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Traffic Light Based Multipath Routing Mechanism for Non-Geostationary Satellite IP Networks

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Abstract: The traffic light based multipath routing mechanism for NGEO satellite IP networks includes a set of traffic lights that indicates the status of congestion at both the current node and the next node. Based on the real time colours indicated as by the traffic lights each packet can adjust its route to another path from its pre-calculated route to the destination in order to avoid congestion. Thus each packet can obtain an approximately optimal transmission path by this real time adjustment. It can also provide a better traffic distribution in case of increased network traffic by means of multipath routing mechanism. Moreover the public waiting queue scheme reduces the packet drop rate by utilizing the free spaces of the buffer queues.This mechanism of TLR also incorporates a defence scheme to eliminate the phenomenon of endless-loop of routing.

Keywords: NGEO satellite network, traffic light, intelligent routing, packet drop rate, load balance.

1. INTRODUCTION

Satellite networks are able to provide worldwide communication environments since it have significantly wide coverage and are effective in facilitating simultaneous modes oftransmissive communications. Recently, the networks using non geostationary Earth orbit (NGEO) satellites have attracted attention for their usability.

Non-geostationary satellite networks provide inherent multicast capability and global coverage potential with low latency and power requirements. For the efficient data transmission in NGEO satellite networks an effective routing strategy is required. However, due to the periodic rotation of the satellites around the earth, NGEO satellites have dynamic and predictable topologies with frequent link switching causes difficulty for a proper route planning and therefore the traditional routing strategies cannot be applied directly.

Previous routing strategies mainly focus on finding the transmission path which has shortest end to end propagation delay. These simple strategies may get failed whenever there is a heavy network traffic that may leads to abnormal increase in the packet drop rate at the network layer and also the cumulative queuing delay during transmission becomes non-ignorable large. The communication demands will be different for every regions of earth because of the population difference and this may leads to an unbalanced traffic distribution over the entire satellite network constellation. If the propagation delay is considered only as the routing metric there may some heavily congested nodes in the pre-routed paths that may leads to high packet drop rate.

Thus in order to deal with the above situations we have to consider the expected queuing delay and congestion status into account for the optimal transmission of packets through the routes. The multipath routing mechanism can be introduced to better use the free spaces in inter satellite links and can achieve a proper load balance over the entire satellite constellation. Based on the above situations, a traffic light based multipath routing mechanism (TLR) that may relive the situation of long queuing delay, increased packet drop rate and unbalanced traffic distribution in NGEO satellite networks by considering both the expected and the real time queuing delays, considers both current hop and the next hop congestion and adjusts the pre-calculated route based on the real time situation.

2. TLR MECHANISM

TheNGEO satellite constellation is multihop iridium like backbone structure that consists of S=M*N

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Satellites, where M is the number of orbits and N is the number of satellites at each orbit. There will be buffer queues allocated for each ISL in order to store the data packets temporarily that have to be sent out to the next hop by the ISL. Each ISL maintains a traffic light to indicate the traffic condition in the particular direction. Moreover the public waiting queue constructed by borrowing the free space from the buffer queue reduces the packet drop rate by storing the data packets for further processingunder heavy traffic conditions in any direction.

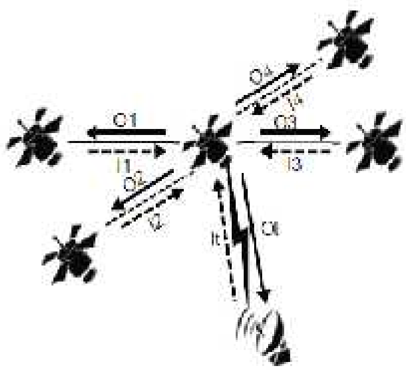

Fig 1. Satellite Linking Relationships

2.1 Traffic Light Setup and Update

1) Step 1, Consider the Current Hop

Inorder indicate the congestion status at each buffer queues and to avoid the unwanted packet loss the taffic lights are deployed at each directions. In case of current hop we here by consider the queue occupancy rate (QOR_n) which is defined as the rate of number of packets in the queue to the length of the queue of the buffer queue Q(n). When the QOR is less than or equal to the pre-set threshold value T_1, the traffic light colour will be GREEN, which indicates the queue is free and some more packets can be inserted over there. When the QOR is above T_1 and less than another pre-set threshold value T_2 the traffic light colour will be YELLOW, which indicates that the buffer queue is slightly congested and the packets has to be rerouted to some other directions. Finally when the QOR is greater than or equal to T_2 the traffic light colour will be RED which prevents the further insertion of data packets in the queue that may leads to packet drops.

