International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 10 (2015) pp. 24999-25016

http://www.ripublication.com

QoS Guided Route Discovery Based on Bandwidth and Latency

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Abstract

A mobile ad hoc network is a self-organizing and rapidly deployable network. In MANET there is no wired backbone or centralized control. The main Quality of Service (QoS) metrics are namely bandwidth, latency and jitter for finding better routes. In this paper, the above mentioned QoS metrics are considered for routing. This technique will provide delay requirements of hard real-time traffic based on the expiration delay to deadline. In this approach each packet of the admitted real time flow is transmitted from the source to the destination before the expiration delay to deadline. The advantage of this technique is that the bandwidth and delay satisfied best path is selected.

Introduction

MANET

A mobile ad hoc network is a self-organizing and rapidly deployable network. In MANET there is no wired backbone or centralized control. The nodes interact with each other using scares wireless channels in a multihop manner. The ad hoc network has high dynamic topology which will result in the mobility of the nodes and there will be change in the propagation condition and also there will be no fixed architecture. MANET plays a very important role in providing service everywhere and they also support future generation networks. The Adhoc wireless network consists of the mobile devices which are equipped with interfaces and networking capability which are adaptive in nature and is self organizing [1][2][3].

Route Discovery Based on Bandwidth and Latency

In the case of proactive schemes every node constantly maintains the complete routing information of the network. The route is readily available when the node needs to forward a packet hence there is no delay in searching for a route. [1]

Routing protocols proposed for ad hoc networks are mainly divided into two categories: table-driven (proactive) and on-demand (reactive). To provide parallel safe path the multipath routing schemes is very important and will also assure the QoS. Routing algorithms need frequently discovering new routes and update the routing tables according to the changes. Limited wireless bandwidth requires the routing algorithms to reduce the amount of control traffic generated to build and maintain routing tables and to discover new routes. Nodes should be able to route packets by transmitting the least possible control bytes into the network allowing the maximum use of available bandwidth for data transfer. Multipath routing is very effective in providing bandwidth aggregation and load balancing [2][3][4].

The main QoS metrics are namely bandwidth, latency and jitter, for finding better routes. The route should satisfy the QoS and also allows a node to specify a QoS metrics which should be satisfied in the exposed path. The source may also use a route which is already known from its cache, and then the route discovery can still be performed to find a better route. The routing protocol should collect the local information of the nodes and select the head nodes, which will calculate the routing path meeting the bandwidth requirements.

The delay-sensitive flows which have the end-to-end delay as requirement has to be selected and also the bandwidth-sensitive flows which have the throughput as requirement and the best effort flows has to be selected for the better result [5][6][7].

Issues in QoS routing

With the available maximum latency or a given available bandwidth it is very difficult to find a route with sufficient quality. Generally low-latency paths are chosen, a node searching for a path along which to route a high-bandwidth flow may not find an appropriate route with either DSR or AODV even if the route with adequate bandwidth exists [9].

Previous Work and Its Drawbacks

In [12], reliable and effective cache management technique was proposed. In this technique initially, a combined weighted function for each route is estimated and stored in the cache, based on the parameters route length, traffic load, energy, signal strength. Then based on the combined weight function, the routes are arranged such that routes with minimum length and traffic load, maximum energy level and freshness are listed first in the route cache. The route cache is updated such that routes with least weight functions are removed from the list.

In optimized reliable and load balanced protocol [13][14], the overhead was reduced during data transmission. The optimization is performed in two phases. In the first phase, the route for the data packet transmission is determined and the bloom filter is used for the estimation of the compressed source route at every node. In the second phase, before the transmission of the data packet, the related information of the transmitting intermediate node is deleted.

The drawback of the above works is that it can only provide paths between sources and destinations regardless of the Quality of Service (QoS) requirements like

bandwidth and delay guarantees. These demands are very frequent especially for real time applications.

As an extension to these works, in this paper, QoS guided route discovery technique based on bandwidth and delay is proposed.

Related Work

Anil Rawat et al., in paper [5] have proposed enhancements in DSR to provide secured route discovery and improved QoS. The paper evaluates integration of Secured Routing Protocol (SRP) and Secured Message Transmission (SMT) with DSR to get Secured Dynamic Source Routing (S-DSR), which is capable of secured route discovery. The proposed extension also incorporates concurrent usage of multiple cached routes for improved throughput and explores possible enrichment to route cache management resulting in improved efficiency. A novel idea of proactive route discovery, particularly for high and sustained bandwidth dependent applications like video conference, voice over IP etc., has been proposed. The paper finally concludes with remarks on a possible comprehensive S- DSR protocol, incorporating better route cache maintenance scheme, proactive route discovery and integration of SRP/SMT features for secured route discovery and secured data transmission.

Sofiane Ouni et al., in paper [6], have presented a new routing algorithm based on DSR to get the guarantee of hard real Time traffics. This algorithm is based on a node resource reservation for each traffic path. An admission control is made to preserve the reserved node resources and is adapted to node mobility by preventing path breaking. This routing protocol is implemented under NS2 and simulation results perform more stable time features than classical routing.

