A Large-Scale Emulation Method of AOS Protocol Based on Space Network Emulation Platform

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Abstract. Advanced Orbiting System (AOS) protocol is a link layer protocol for space network communication specified by CCSDS. On the basis of the proposed semi physical emulation platform in our previous work, this paper implements the AOS gateway and further proposes the design of AOS scale emulation. Corresponding experiment is conducted to validate the scale AOS emulation in the proposed emulation platform. The experimental results show that the large-scale AOS protocol emulation scheme is effective and any two nodes can communicate with each other.

Keywords: AOS · Space network · Scale emulation · Semi physical emulation platform

1 Introduction

Space Information Networks (SIN) are network systems based on space platforms, such as satellites, stratospheric balloons, and so on [1]. In recent years, with the continuous improvement and development of inter satellite communication technology, its application prospects and economic value are also increasing [2–4]. Those technologies used in the terrestrial network may not be compatible with those technologies used in SIN [5]. To solve the problem of the difference between the terrestrial network and the space network, many new technologies have been developed. These technologies need to be verified repeatedly before they can be put into used. We have proposed the semi physical emulation platform for space networks to verify these technologies [6].

The general structure of the semi physical emulation platform for space networks is shown in Fig. 1. According to the space network protocol standard specified by CCSDS [7], the Advanced Orbiting System (AOS) protocol is widely used in the data link layer of various space networks except similar parts of the terrestrial networks [10]. Obviously, the emulation platform should support AOS emulation.

However, AOS frame cannot be transmitted in Ethernet. At present, the emulation method of AOS protocol is to add AOS frame header for data packets and use channel simulator such as the space network channel or cortex (CRT) to realize frame

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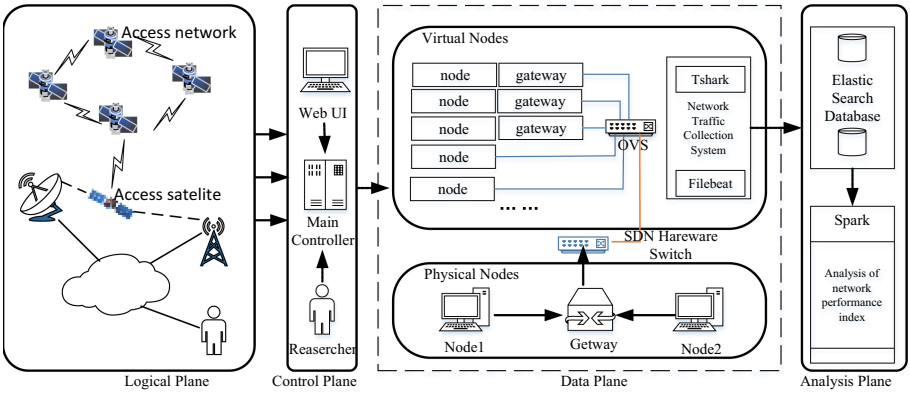


Fig. 1. Architecture of emulation platform

transmission [11–14]. Although these methods can truly restore the communication process of AOS protocol, they are expensive and cannot be used for large-scale emulation. Therefore, an AOS emulation method based on emulation platform is urgently needed to realize AOS scale emulation.

This paper implements the AOS gateway and further proposes the method of AOS scale emulation based on emulation platform, and the effectiveness of this method is verified.

The rest of the paper is organized as follows. In Sect. 2, according to the requirements of emulation platform, the design of AOS large-scale emulation is proposed. In Sect. 3, we implement the design and tests the related functions. Finally, the conclusion is made in Sect. 4.

2 Design for AOS Scale Emulation

2.1 Design of the AOS Gateway

In the emulation platform, AOS protocol emulation is mainly realized by AOS gateway, and the process is shown in Fig. 2. The gateway removes packet's Ethernet header and adds AOS frame header, IP header and Ethernet header. Packets reception is a reverse process.

The structure of AOS gateway is shown in Fig. 3. In a point-to-point emulation scenario, the packet of the sender is captured by the gateway. After removing its Ethernet packet header, it is sent to the next program to encapsulate the AOS frame header. In order to transmit AOS frame in Ethernet, it is necessary to add IP header and Ethernet header to AOS frame. After completing the above steps, the packet can be sent to the network.