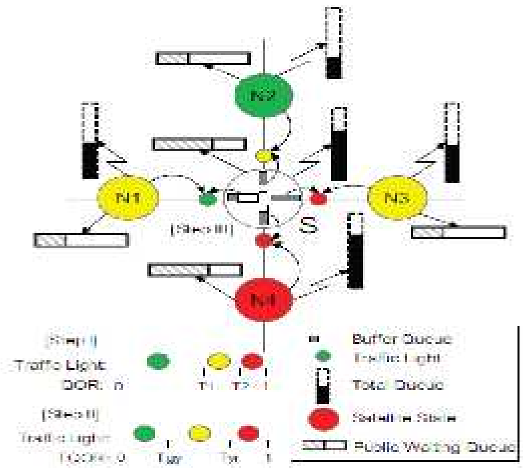

Fig.2 Traffic Light Colour Setting Scheme

In order to achieve the expected TLR mechanism each satellite has to wait a time Δt (the time interval) so as to recognise the changes and shifts for the threshold values T_1 and T_2.

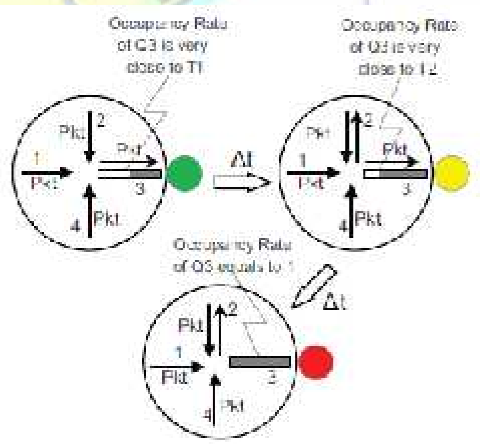

Fig 3. Extreme Situations for T_1 and T_2

Thus T_1 and T_2 should satisfy the following criteria to ensure that the QOR not grows beyond T_2;

$$(T2 - T1)\, L \cdot APS \geq (I - O)_{max} \cdot \Delta t \qquad (1)$$

L is the length of the queue, APS represents the average packet size and $(I - O)_{max}$represents the maximum difference between input and output traffic rates.

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Similarly in order to avoid the packet drop due overflow of the buffer queues T_2 must satisfy;

$$(1-T2)\cdot L\cdot APS \geq (I'-O')max\cdot \Delta t \qquad (2)$$

Thus from (1) and (2) we can obtain,

$$T1 \leq 1-\frac{[(I-O)max+(I'-O')max]\cdot \Delta t}{L\cdot APS} \qquad (3)$$

$$T2 \leq 1-\frac{[(I'-O')max]\cdot \Delta t}{L\cdot APS} \qquad (4)$$

2) Step 2, Consider the Next Hop

Inorder to achieve low packet loss and queuing delay the next hop congestion status has to be considered. The Total Queue Occupancy Rate (TQOR, considering the entire queue as whole) is taken into account for determing the traffic light colour. If TQOR is below the threshold value T_{gy} the traffic light colour will be GREEN. If the TQOR increases to the threshold value T_{gy}then the traffic light colour will be YELLOW that indicates the chances for congestion with further packet insertion. If the TQOR increases to the threshold value T_{yr} then the traffic light colour will be RED. Each satellite informs the state changes to the neighbours and there by each satellite should know about the near real time congestion status of its neighbours. Now cosidering the entire buffer queues Q(d_1, d_2, d_3, …..,d_k) tha values of T_{gy} and T_{yr} should meet,

$$Tgy \leq \frac{1}{k-1} \qquad (5)$$

$$Tyr \leq \frac{p}{k-1} \qquad (6)$$

Where p reprents the candidates next hop direction and k represents the neighbours.

