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Sequential Explanation

The development of routing algorithm for LEO satellite networks

Keqiang Li once said the Internet is one of the greatest inventions of human beings. Information can be transferred instantly even between people who is miles apart. However, there is no terrestrial network in more than 70% places of the earth, including seas and backward countries. To achieve the goal of global coverage, satellite networks have been a hot field. With advantages such as lower propagation delay and the ability to provide all-weather service, Low Earth Orbit(LEO) satellite networks are studied most. And the routing algorithm is one of the most import parts of this study.

Unlike terrestrial networks, the topologies of LEO satellite networks change frequently due to the periodic move of satellites. It is also the biggest challenge for routing algorithms. Previously, because the movements of satellites are predictable, routing algorithms divide one operation period into several time slices. In each time slice, the network topologies do not change and thus static routing calculation method like Dijkstra can be used directly and propagation delay is used as the weight of link. This kind of strategies are simple to operate and can get rather good results if the network traffic is not heavy. However, with the explosive growth of information, considering propagation delay only is not enough and queuing delay can be non-negligible large. To gather all queuing delay of satellite links, an “Orbit Speaker” scheme is proposed. Meanwhile, queuing delay prediction method is proposed to make algorithms more accurate. But the convergence time of this kind of algorithm is not satisfying. Under high traffic load, the queuing delay collected in this scheme may be outdated. Besides, due to non-uniform distribution of satellite users, some links are expected to be heavily loaded or even congested while others remain underutilized. To avoid congestion and achieve better load distribution, an explicit load balance scheme is proposed. When a satellite is about to get congested, it will send a notification to its neighbors and request its neighbors to decrease the sending rate. But without considering link congestion, packets may be dropped before being sent to next hop. To cope with this issue, another strategy is proposed. Packets may be rerouted considering both current hop and the next hop. Although these methods reduce packet drop rate, the end-to-end becomes unstable and sometimes abnormally high for they do not solve high convergence time problem completely. Till recently, this problem is solved using a state-aware routing model. In this model, the satellite link is classified into several states base on the queue occupancy rate. To ensure the chosen routing paths are as optimal as possible, link states are monitored and will be broadcast to other satellites immediately when changes. And when receiving link state change notification, the routing table is dynamically updated using an efficient SPT update algorithm.

Along all these years, lots of efforts were put into the development of routing algorithm for LEO satellite networks. Each algorithm has its own advantages and the judge of one algorithm should be based on the situations at that time.