Grouping Asynchronous Link Switching Method in Satellite Optical Network

Fangfang Zheng, Guiming Lu
School of Information Engineering,
North China University of Water Resources and Electric Power
Zhengzhou,450046, China

Abstract

To solve the system performance deterioration caused by synchronous switching in satellite optical network, this paper proposed a grouping asynchronous switching method. The simulation results show that the proposed scheme can effectively improve delay performance.

Introduction

Nowadays, with the increasing application of space in human society, more and more attention is given to satellite optical communications because of its large communication capacity, strong anti-interference ability, good confidentiality and other advantages. Laser inter-satellite link (ISL) is the primary way to achieve data interaction in a satellite network. Comparing with microwave ISL, laser ISL has a capture, tracking and aiming (ATP) process when establishing a new link. That is to say, the reconstruction time of laser ISL is long and not negligible. Hence, it is necessary to consider that the influence of partial laser ISLs disconnection on system performance when the topology changes.

we proposed a grouping asynchronous link switching (GALS) method to address the system performance deterioration caused by synchronous handover method when topology changes in satellite optical network. In this method, the topology structure between different orbital altitudes is regarded as a bipartite graph. We will do the merge and intersect operations on adjacent bipartite graph, which will generate multiple subgraphs. According to the common edge of the subgraph and the previous bipartite graph, the laser ISLs will be switched as a group.

GALS scheme

Firstly, convert the topological structure into the corresponding bipartite graph, denoted as Gi. We take two consecutive topological states and denote them as Gi and Gi+1 respectively. And we will delete the ISLs that have not changed. Then, combining two bipartite graphs to get a graph that contains all the mutative ISLs. ISLs that change before and after topology switching are mainly classified into two types. One is that the LEO satellite at one end of the link has changed, but the MEO satellite has not changed. The other is the case that the MEO satellite has changed, while LEO remains unchanged. Finally, merging this graph with the former original bipartite graph, we will get multiple independent subgraphs. Each subgraph means a switched group. In other words, the number of subgraphs is also the number of groups for asynchronous group switching. Simultaneously, the common edge of the subgraph and the former bipartite graph is the link in the group that needs to be switched at the same time. Specific details of GALS method are shown in Figure 1.