Similarly, after receiving a packet with AOS frame, the gateway first removes the external Ethernet header and IP header. The remaining AOS frame structure is sent to the next program. The program sends the IP packets contained in the AOS frame to the next program, encapsulates the Ethernet head and sends it to the host.

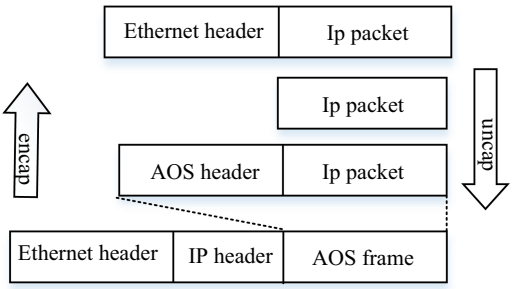


Fig. 2. AOS emulation principle

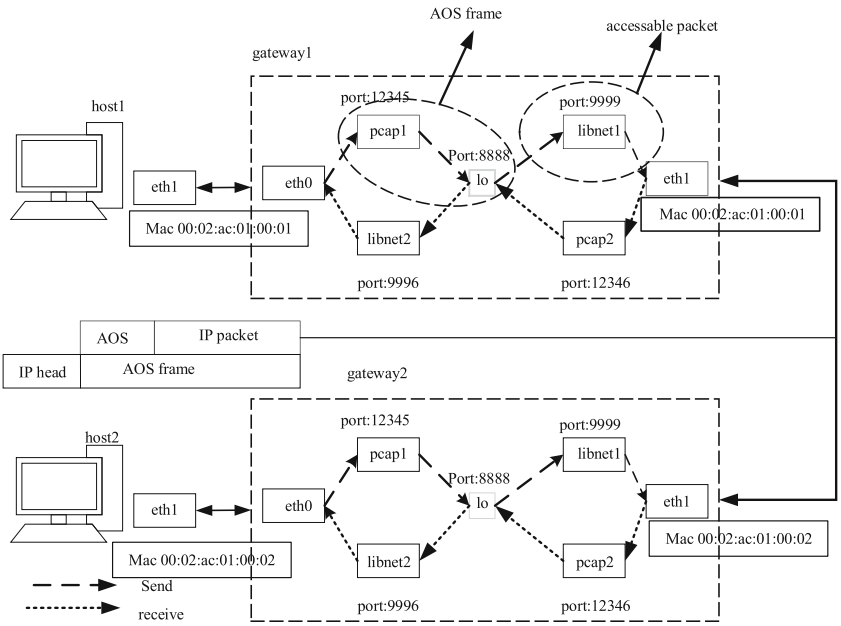


Fig. 3. Architecture of gateway

2.2 Method of AOS Scale Emulation

The implementation of AOS scale emulation is based on the multi links information stored in the database, as shown in Fig. 4. In the figure, each link is determined by two gateways. All links correspond to the data table.

The original Ethernet header was removed during packet processing. In order to transmit packets in the network, we need to construct the Ethernet header again. Therefore, the MAC address of the gateway should also be stored in the data table. The process of automatically uploading MAC address by gateway is shown in Fig. 5. The gateway reads the local MAC address and the corresponding network card name,

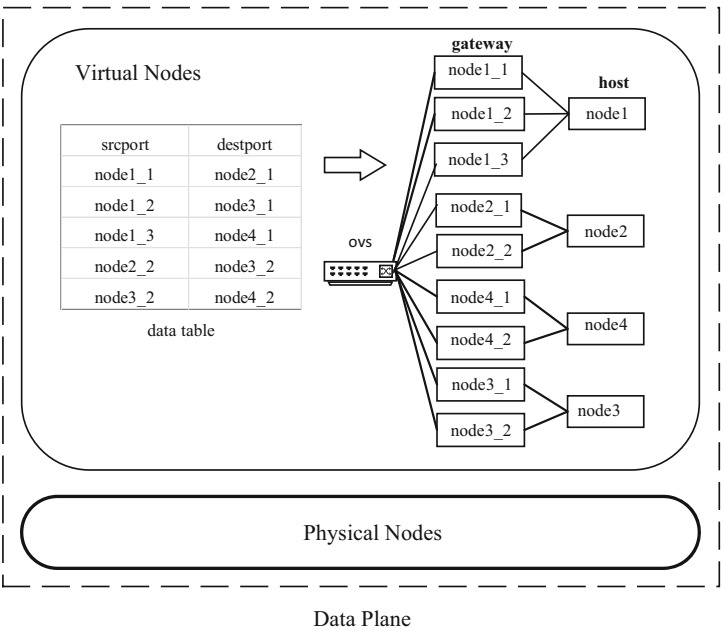


Fig. 4. Structure of AOS scale emulation.

uploads them to the corresponding location in the data table, and reads the MAC address of the destination gateway.