Shun Liu et al., in paper [7] have proposed a delay-aware multipath source routing (DMSR) protocol to provide QoS support for realtime multimedia applications in wireless ad hoc networks. Based on local information, node delay is calculated as metric for route path selection in the DMSR protocol. The metric takes into account the number of the neighbor nodes of the forwarding nodes, the channel busy time and the number of packets in the send buffer.

Jose L. Muñoz et al., in paper [8] have proposed a distributed and easy-to-implement routing mechanism based on reputation for the provision of MPEG-2 video-streaming services over MANETs. The main novelty that they introduce regarding the existent literature is the proposal which is service aware, that is to say, they consider the video-streaming service characteristics to develop a cross-layer design with the routing protocol. In addition, they do not introduce extra signaling overhead to monitor reputation due to the use of standard video-streaming end-to-end signaling.

Wei Liu et al., in paper [10] have proposed a cross-layer designed Device-Energy-Load Aware Relaying framework, named DELAR, to achieve energy conservation from multiple facets, including power-aware routing, transmission scheduling and power control. In particular, they design a novel power-aware routing protocol that nicely incorporates device heterogeneity, nodal residual energy information and nodal load status to save energy. In addition, they develop a hybrid transmission scheduling scheme, which is a combination of reservation-based and contention-based medium

access control schemes, to coordinate the transmissions. Moreover, the novel notion of “mini-routing” is introduced into the data link layer and an Asymmetric MAC (A-MAC) scheme is proposed to support the MAC-layer acknowledgements over unidirectional links caused by asymmetric transmission power levels between powerful nodes and normal nodes. Furthermore, they present a multi-packet transmission scheme to improve the end-to-end delay performance.

Proposed Work

Overview

In this paper, QoS guided route discovery technique based on bandwidth and delay is proposed. The Real-time route discovery and reply phase are considered to provide the quality of service. To provide the delay requirements of hard real-time traffic, a new solution is proposed based on the expiration delay to deadline. In this approach each packet of the admitted real time flow is transmitted from the source to the destination before the expiration delay to deadline. The route is selected by considering bandwidth metrics from the cache by applying the Route Selection Based on QoS Metrics from the Cache technique. This approach is also known as S-DSR approach which will also select a secure route.

System Design

In previous work during source and destination routing Quality of Service (QoS) requirements like bandwidth and delay guarantees are not considered. These metrics are very important in the case of real time flows.

Real-time route discovery phase

In the route discovery phase, the sender will find a path to the destination which will satisfy the delay requirements of the real-time flow. When a node has to send real time data to any other node, then it will broadcast a route request with the expiration delay to deadline needed. The node receiving the route request makes the admission control test to decide if it can accept a new real-time flow or not. This activity is as shown in the figure (1)