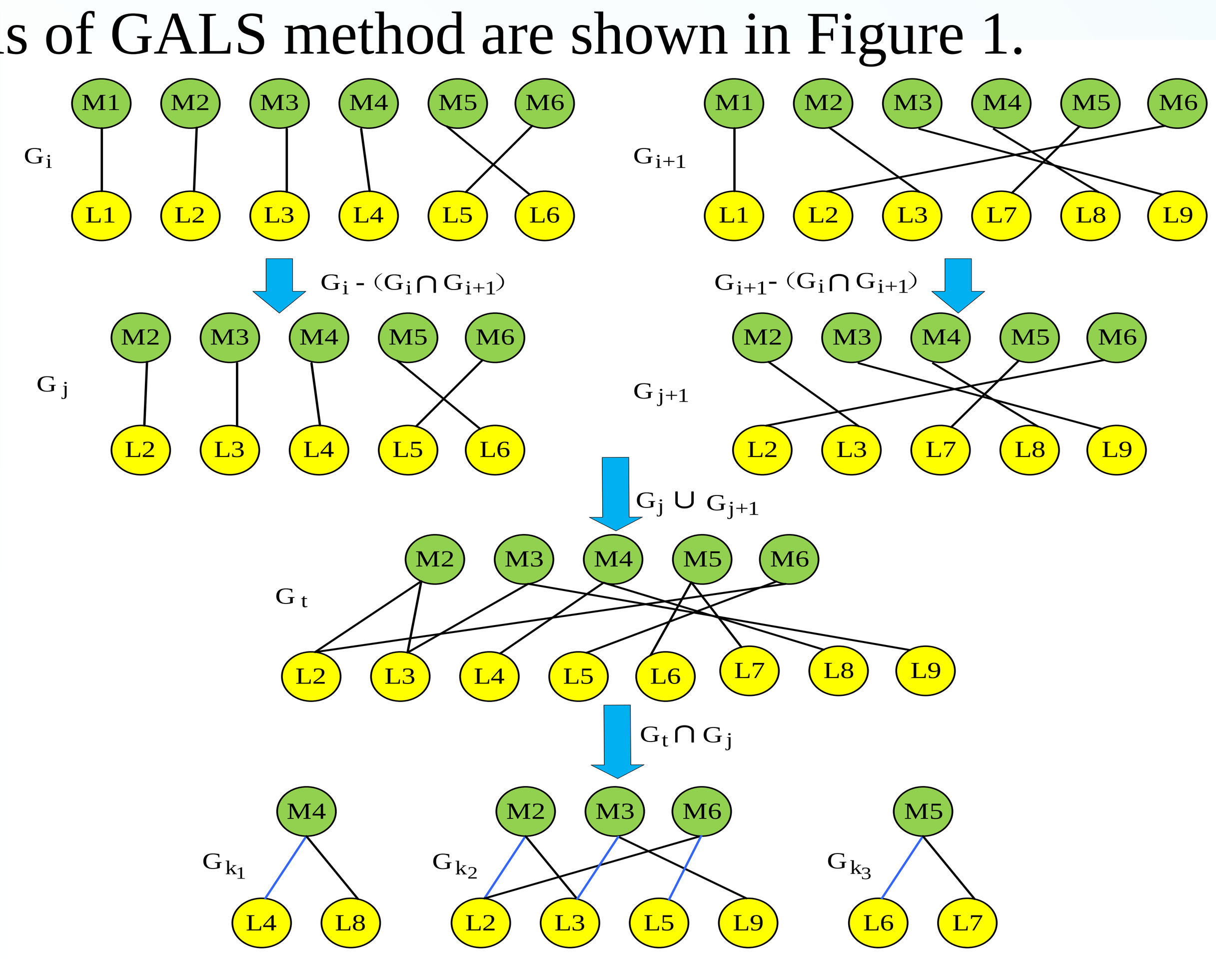

Fig.1 The principle of GALS scheme.

Experiments and Results

In this subsection, the inter-layer ISL between LEO constellation and MEO constellation is taken as an example for performance simulation. It is significant to note that each satellite only has no more than 4 laser communication terminals (LCT). The specific parameters of LEO and MEO constellations are shown in Table I. Moreover, the reconnection time of LCT is not more than 30 seconds.

Constellation Parameters	*Constellation Type*	
	LEO	*MEO*
Altitude (km)	500	21528
Inclination (degrees)	35	55
Number of Planes	5	3
Number of Sats per Plane	21	8

Table I Constellation parameters.

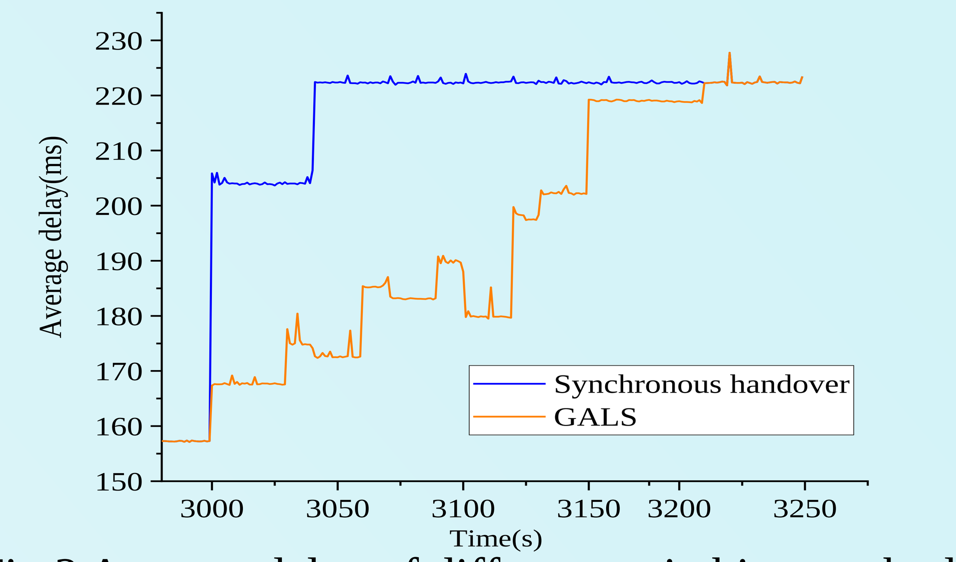

Fig.2 Average delay of different switching methods.