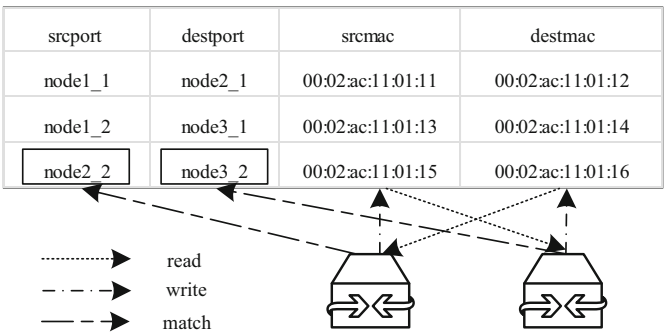


Fig. 5. Format of data table

3 Experiment and Discussion

3.1 Experimental Scenario

The AOS scale emulation design is verified by experiments. In order to be able to test the function of AOS gateway in a comprehensive way, we use the network topology

shown in the Fig.6. Six nodes are interconnected, and host1 has 5 gateways corresponding to other hosts. In this structure, host1 can communicate with other hosts.

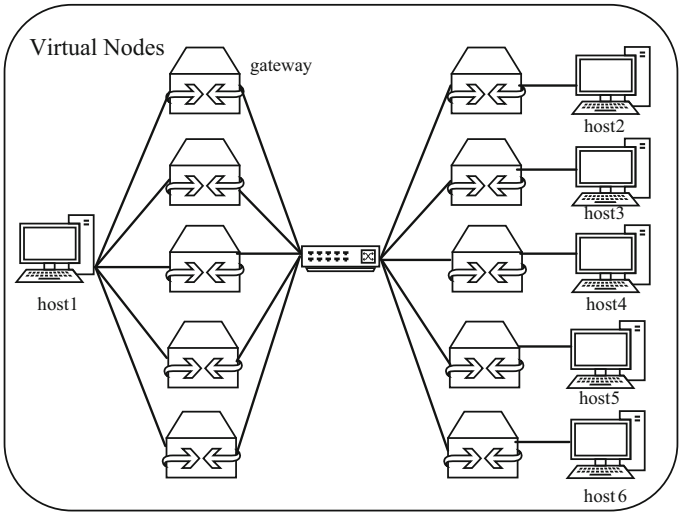


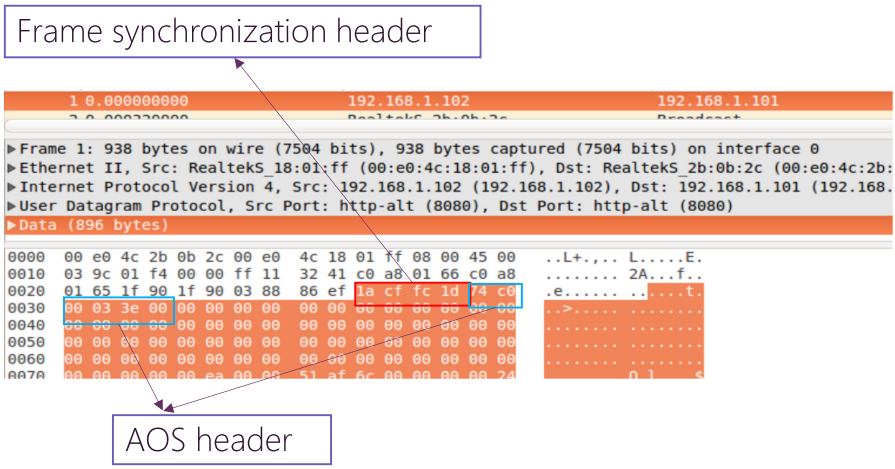
Fig. 6. Experimental link

Each network card of the gateway is listening by a program to capture the packets that need to be processed. The network card of the gateway is monitored by the program. The program captures and processes the packets passing through the network card. Only the packets coming from outside the gateway need to be processed, so the MAC address is used as the basis of whether to capture the packets.