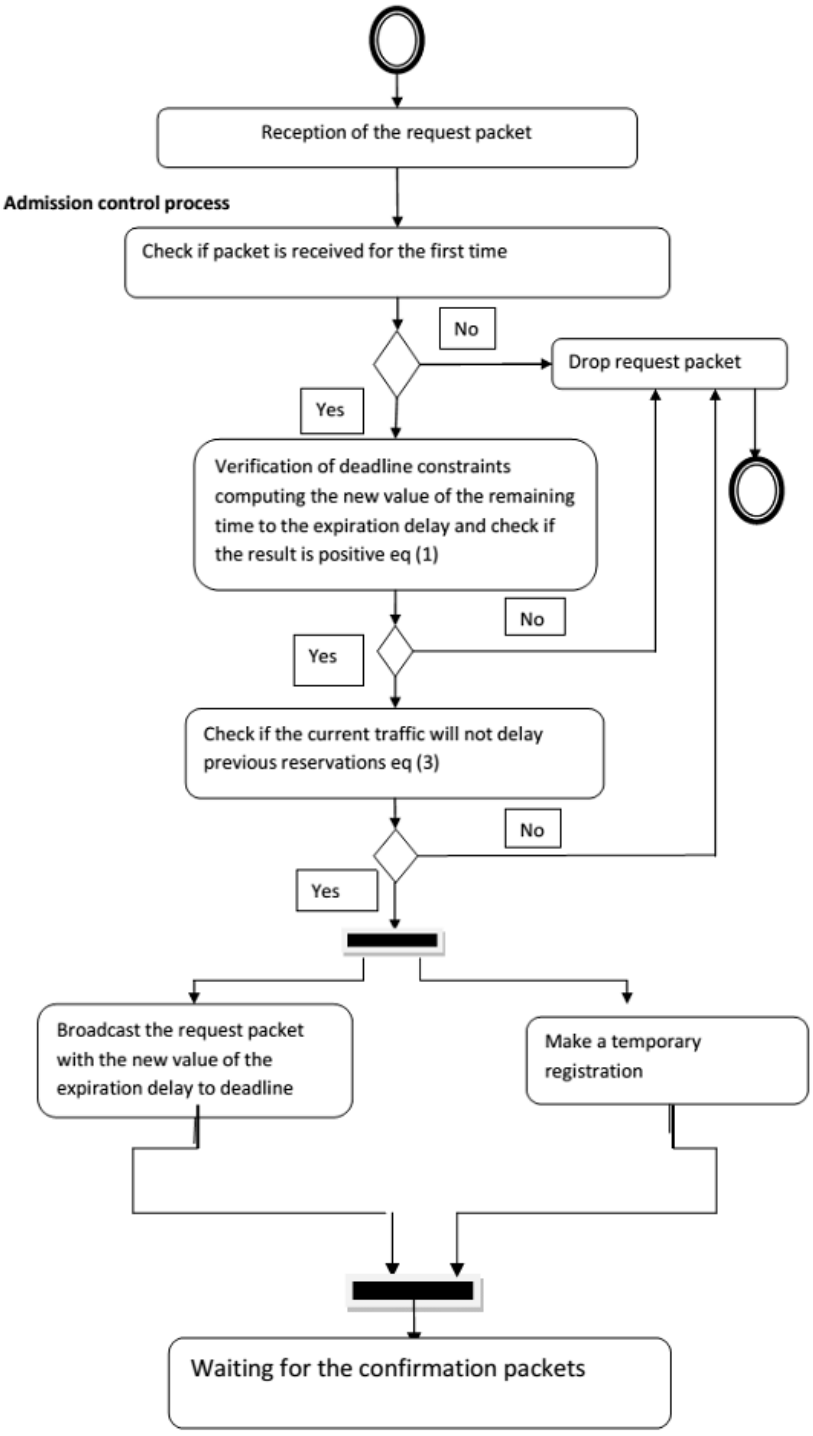

Figure (1) Activity diagram of intermediate node behavior in real time route request phase

The admission control test will ensure that the network can admit the new flow and then it will satisfy its constraints without disturbing the real-time flows already confessed in the network. If the delay constraints are satisfied then two conditions has to be checked.

1. Check the satisfaction of the new flow
2. Check the satisfaction of the previous real time flows transmitted over the network in the case of accepting this new flow.

The first condition is that the expiration delay to the deadline of the new flow can be respected which means that the transmission time between the source and the destination is still lesser than the expiration delay to deadline. Hence the time spent by the packet in each node and the communication time between nodes. So each node receives the remaining time of the expiration delay from the previous node. Now from this received value, the node subtracts the time taken to transfer the request packet from the previous node and the packet processing time. The attained value should be positive to maintain the respect of deadline on transmission. This is represented by the following formula:

$$E_k^{i-1} - T_{TL} - T_{TS} > 0 - - - -(1)$$

Where

E_k^{i-1} is the remaining time of the expiration delay to deadline, for the traffic k, received from the node (i-1).

T_{TL} is the local processing time of any message.

T_{TS} is the transmission time between two neighboring nodes in the worst case.

The local processing time is considered as the sum of the processing time machine and the time spent by the packet in the queue:

$$T_{TL} = T_a + T_{TM} - - - - -(2)$$

Where T_{TM} is the processing time machine and T_a is the time spent by the packet in the queue.

The first condition (1) checks that packet can reach the destination before the expiration delay to deadline, the second condition forced that a new flow should not delay the other real-time flows which already confessed and stop them to respect their expiration delays to deadline. In order to check the respect of deadline, all reserved traffic with their remaining times has to be saved. The additional traffic should not delay previous ones to respect their expiration delay to deadlines. Hence the first condition is recalculated to all the accepted flows taking into account the changes if the new flow is admitted. This formula is as given below

$$\forall_j, 1 \leq j \leq res; E_j^{i-1} - T_{TL} - T_{TS} > 0 - - - -(3)$$

Where res is the number of real-time flows already admitted in the node.

The node will take the decision whether it can admit a new real time flow or not, depending upon the formulae (1) and (3). Suppose if the route is admitted then the node broadcasts the route request packet with the new remaining time to the deadline and also will make some provisional reservation. Else the node will reject the route

request packet and will not send it anywhere because the node cannot satisfy the delay constraints. Hence it will not belong to the path which exists between the source and the destination of the actual real time traffic.

Real-time route reply phase

This phase will help us to effectively reserve the path between the source and the destination. Suppose if the route satisfies the delay constraints between the transmitter and the receiver then it should be passed on to the source and inform the nodes belonging to this route about the new real-time traffic and the final remaining time to deadline. The node activities in this phase are as shown in the below figure (2)

