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User popularity-based packet scheduling for congestion control in ad-hoc social networks

Feng Xia [a,*], Hannan Bin Liaqat [a], Ahmedin Mohammed Ahmed [a], Li Liu [a], Jianhua Ma [b], Runhe Huang [b], Amr Tolba [c,d]

[a] *School of Software, Dalian University of Technology, Dalian 116620, China*
[b] *Faculty of Computer and Information Sciences, Hosei University, Japan*
[c] *Riyadh Community College, King Saud University, Riyadh 11437, Saudi Arabia*
[d] *Mathematics and Computer Science Department, Faculty of Science, Menoufia University, Egypt*

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ABSTRACT

Traditional ad-hoc network packet scheduling schemes cannot fulfill the requirements of proximity-based ad-hoc social networks (ASNETs) and they do not behave properly in congested environments. To address this issue, we propose a user popularity-based packet scheduling scheme for congestion control in ASNETs called Pop-aware. The proposed algorithm exploits social popularity of sender nodes to prioritize all incoming flows. Pop-aware also provides fairness of service received by each flow. We evaluate the performance of Pop-aware through a series of simulations. In comparison with some existing scheduling algorithms, Pop-aware performs better in terms of control overhead, total overhead, average throughput, packet loss rate, packet delivery rate and average delay.

1. Introduction

Mobile Social Networking in Proximity (MSNP) is based on the principle of geo proximity and social relationship which allows users to know about the availability of nodes in social networks [1]. The nodes that are involved in Mobile Social Networks (MSNs) use intrinsic content features with context of items and the objectivity of human for better searching of relevant users [2]. In MSN, the MSNP provides direct connectivity to users when they are in proximity. This technique is helpful to reduce the user's data cost which solves the issue of unnecessary data traffic, passing through Internet. An Ad-hoc Social Networks (ASNETs) is a branch of MSNP that has emerged as a new area of research with multiple innovative applications [3]. It facilitates users to communicate with each other using social features such as similarity, centrality, community, social graph, human mobility pattern and tie strength [4]. The nodes in ASNETs communicate with each other using scarce wireless interface and node capacity. Accordingly, if there is a huge number of data transfer on a single intermediate node without any proper scheduling mechanism then ASNETs involves in congestion. The occurrence of congestion in ASNETs is due to the reason of some popular sender nodes when they come in proximity area and transfer large amount of data. Thus, if any type of delay occurs in transferring data packets of popular node on intermediate node then congestion occurs. Although, the throughput of ASNETs and reduction of congestion on the intermediate node can be improved by designing a packet scheduling algorithm that works according to the concept of ASNETs or MSNP. This is because packet scheduling

* Corresponding author.
E-mail address: f.xia@ieee.org (F. Xia).

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provides efficient sharing of bandwidth resources among nodes. It also provides solution to the problems caused by multiple connections after sharing one link.

To improve the performance of scheduling algorithm, existing research provides an efficient solution at Medium Access Control (MAC) layer (such as reduction in collision at the MAC layer and fairness in bandwidth sharing [5–7]) and routing layer [8–10]. However, the work related to efficient queue scheduling mechanisms for wireless interface has not been broadly addressed specially in ASNETs environments. This occurs because ASNETs provides social property (Popularity) based communications between nodes, whereas existing ad-hoc networks use simple priority scheduling such as First-In-First-Out (FIFO) order. Scheduling the data packets based on popularity means that we forward the data packet of the most popular node initially from the intermediate node, which can solve the congestion related problem [11]. This is due to most popular node receiving lots of data from other nodes that create congestion in the intermediate node at an earlier stage. In another aspect, the availability of the most popular node signifies that it has a strong social strength and importance in the network. Consequently, for avoiding the dropping of most popular node's data packets from an intermediate node, the earlier transfer of it is necessary. Scheduling based on social popularity also plays a vital role in increasing the system throughput. As a result of the above reasons, we need to solve such congestion issues by utilizing maximum bandwidth without wastage of resources. Similarly, our previous work (TIBIAS) [12] also solved the congestion related issues in ASNETs and provided maximum utilization of resources after adjusting the data rate with proper bandwidth sharing scheme. TIBIAS provided a sender side solution, which was based on the transport layer and it used social property (*similarity*) for setting the data rate. As compared to TIBIAS, this scheme provides intermediate based solution that manages queue at network layer. The management of queue is based on the proper scheduling of the data packets. Furthermore, for efficient utilization of resources, Pop-aware employs the degree centrality social property.

In order to solve above scheduling issues, this paper proposes a novel data-scheduling algorithm called User Popularity-based Packet Scheduling for Congestion Control in Ad-hoc Social Networks (Pop-aware). Our algorithm is divided into two main processes. First, to make proper decisions for scheduling, it calculates the load of data packet at intermediate node. After calculating it, we start the scheduling scheme. Secondly, we set prioritization value to the flow. To provide the efficient solution in an MSNP based ASNET model, our Pop-aware algorithm sets prioritization based on the *degree centrality* social property, which indicates the popularity level of a node's data packets.

In this paper, we present and discuss an extended version of our work [13]. We provide a broader view of literature in terms of related work. This paper also enhances the algorithm description (pseudocode) by involving cases regarding the introduction of new data when any node is proximal to intermediate node. Furthermore, in comparison to [13], this paper provides theoretical analysis of scheme and conducts further simulations using appropriate evaluation metrics such as control overhead, total overhead, packet delivery rate and average delay with number of connections. In order to briefly understand the concept of degree centrality, we also present mathematical calculations. This is done to further assess and ascertain the performance of our proposed algorithm. In summary, the contribution of this work includes:

- **Avoiding the packet dropping problem:** Pop-aware calculates the load at the intermediate node to start the scheduling process. This decision helps to avoid the dropping of the most popular node's data.
- **Controlling congestion effectively:** Pop-aware provides a higher priority to the flow of data packets that have highest degree centrality. It is helpful to control the congestion at the intermediate node and fully utilize the available bandwidth.
- **Fairness:** We devise a mechanism that can provide fairness of service received for each flow based on served and non-served concept. It can also provide fair utilization of resources between nodes after calculating the throughput ratio for each flow.
- **Proper scheduling decision:** We propose a set of scheduling techniques on the arrival of new flow data packets after calculating its rates and *degree centrality* values to reduce delivery delay, while achieving higher throughput.
- **Extensive simulations:** We conducted comprehensive simulations to evaluate Pop-aware's performance in comparison with other scheduling protocols.

The rest of the paper is organized as follows: related work is discussed in the next section. Section 3 describes network model and preliminaries. Section 4 presents our Pop-aware scheduling algorithm with design problems. In Section 5, we present the performance analysis and further calculation of methodology with discussions of evaluations is provided in Section 6. Finally, we conclude the paper in Section 7.

2. Related work

In MSNs, stream data and the life logs use large amount of internet resources and their combination is called social streams. This social stream utilizes large amount of internet resources but provides easiness in collection of information and social activities of users [14]. The online MSNs exploit social behaviors among users for better utilization of resources. These social behaviors depend upon the social interaction and connectivity among users that are helpful to enhance the performance of system [15,16]. As compared to online MSN, MSNP reduces the cost of communication after using ASNET concept. In ASNETs, communication between nodes is without any infrastructure. Therefore, in ASNETs nodes are assigned to different groups that are based on semantic matching of users' interest [17]. Furthermore, users exploit some social