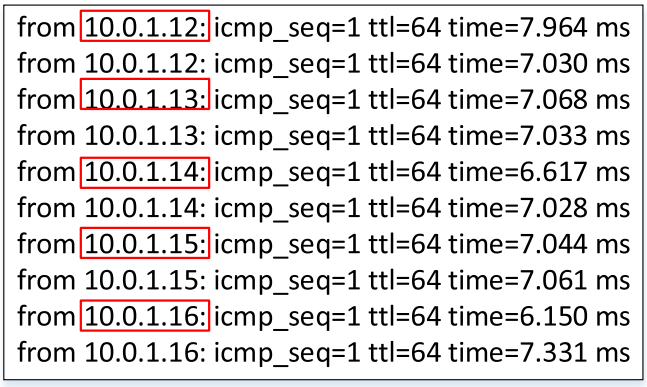
3.2 Results

The communication between nodes can effectively verify the function of the design. To prove this, host1 sends ICMP request messages to other five nodes. The result is shown in Fig. 7(b). Obviously, the communication between two end nodes needs to go through gateway and forwarding node. If ICMP reply message can be received, it indicates that AOS gateway can normally perform encapsulation and uncapsulation services. The packets structure through the gateway is shown in Fig. 7(a).

The experimental results show that two nodes can communicate with each other and the packets contain the structure of AOS frame header.



(a)



(b)

Fig. 7. Experimental result.

4 Conclusion

In this paper, combined with software emulation and database, the design of AOS scale emulation based on the semi physical emulation platform for space networks is proposed. Corresponding results show that AOS large-scale emulation realizes the normal communication function. It is an ideal way to realize AOS protocol scale emulation.

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References

1. Bai, L., de Cola, T., et al.: Space information networks. Wirel. Commun. **26**(2), 8–9 (2019)
2. Deren, L.I., Shen, X., Gong, J., et al.: On construction of China's space information network. Geomatics and Information Science of Wuhan University (2015)
3. Mukherjee, J., Ramamurthy, B., et al.: Communication technologies and architectures for space network and interplanetary internet. Commun. Surv. Tutor. **15**, 881–897 (2013)
4. Yang, Z., Hewu, L., Qian, W., et al.: Simulation platform for inter-domain protocols validation of integrated space-terrestrial network. J. Commun. **40**, 1 (2019)
5. Yu, Z.A., Bo, W.B., Bg, A., et al.: A research on integrated space-ground information network simulation platform based on SDN. Comput. Netw. **188**, 107821 (2021)
6. Lu, T., et al.: A scalable network emulation architecture for space internetworking. In: 2016 IEEE International Conference on Communication Systems (ICCS), pp. 1–5 (2016). https://doi.org/10.1109/ICCS.2016.7833653
7. what is CCSDS?. https://public.ccsds.org/default.aspx
8. Zhao, J., Zeng, L., Yang, W., Qian, L.: AOS space data link protocol performance analysis and simulation. In: IET International Conference on Communication Technology and Application (ICCTA 2011), Beijing, pp. 287–290 (2011). https://doi.org/10.1049/cp.2011.0676
9. Li, H., Zhou, H., Zhang, H., et al.: EmuStack: an OpenStack-based DTN network simulation platform. In: International Conference on Networking & Network Applications. IEEE (2016)
10. Hooke, A.J.: CCSDS advanced orbiting systems: international data communications standards for the space station freedom. IEEE Netw. **4**(5), 13–16 (1990)
11. Garcia, L.M.: Programming with Libpcap – Sniffing the network from our own application (2008)
12. Li, Q., Wang, R., Ye, T., et al.: Research and simulation on high efficient frame generation model of AOS considering packet extracting time under finite buffer. In: 2014 IEEE 5th International Conference on Software Engineering and Service Science (2014)
13. Turull, D., Hidell, M., Sjö, P.: LibNetVirt: the network virtualization library. In: Workshop on Clouds, Networks and Data Centers (ICC'12 WS - CloudNetsDataCenters). IEEE (2012)
14. Liu, J., Mann, S., Vorst, N.V., et al.: An open and scalable simulation infrastructure for large-scale real-time network simulations. In: INFOCOM 2007, 26th IEEE International Conference on Computer Communications. IEEE (2007)