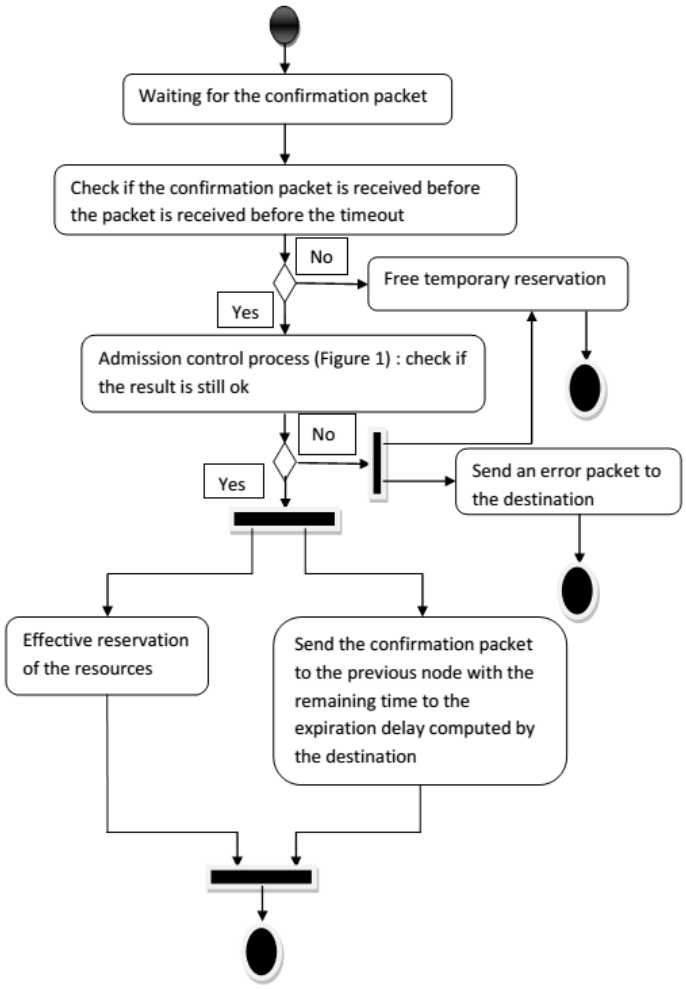

Figure 2 : Activity diagram of intermediate node behavior in real time route reply phase

When the destination node receives the route request packet at the end of route discovery phase, then it will perform the admission control. Suppose if the result of the admission control is negative then the destination will reject the packet. Else it

will send a confirmation packet to the source. This confirmation packet is sent in the reverse order of the nodes making up the path, with the final remaining time to deadline.

The intermediate node when receiving the confirmation packet will execute the admission control again. Suppose if the condition is not satisfied then the confirmation packet will be rejected and the error message is sent to the destination to inform it that it should select another path and the temporary reservation will be freed. Else the intermediate node will reserves the resources and will preserve the remaining time value to deadline sent by the destination and sends the confirmation packet to the next node until reaching the source. Once the confirmation packet is received by the source then it will transmit the data flow through the reserved path until it has not got other packets to send or the path is no longer available. In this case the route discovery phase will be reinitiated to make a new path regarding the real time constraints. At that time the nodes of the old path should release their reservation. This can be achieved by defining a time-out for each reserved flow. Hence the node will be released from the reservation if the traffic is not arriving in the specified timeout. To obtain an appropriate path for such kind of traffics is not sufficient because the paths accessibility and the respect of real time constraints depend also on nodes mobility.

Route Selection Based on QoS Metrics from the Cache

For the DSR protocol normally the QoS metrics are bandwidth, latency and jitters. The S-DSR is designed in such a way that the selection is carried out based on the criteria for the routes from the cache which is based on the above parameters.

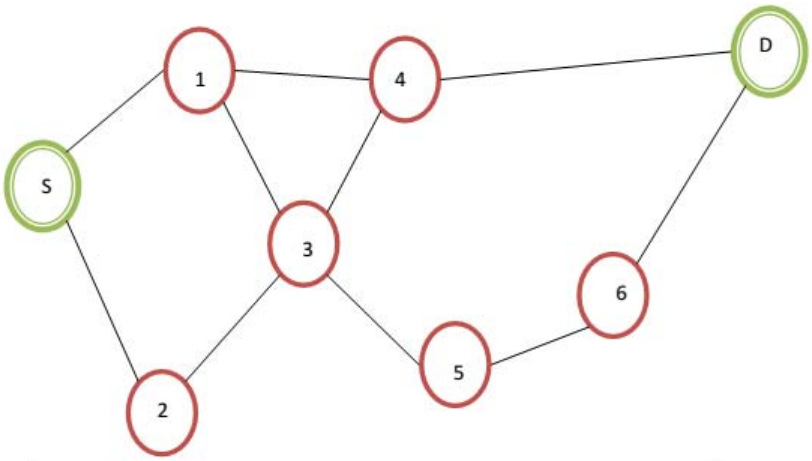

Figure (3) typical logical Ad hoc network schematic

Example: - From the figure (3) assume the link 5 parameters between the nodes according to Table 1.

Table 1: Link parameter between various nodes of Figure 3

Link	**Bandwidth, latency, jitter (Kbps, ms, ms)**	**Link**	**Bandwidth, latency, jitter (Kbps, ms, ms)**
S-1	128, 10, 8	S-2	128, 16, 1
1-4	128, 14, 2	1-3	64, 12, 7
2-3	64, 16, 2	3-4	128, 13, 5
3-5	512, 12, 12	5-6	512, 14, 3
4-D	128, 16, 1	6-D	64, 12, 2

From the above parameter the typical route cache at the source S will look like as shown in Table 2.

