking. Although the recalculation method is applied, we keep the same number of candidate paths in the set. The selection of disjoint paths and recalculation of the set of candidate paths decrease the blocking probability in our new algorithm and CBR. While the use of disjoint paths and recalculation of the set of candidate paths dramatically decreased the flow blocking probability for all network topologies, the best improvement of using these methods observed in RAND80 network. It is possibly, because a random network is likely to give a better chance of selecting disjoint paths in the candidate path set, than the more restrictive topologies of the regular network such as ISP. Fig. 2 shows the impact of selection of disjoint paths and recalculation of the candidate paths set on the presented algorithm (HMB) and the pre-existing localized algorithm CBR. Joining both methods decreases the flow blocking probability by HMB and CBR algorithms.

B. *Blocking Probability*

Fig. 3 represents the HMB algorithm supplemented with the disjoint and recalculation methods. The figure evaluates the output of the new algorithm against the current one (CBR) and the global algorithm (WSP) by calculating the flow blocking probability which is graphed versus a range of load states in several network topologies. The use of HMB notably decreased flow blocking probability in both regular and random topology networks.

Two factors usually affect any routing mechanism. These factors are (1) the main plan of the routing algorithm which is global or localized algorithm and (2) the path selection method of the algorithm. In case of WSP algorithm, the path is chosen accordingly to the regularly updated global state of information. The performance of WSP is extensively distressed, if the regular updates do not keep up with the fluctuations in the network capabilities. Thus, WSP selection method always opts for the most sufficient path proceeding from present global state and follows it, even if the path becomes exhausted till the latest update comes. Consequently, WSP performs as the worse scheme among all the algorithms in the whole selected topologies.

Our algorithm and CBR share the approach of localized routing which does not need any network update but they differ in the path selection way. The preferred path for the CBR algorithm is the one with the maximum credits until it rejects the flows. The credits are decremented after every flow passed, which sanctions the update of the path crediting. Once the rejection occurred, an alternative, higher credited path is chosen. HMB select the best feasible path based on the source view which gets the clear observation of the network.

Therefore, the main feature of the mentioned algorithm contributing to its performance estimated by the flow blocking probabilities and reflected in the Fig. 2. The similar pattern is followed in the all topology networks. The WSP algorithm with the update interval 30 performs the worst because of its extended update interval in the global state. The CBR technique already acts superior to the WSP (30) due to the alternative path selection implemented in its principle of routing. Nonetheless, the flow blocking probability used to credit the alternative path in the CBR still is not as sufficient as bandwidth metric chosen to qualify the path in our suggested algorithm. Thus, the graphs, illustrating the performance of our algorithm, show its better acting expressed in the similar manner in all tested types of networks under the presented range of loads.

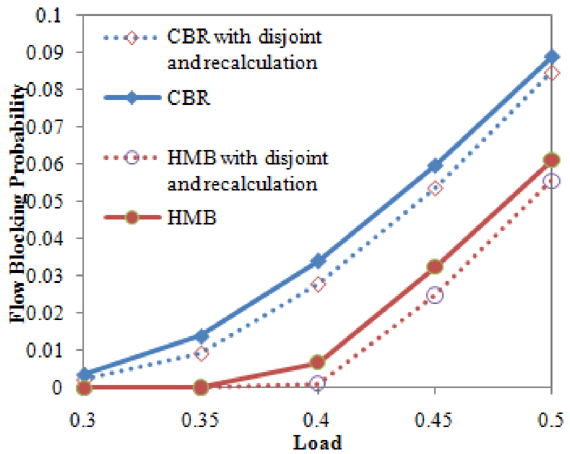
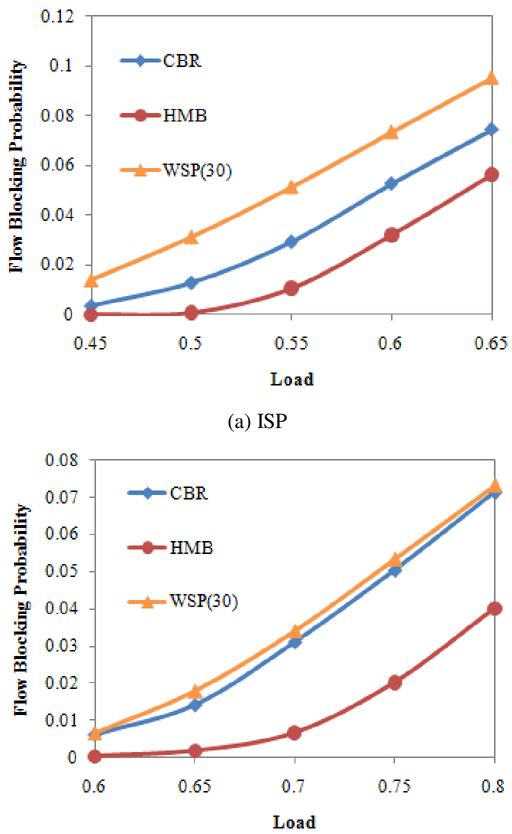


