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Stochastic Petri Net-based performance evaluation of hybrid traffic for social networks system

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ABSTRACT

A social network is a social structure made up of a set of social actors (such as individuals or organizations) and a set of the dyadic ties between these actors. By contrast, for the fixed time duration the size of digital video would be much bigger than that of digital sound. Consequently, providers of social network services can offer real-time chatting among users which could offer satisfactory experiences for users. As one of the most popular content-based social network services (SNS), chatting service plays an important role in current big data era. Also average data packets' transmission via networks is another significant traffic. So how to offer satisfactory Quality of Service (QoS) for users is the key problem which will be solved for SNS provider. For real time communication among users, end-to-end time delay seems to be critical in user's experience. Therefore modeling and evaluating social network systems is an important and urgent issue which offers quantitative basis of SNS with high quality for users. For social network system, the scalability and robust are important for both service provider and users under the circumstance of a large number of users. On the basis of performance evaluation of social network system of one user case, we construct the SPN model and conduct numerical analysis to discover and report the performance with the addition of users. By taking hybrid traffic containing voice and data into account, this paper constructed a Stochastic Petri Net (SPN) model for data and ON/OFF voice traffic for social network system. Then, average time delay of the system was analyzed and model-based simulation is conducted with Stochastic Petri Net Package (SPNP) 6.0. Furthermore, for different parameters of burst rate, idle rate, number of data packets, traffic load and buffer size, variation trends on average time delay are derived thereby. On the basis of the work in this paper, further research on heterogeneous objects of social network systems can be carried on.

1. Introduction

With the rapid progress of Internet technology, people all over the world can communicate with each other much easier than ever. A social network is a social structure made up of a set of social actors (such as individuals or organizations) and a set of the dyadic ties between these actors [1]. The main purpose of developing a social network system is to enhance information sharing and knowledge exchange through social communication [2]. Digital data-based social network, which are generated, transmitted and processed, grows very fast every year. Therefore, one key problem facing social network systems is to develop various applications for users to handle parallel requests.

Take 300 s' digital sound file with mp3 format for example, the file's size is about 3 MB. By contrast, the size of 300 s' video file would take up at least several MB. That is, chatting service would take smaller bandwidth resource and seems to be more compatible with bottleneck links under network environments. Additionally, Facebook and Twitter offer social network services for users with chatting. How to offer satisfactory experiences for users seems to be a key problem for providers of social network services.

Skype and Twitter are typical examples that can handle integrated services containing real-time voice and video traffics. However, compared to voice traffic, real-time online video chatting would cost more bandwidth resource. That is, under the circumstance of unsufficient bandwidth, the social network system could hardly offer satisfactory experience for users on video conversations. Due to the advantages of having small bit rate, voice traffic is still popularly used in current big data era. Consequently, the building of a robust, scalable social network system should

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consider several characteristics, which are parallel requests by multiple users, bandwidth constraints of networks, etc. Nowadays, methodologies of performance evaluation for social network system and related systems mainly take three ways, which are direct measurement, mathematic modeling [3–10], and simulation. Mathematic modeling and simulation are undoubted useful methodologies. Consequently, how to model and evaluate the behaviors of participants is an important issue which offers theoretical foundations for building and deploying manage systems for entertainment performance chains. Petri nets, which was first developed in 1962 by C.A. Petri in his PhD. dissertation, is powerful in modeling concurrent, distributed, asynchronous behaviors of a system [11]. With algebra theory and the net theory as its mathematical basis, the Petri nets theory has been successfully employed to describe various relations and behaviors of the discrete event system and communication networks [12]. Following these concerns, timed model of PNs are briefly divided into two main groups: Timed PN (TPN) with deterministic or interval duration of events/transitions; Stochastic PN (SPN) with random/stochastic durations. The most commonly used SPN models are PN models that are augmented with a temporal specification by associating a firing delay with transitions. The specification of the firing delay is of probabilistic nature, so that either the probability density function (pdf) or the probability distribution function (PDF) of the delay associated with a transition is needed [13].