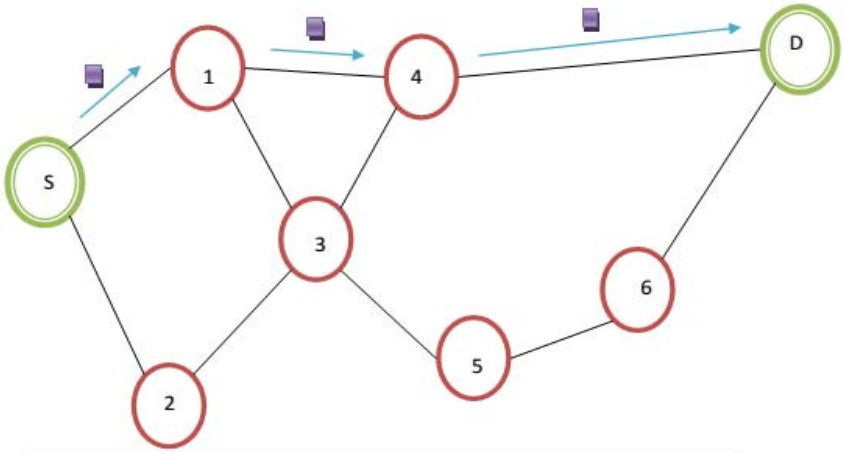

Figure (4) Selection of the best possible route

The best possible route is selected by considering the QoS metrics like bandwidth, jitter and latency which are present in the table. The selected route is as shown in the above figure (4).

Table 2: Typical route cache entries in S-DSR

Destination	Intermediate Node list	Minimum Bandwidth (Kbps)	Latency (ms)	Jitter factor (ms)	Time stamp	Category
D	1-4	128	40	11	13:40:45:75	L
D	1-3-4	64	51	21	13:40:43:00	L
D	1-3-5-6	64	60	32	13:40:43:99	S
D	2-3-5-6	64	70	20	13:41:06:23	S
D	2-3-4	64	61	9	13:41:12:45	S
D	2-3-1-4	64	74	13	13:41:13:13	S

Minimum bandwidth is the bandwidth of the weakest link in the route. Latency and jitter are cumulative figures, as produced by all the intermediate nodes put together. Latency and jitter are computed in milliseconds (ms), while bandwidth is typically mentioned in Kbps. The time stamping is used for stamping latest route verification for availability. To select an efficient selection of route from the cache, the routes can be sorted in a periodic basis and the sorting criteria could be defined by the source, based on the application's requirement. The best cached route will be on the first of the list for efficient selection by the S-DSR algorithm.

Advantages

- The bandwidth and delay satisfied best path is selected.
- The QoS aspects are very effectively considered.
- This approach will reserve the resources to the selected paths
- This approach will also select a route which is secure.

Simulation Results

Simulation Model and Parameters

The Network Simulator (NS2) [11], is used to simulate the proposed architecture. The IEEE 802.11 MAC layer is used for communication among the devices, providing access to the physical channel for all types of transmissions and appropriate security mechanisms.

In the simulation, 50 mobile nodes move in a 50 meter x 50 meter region for 50 seconds of simulation time. All nodes have the same transmission range of 40 meters. The simulated traffic is Constant Bit Rate (CBR) and video Traffic.

The simulation settings and parameters are summarized in table.

Table 3: Simulation Settings

No. of Nodes	50
Area Size	50 m X 50 m
Mac	IEEE 802.11
Transmission Range	40m
Simulation Time	50 sec
Traffic Source	CBR and Video Traffic
Packet Size	512
Rate	50,100,150 ,200 and 250kb
No. Of flows	1,2,3,4 and 5

Performance Metrics

The proposed **QoS** Guided Route Discovery Based on Bandwidth and Latency (QRDBL) is compared with the Delay-aware Multipath Source Routing (DMSR)

technique [7]. The performance is evaluated mainly, according to the following metrics.

- **Throughput:** It is the amount of data received at receiver measured in Mbits/sec.
- **Delay**: It is the average time taken by the nodes to transmit the data packets to the receiver.
- **Packet Delivery Ratio**: It is the ratio between the number of packets received and the number of packets sent.
- **Packets Received**: It is the average number of packets received by the receiver node.

Results

Case-1 (CBR Traffic scenario)

(i) Based on Flows

The number of CBR traffic flows is varied from 1 to 5 and the performance metrics as specified above are measured for both the techniques.