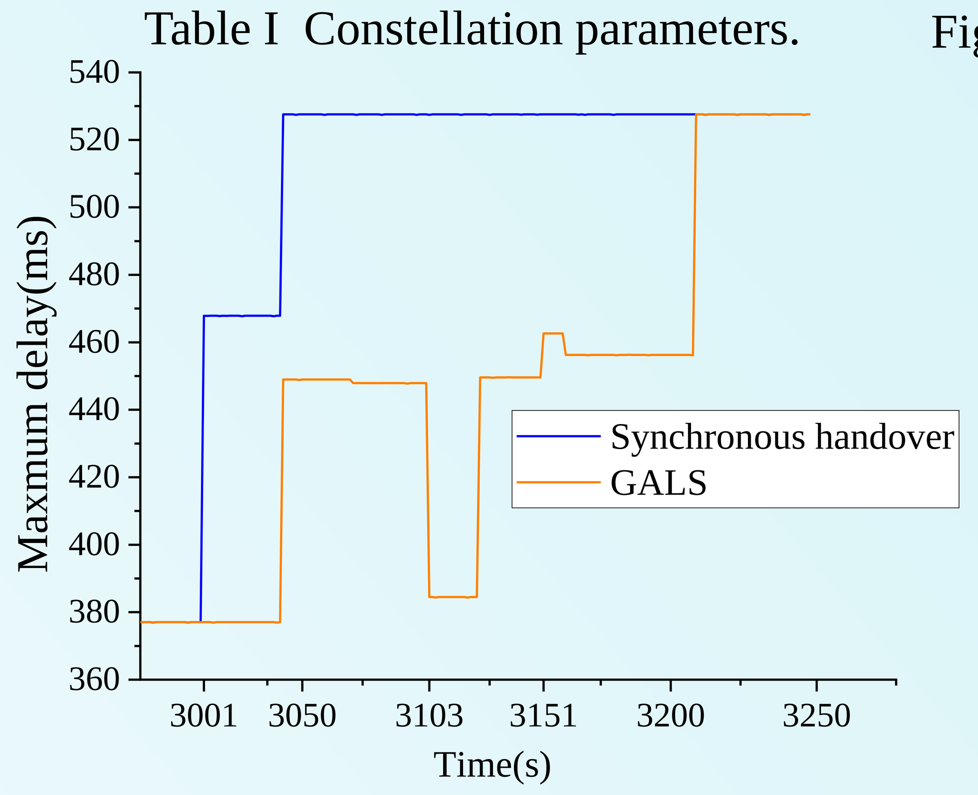

Fig.3 Maximum delay of different switching methods.

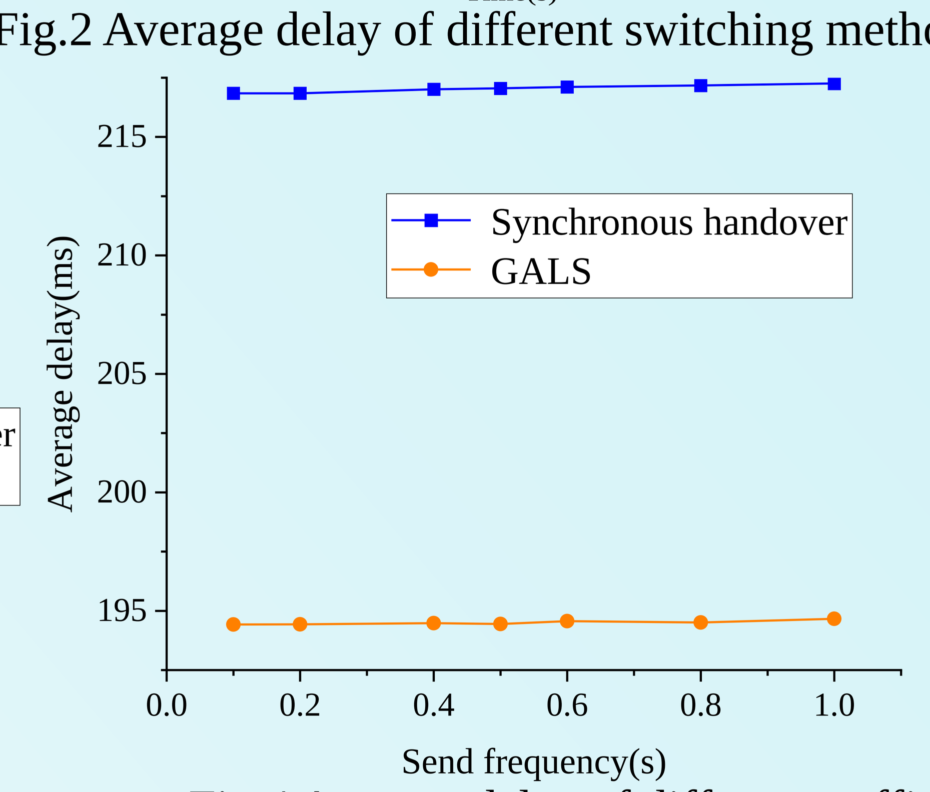

Fig.4 Average delay of different traffic with different methods.

The average delay and maximum delay performance under different handover methods are illustrated in Fig. 2 and Fig. 3. It can be observed that the average delay and maximum delay of GALS scheme are lower than those of synchronous switching scheme. The reason is that the number of links in GALS scheme is far less than that of synchronous switching method, resulting in reduced latency. In general, GALS scheme can improve the average delay and maximum delay performance by about 10% and 12.2% respectively compared to the synchronous handover scheme.

Fig.4 shows that the average delay of GALS method is always lower than synchronous switching method under any flow intensity. Comparing with synchronous handover method, the average network delay of GALS scheme is improved about 10.4%. This is because all the links that need to be switched to the synchronous switching method are all broken at the same time. This makes the number of data transmission hop increase, resulting in increased network delay.

Conclusion

We proposed a grouping asynchronous link switching method to solve the system performance caused by synchronous handover method in satellite optical network. The proposed scheme regarded the topology of inter-layer links between different orbital altitudes as a bipartite graph. The scheme performs union and intersection operations on consecutive bipartite graphs and obtains their individual subgraphs. By intersecting an independent subgraph with the previous binary graph, multiple links requiring group switching can be achieved. The simulation results demonstrate that the proposed scheme can improve the average delay and maximum delay by about 10%,12.2% respectably compared to synchronous handover method. Moreover, we also compare the average delay performance at different flow intensities. The average delay performance of proposed method is always better than synchronous handover scheme.