Many works have analyzed systems about social network and communication. Ref. [14] dealt with the problem of automatically generating the user's social network by using different sources of available interaction data such as physical proximity, text messages, phone calls and video chats. Ref. [15] concentrated on combining topic models with social networks for chat data mining. Its results showed that the inferred social graph may be used to enhance topic identification of a chat room when combined with a state-of-the-art topic and classification models. Ref. [16] presented a multi-model social networking system aimed at sharing geographic information among proximate users. The system was accessible via a traditional web-based interface as well as a voice-based interface suitable for mobile phones. Ref. [17] proposed an adaption framework for building a robust personalized language model. The experiments on Facebook dataset reported very encouraging improvements in terms of both model perplexity and recognition accuracy. Ref. [18] established an ON/OFF model to simulate single user conversations in Instant Messaging (IM) system on the basis of analyzing the conversational behaviors of IM users. By comparison between statistical and queuing performances, conclusions on probability density function (PDF) of ON and OFF periods were further drawn. Ref. [19] revealed the statistical features of social network structures by analyzing various data of different telecommunications services. Additionally, the email logs were classified according to the number of destination addresses to evaluate the cause for the difference.

Ref. [20] established a petri nets-based model and reported the numerical results of performance evaluation for data and ON/OFF voice traffic hybrid system. But it did not take multiple users' competition in using shared resource into account. Actually, for Client/Server or Browse/Server-based network systems, the scalability and robust are important for both service provider and users under the conditions of a large number of users.

The scalability of social network system is one key index to judge the system's priority and weakness. Therefore it plays an important role in the designing and running phase of social network system. The main contributions of this paper are described as follows. On the basis of performance evaluation of social network system of one user case, we construct the SPN model and conduct numerical analysis to discover and report the performance with the addition of users. For this reason, by taking the social network system with data and ON/OFF voice traffics in the case of multiple users as the research object, this paper studies the effect of different parameters' change on social network system.

The remainder of this paper is organized as follows. In Section 2, ON/OFF voice traffic's characteristics is introduced. The Stochastic Petri Net (SPN) model for social network system with data and ON/OFF voice traffics between two users is constructed in Section 3. In Section 4, the performance of social network system is evaluated with SPNP software [21]. Finally, Section 5 concludes this paper.

2. Preliminaries knowledge

ON/OFF model can be used to simulate conversations among users [18]. Here we introduce the classic voice model as follow. A number of voice and data models can be represented as ON/OFF source models. When a source is ON (active), it generates packets with constant inter-arrival time. When the source is OFF (silent), it does not generate any packet. As for voice source modeling, the process of a voice call can be modeled as a two-state Markov chain. The state transition diagram is shown in Fig.1. If we assume the rates of from state OFF to state ON and from state ON to state OFF to be λ_{OFF} and λ_{ON} respectively, the average lengths of the ON period and the OFF one are $1/\lambda_{ON}$ and $1/\lambda_{OFF}$ correspondingly [22].

3. SPN model for the social network system with data and ON/OFF voice traffics between two users

In social network systems, various types of traffics containing audio, video, image and average file can be transmitted. For communication among users, end-to-end time delay is an important index for users to experience. In the case of more than three users, the communication process among them can be regarded as the combinations of two users. We concern the whole communication process for data and ON/OFF traffics between two users.

By referring to some Petri net-based or Markov-based models, the Poisson processes of users' behaviors are considered to be the common assumptions and match well with the actual situations. The following works are two typical and related references about performance analysis of systems [23,24].

Therefore we make the similar assumptions as follows: (1) the performance of two users are alike; (2) data and voice generated from users follow the Poisson process; (3) data and voice are delivered independently in the social network system. Fig. 2 shows our constructed SPN model for the social network system with data and ON/OFF voice traffics between two users. Table 1 gives the description of related objects in the SPN model.

As Fig. 2 shows, take one user for instance, P_{ON1}, T_{ON1}, P_{OFF1} and T_{OFF1} are utilized to model the behavior of ON/OFF transmission link. That is, activity state and silent state turn to be alternatively by applying T_{OFF1} and T_{ON1} respectively. The arc from place P_{ON1} to

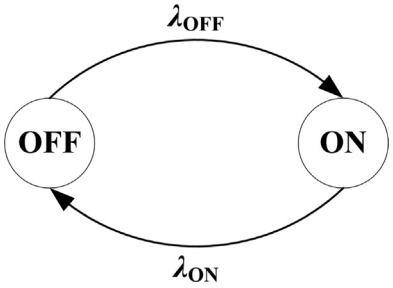

Fig.1. The state transition diagram of ON/OFF model.