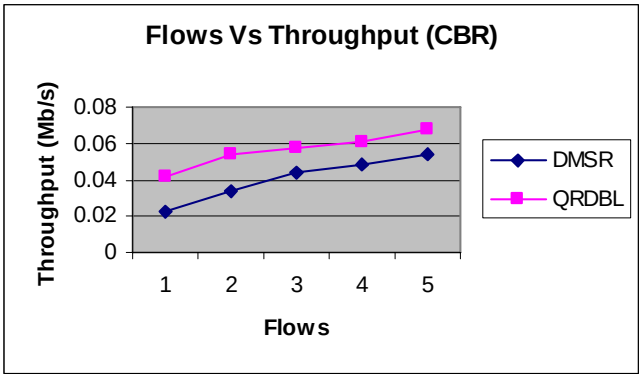

Figure 5: Flows Vs Throughput

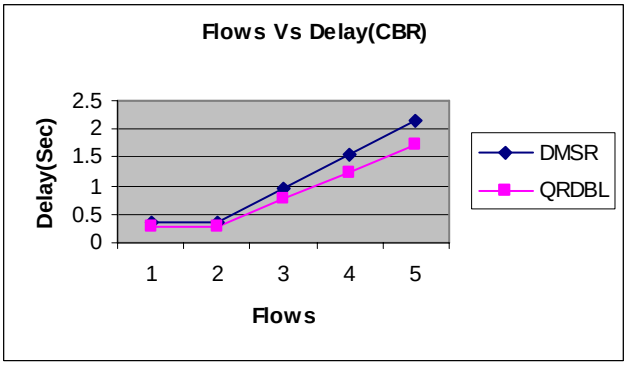

Figure 6: Flows Vs Delay

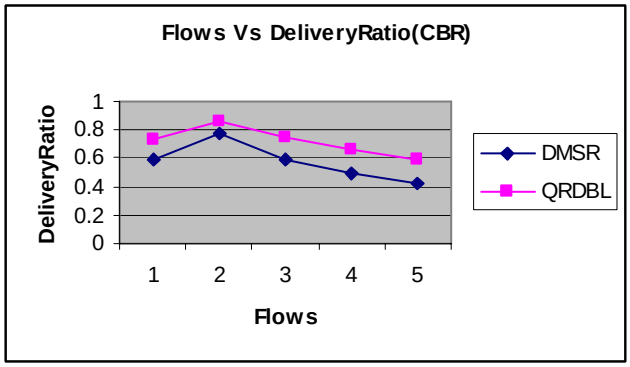

Figure 7: Flows Vs Delivery Ratio

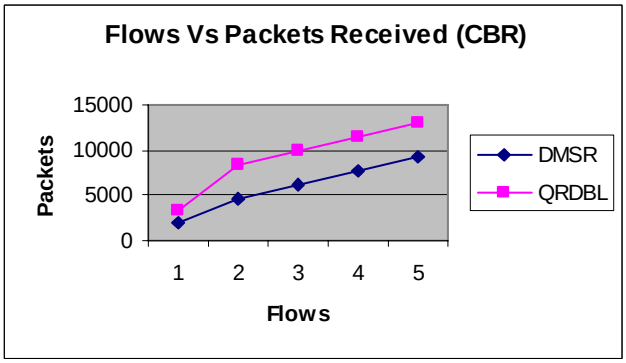

Figure 8: Flows Vs Packet Received

Figure 5 to 8 show the throughput, delay, packet delivery ratio and packets received for DMSR and QRDBL when the number of flows increased. From the figures, it can be seen that QRDBL outperforms DMSR in terms of throughput by 20%, in terms of delay by 20%, delivery ratio by 21% and packets received by 36%.

(ii) Based on Rate

The transmission rate of CBR traffic is varied as 50,100,150,200 and 250Kb and the performance metrics are measured for both the techniques.

