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Design of adaptive backoff algorithm for satellite network using grey system

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Abstract

In contention-based satellite communication system, collisions between data packets may occur due to the randomly sending of the packets. A proper delay before each transmission can reduce the data collision rate. As classical random multiple access protocol, the slotted ALOHA (S-ALOHA) reduces the data collision rate through time slot allocation and synchronous measures. In order to improve the stability and throughput of satellite network, a backoff algorithm based on S-ALOHA will be effective. A new adaptive backoff algorithm based on S-ALOHA using grey system was proposed, which calculates the backoff time adaptively according to the network condition. And the network condition is estimated by each user terminal according to the prediction of the channel access success ratio using the model GM (1,1) in grey system. The proposed algorithm is compared to other known schemes such as the binary exponential backoff (BEB) and the multiple increase multiple decrease (MIMD) backoff. The performance of the proposed algorithm is simulated and analyzed. It is shown that throughput of the system based on the proposed algorithm is better than of system based on BEB and MIMD backoff. And there are also some improvements of the delay performance compared to using BEB. The proposed algorithm is especially effective for large number of user terminals in the satellite networks.

Keywords backoff algorithm, grey system, model GM (1,1), slotted ALOHA, satellite communication system

1 Introduction

Satellite communications is now widely used such as broadcasting and telecommunications, and it's also generally used in military applications because of its advantages of greater system capacity, the ability to serve more user terminals, more diversified services type and so on.

In satellite communication system there are many key technologies such as transmission control, routing and multiple access technologies in which the multiple access technologies are crucial to improve the spectrum utilization and transmission delay performance as well as system capacity of satellite communication system [1]. As classical random multiple access protocol, the S-ALOHA has been widely used in satellite communication system. S-ALOHA reduces the data collision rate through time slot allocation and synchronous measures. However, there also exist some problems using S-ALOHA in satellite communication system such as the instability caused by S-ALOHA, which means that the data collision rate is somehow high. Thus optimizing the retransmission mechanism of S-ALOHA combined with the backoff algorithm is a common and effective way [2]. Many kinds of backoff algorithms have been reported, such as BEB [3], multiple increase linear decrease (MILD) backoff [4], MIMD backoff [5] and so on. In these algorithms, when the data packets is collided and is to be retransmitted, the increase and decrease in the contention window (CW) are both statics, the change in the CW does not depend on network conditions adaptively. Therefore adjusting the CW adaptively according to the traffic load or channel status has become a research emphasis. The introduction of prediction algorithm provides a reference for adaptive backoff algorithm. In Ref. [6], the relationship between the

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access success ratio and network status was demonstrated by method of probability statistics. But the step of the algorithm proposed in Ref. [6] was complicated and there are some deviations which will affect the accuracy of the proposed algorithm. In Ref. [7], a backoff scheme using fuzzy logic was proposed. The main idea of this backoff scheme is using fuzzy logic to predict the access success ratio and then set the CW according to the predicted value. But the mapping between the access success ratio and network status hasn't been researched. In Ref. [8], a backoff algorithm based on flow prediction was proposed. In this algorithm, a flow predictor is introduced to achieve the purpose of adjusting the CW dynamically. But there was no effective prediction algorithm in Ref. [8].

In terms of prediction algorithm, grey system focuses on the problem with 'small sample' and 'poor information', which will be obstacle to other prediction algorithmss [9]. As a core prediction model of grey system, model GM (1,1) provides the theoretical basis for the application of grey system prediction. Model GM (1,1) prediction is easy to use and has the very high accuracy. Based on studying the principle of model GM (1,1), model GM (1,1) is used in this article to predict the channel access success rate. The predicted result is as the standard for jugging the network conditions and is crucial to set the length of the backoff time.

The main contribution in this article is an adaptive algorithm for satellite network based on S-ALOHA using grey system. Model GM (1,1) is used to provide the reference access success ratio to user terminals. The purpose of this proposed algorithm is to prevent user terminals from sending data packets when the traffic load is heavy, which will increase the rate of collision, result in a loss of system throughput. The rest of the article is organized as follows. In Sect. 2 the implementation scheme of adaptive backoff algorithm for satellite network based on S-ALOHA using model GM (1,1) prediction will be introduced, while in Sect. 3, the principle and analysis of the proposed algorithm will be presented. Simulation results and performance comparisons will be discussed in Sect. 4. Finally the concluding remarks are drawn in Sect. 5.

2 Implementation scheme and system model

In general structure of satellite communication system, often one or more satellites, several gateway stations and multiple ground user terminals are used. Based on research of S-ALOHA and combined with the model GM (1,1) prediction, an adaptive algorithm for satellite network based on S-ALOHA using grey system GM-B was proposed in this article. The implementation scheme of GM-B is shown in Fig. 1. There are three main function modules in the implementation scheme, including model GM (1,1) prediction module, network evaluation module and adaptive backoff module.

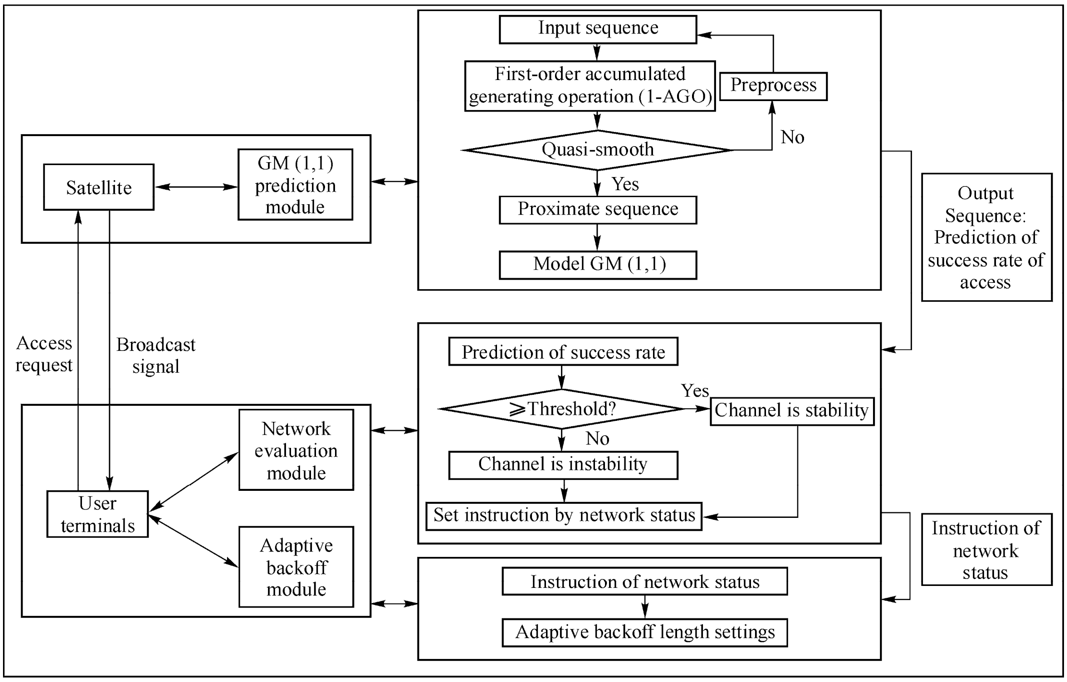

Fig. 1 The implementation scheme of adaptive algorithm based on S-ALOHA using model GM (1,1)