3) Step 3, Consider both current hop and the next hop

Finally both the current hop QOR and the next hop TQOR are combained to detemine the final traffic light colour in each directios of the entire satellite constellation.

The public waiting queue stores the pasless packets and there by avoids the packet drop rate. The length of the publc waiting queue has some limitations of size. Thus it incorporates a field called as TTW(Time To Wait) field allocated in it. Whenever the traffic light colour turns to RED the TTW value of the packet will be reduced by value of 1. When the TTW value is reduced to 0 the packet will get discarded.

The TLR mechanism always calculates two best routes for each pair of source and destination periodically. When the packets arrive in the network it chooses the next hop of the best route (BR.nxtHOP) for transmission. If the traffic light colour in BR.nxtHOP is RED as the direction is congested then it goes for the second best route (SBR.nxtHOP) for the transmission task. If both directions shows RED the the packets get inserted to th public waiting queue temporarily.

The TLR mechanism incorporates a special mechanism to avoid the endless loop of routing. Due to routing loop problem a packet starting from a node travels through several nodes and return back to the same starting node to form a loop and this may disable the network.Thus inoder to avoid this a method in which the packets records every passed hops in its header field as it travels in the network. So whenever the data packets arrive it will checks for the node ID at its header field and if it appears, it will be ruled out.

3. RESULTS AND DISCUSSION

The simulations are carried out using the Network simulator 2 inorder to verify the performance of TLR mechanism.

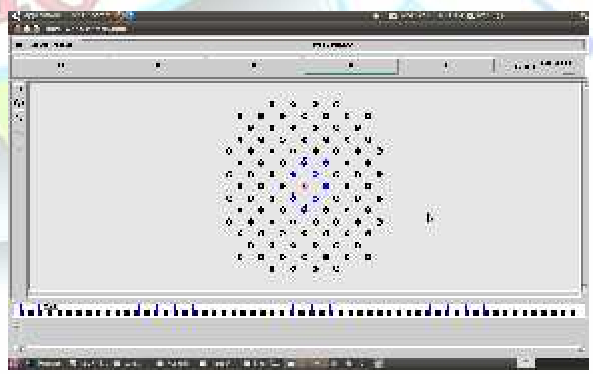

Fig.3.1 Node formation

Fig 3.1 shows that the node formation. The number of nodes required for data transmission is formed. The blue colour node indicates the primary users and the red colour node indicates the base station.

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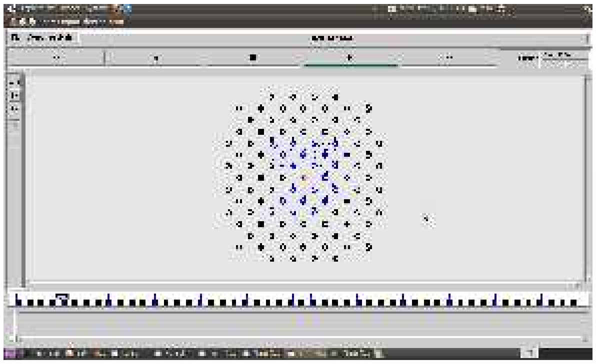

Fig.3.2 Data transmission between nodes

Fig 3.2 shows that the number of packets transmitted from the node to base station. At a time data transmission occursdifferent nodes.

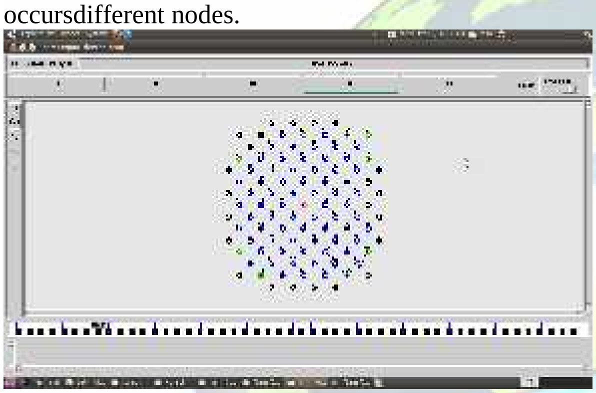

Fig. 3.3 Data transmission between primary user and secondary users

Fig. 3.3 shows thee data transmission occurs from the primary user to the secondary users and also the secondary user to the primary users.