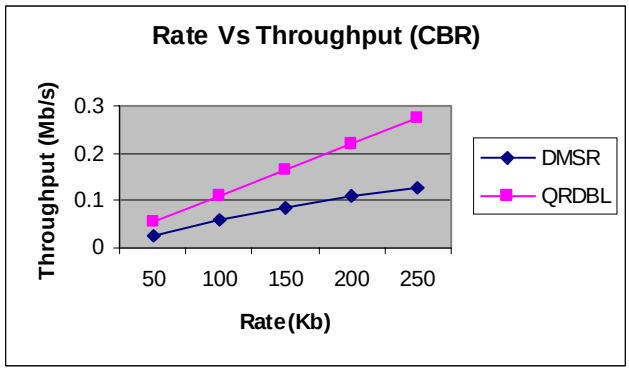

Figure 9: Rate Vs Throughput

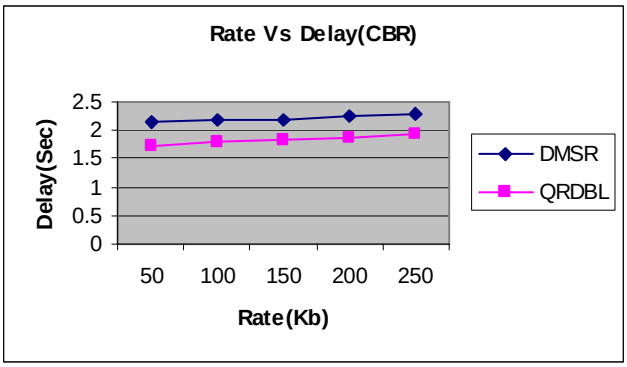

Figure 10: Rate Vs Delay

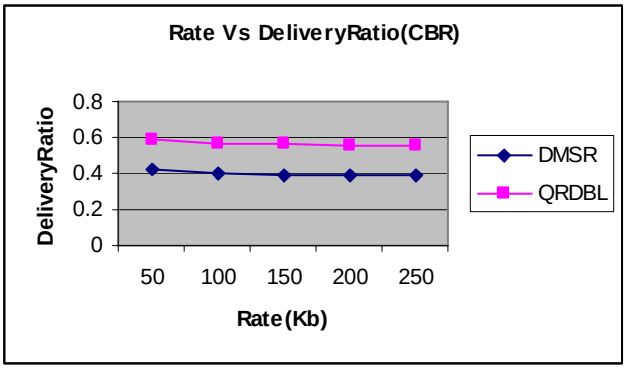

Figure 11: Rate Vs Delivery Ratio

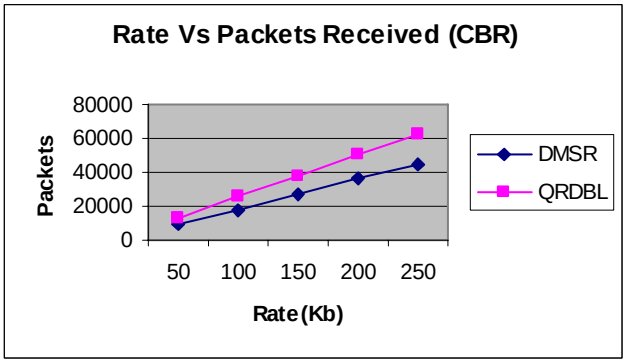

Figure 12: Rate Vs Packet Received

Case-2 (Video Traffic Scenario)

(i) Based on Flows

The number of Video traffic flows is varied from 1 to 5 and the performance metrics are measured for both techniques.