Figure. 2 Impact of disjoint paths and recalculation the candidate path set of different algorithms on RAND80 network.



(b) Rand45

Figure 3. Flow Blocking Probabilities in different topologies

C. *Impact of Bursty Traffic*

As presented in [6, 10] we now analyse the performance of proposed algorithm HMB and CBR bursty settings. The experiment is carried out using various flow lengths according to a Weibull distribution with shape parameters 0.4 and 0.7. The burstiness is incremented by a small shape value. Fig. 3 shows the flow blocking probability versus the offered load with different shape values for the random topology network RAND80. The amplified burstiness in the arrival process causes an increased blocking probability over the range of loads used. Although there is no major impact of burstiness in the RAND80 topology, other sets of the experiments (data not presented here) demonstrate that burstiness has considerable effect on the performance of our algorithm and CBR in other network topologies.

Compared to the CBR, our algorithm showed superior performance. Used shape parameters, especially 0.4, worsened only the CBR performance, presented by a notable dissociation of the 0.7 shape parameter graph. This can be explained by the CBR principle of routing decisions of blocking probability elevated with burstiness. Clearly, HMB algorithm outperformed CBR and happened to be the best. Although 0.4 shape parameter insignificantly worsened the performance of both HMB and CBR, HMB performance was not greatly affected by burstiness of traffic, since its routing decision is taken based on the bandwidth as QoS metric.

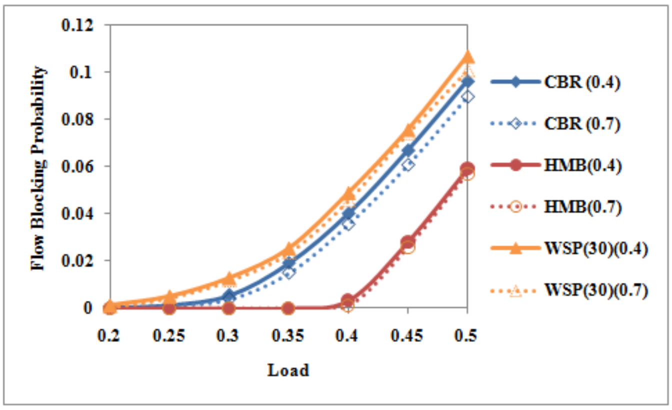


Figure 3. Impact of Bursty traffic on Random 80 network.

VI. Conclusion

On the basis of the previous research of the localized routing, we analyzed the functionality of the CBR which appeared to be the best amongst existing global and localized routing algorithms. In our study we offered two methods to improve the performance of the CBR algorithm and introduced new localized routing algorithm HMB. We analyzed its performance and compared it to CBR and WSP in different network topologies. In three types of networks, ISP, RAND45 and RAND80, our algorithm consistently performed better than both CBR and the global routing algorithm WSP.

The methods offered for selecting the candidate paths, which are disjoint paths and recalculation, not only improved the function of the CBR algorithm but allowed the proposed algorithm to perform more beneficially. We analyzed the performance of the HMB algorithm with disjoint and recalculation path methods. The HMB algorithm generally gave the best performance and decreased blocking probability the most.

Although CBR algorithm, based on highest path credit, was designed to select the candidate path, it still does not reflect the quality of path like bandwidth, and delay, which both are examples of QoS constraints and mirror the path superiority to be selected or rejected. Our algorithm in this paper acts perfectly using bandwidth as QoS metric. Future work will investigate the influence of delay as a QoS metric on the performance of some new localized routing algorithms.

VII. References

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