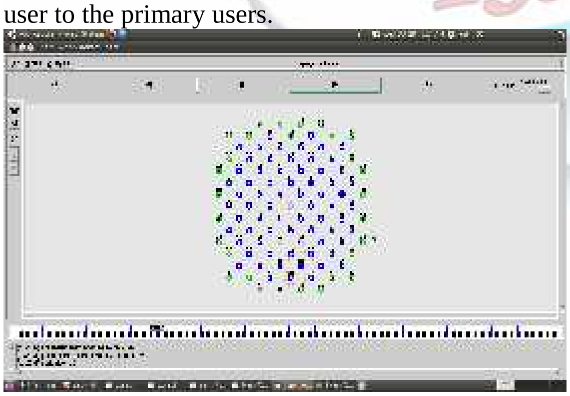

Fig. 3.4Traffic flow

Fig. 3.4 shows that the traffic occurs between the internal nodes and it's avoided by the secondary users. Here clear traffic from 67 node to 45 node.

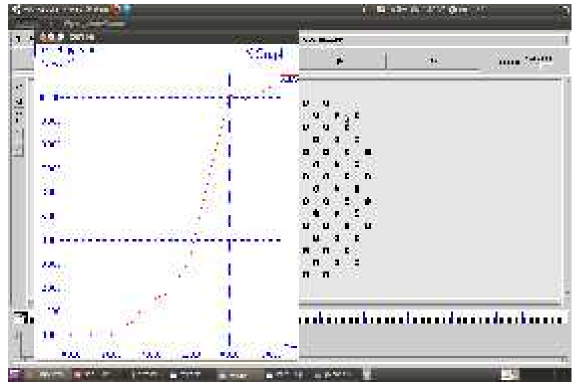

Fig. 3.5 Delay graph

Fig. 3.5 shows that the delay graph. The delay decreases from the previous method. It also reduces the time delay and packet transmission delay.

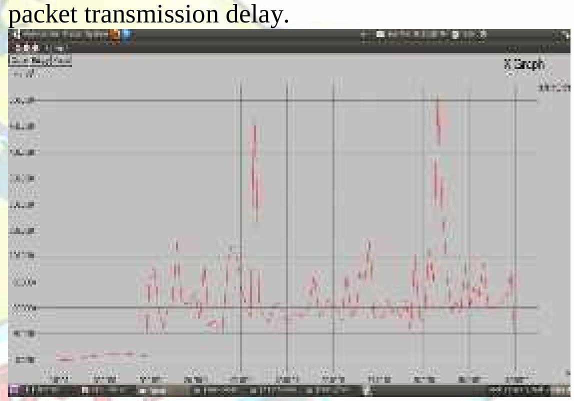

Fig. 3.6 Bandwidth graph

Fig. 3.6 shows that the bandwidth efficiency. This method utilizes the total network bandwidth efficiency. The packets transmitted between the utilization of the total networks.

4. CONCLUSION

In this paper, the traffic light based multipath routing mechanism for NGEO satellite IP networks adjusts the pre-calculated route based on the real time condition in the satellite networks. The traffic lights deployed in each ISL shows the congestion status and then re-route the network paths based on the traffic light colours by considering the QOR along the current hop and TQOR along the next hop. The periodic state changes for satellite networks are informed to the neighbours based on the total queue occupancy rate. Moreover the public waiting queue temporally stores the pass less data packets and there by reduces the packet drop rate. The TLR mechanism avoids the endless loop of routing that may causes increased cpu

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processing and large bandwidth usage. It can able to achieve a proper and balanced traffic distribution over the entire satellite constellation. Thus the TLR mechanism provides better performance in avoiding congestion and increasing the total throughput.

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