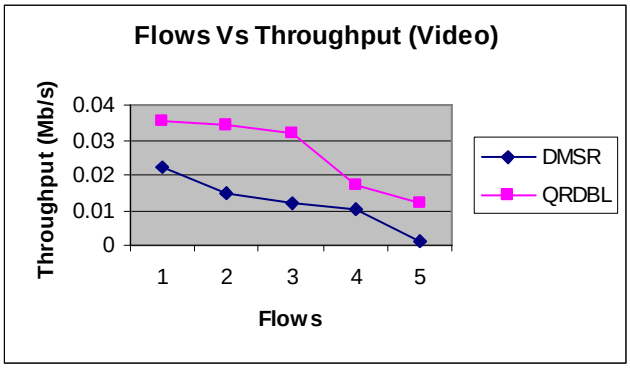

Figure 13: Flows Vs Throughput

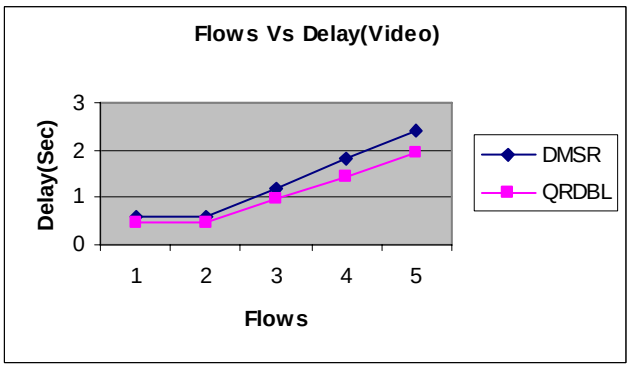

Figure 14: Flows Vs Delay

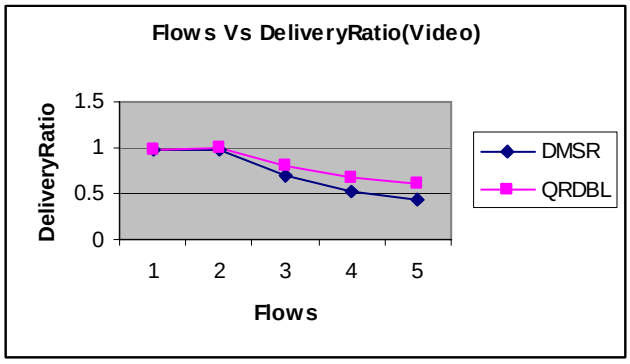

Figure 15: Flows Vs Delivery Ratio

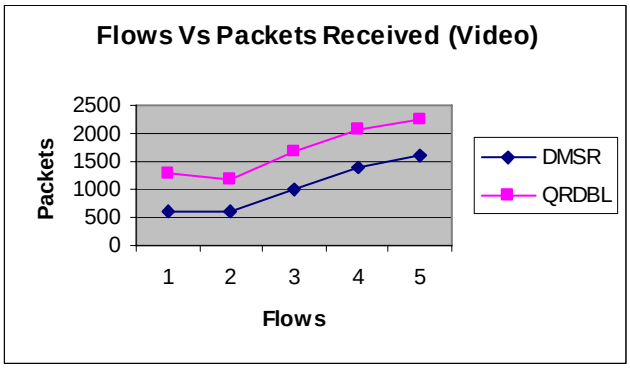

Figure 16: Flows Vs Packets Received

Figure 13 to 16 show the throughput, delay, packet delivery ratio and packets received for DMSR and QRDBL when the number of flows is increased. From the figure, it can be seen that QRDBL outperforms DMSR in of throughput by 49%, delay by 20%, delivery ratio by 14% and packet received by 40%.

(ii) Based on Rate

The transmission rate of Video traffic is varied as 50,100,150,200 and 250Kb and the performance metrics specified above are measured for both the techniques.

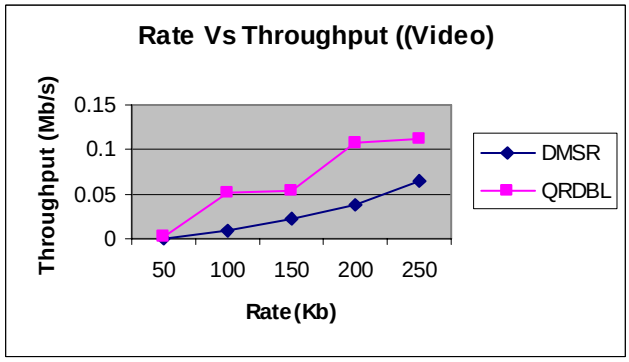

Figure 17: Rate Vs Throughput

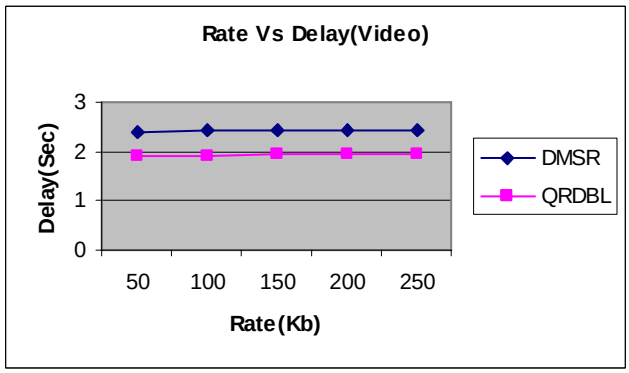

Figure 18: Rate Vs Delay

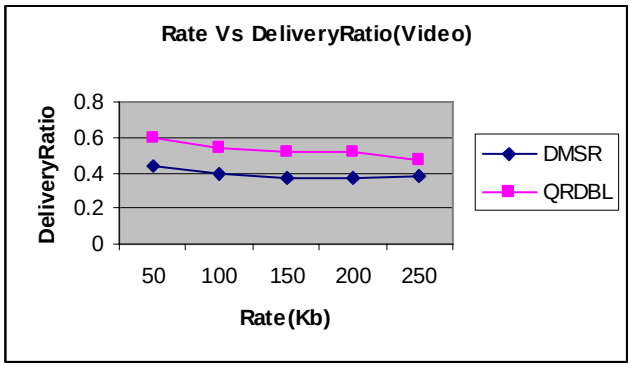

Figure 19: Rate Vs Delivery Ratio

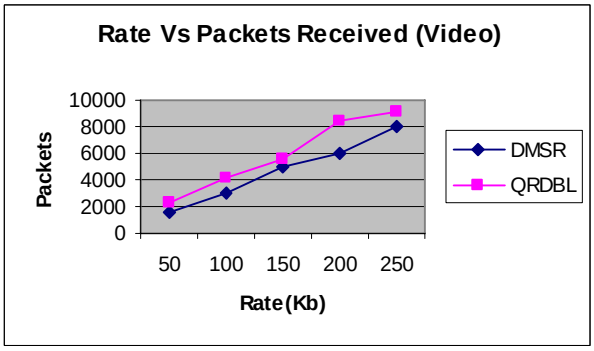

Figure 20: Rate Vs Packet Received

Figure 17 to 20 show the throughput, delay, packet delivery ratio and packets received for DMSR and QRDBL when the number of flows is increased. From the figure, it can be seen that QRDBL outperforms DMSR in of throughput by 59%, delay by 20%, delivery ratio by 26% and packet received by 22%.

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Conclusion

The QoS metrics like bandwidth and delay are considered in this paper. Here the Real-time route discovery and reply phase are considered to provide the quality of service. To provide the delay requirements of hard real-time traffic the new solution is proposed based on the expiration delay to deadline. Each packet of the admitted real time flow is transmitted from the source to the destination before the expiration delay to deadline. Route is selected by considering bandwidth metrics from the cache by applying the Route Selection Based on QoS Metrics from the Cache technique.

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