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Procedia Computer Science 52 (2015) 460 – 467

Procedia
Computer Science

6th International Conference on Ambient Systems, Networks and Technologies
(ANT 2015)

Minimizing Communication Interference for Stable Position-Based Routing in Mobile Ad Hoc Networks

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Abstract

For efficient communication in a mobile ad hoc network (MANET) dealing with interference while performing multihop routing is of great importance. By establishing an interference-aware route we can potentially reduce the interference effects in the overall wireless communication, resulting in improved network performance. Typically, mobile devices, represented by nodes in a MANET, are used to broadcast in limited shared media. Therefore, using both routing and scheduling mechanisms for wireless transmissions reduces both redundancy and communication interferences. We study communication interference problems in the context of maintaining stable connection routes between mobile devices in MANETs. In this paper, we extend our previous position-based stable routing protocol (namely, the Greedy based Backup Routing Protocol with Conservative Neighborhood Range) to maintain connection stability while minimizing the number of corrupted packets in the presence of more general communication interference. Simulation results demonstrate the effectiveness of the new protocols.

Peer-review under responsibility of the Conference Program Chairs
Keywords: Mobile Ad Hoc Networks; Path Stability; Interference

1. Introduction

Mobile ad hoc networks (MANETs) are a type of wireless network where mobile devices are themselves responsible for communication with each other without the presence of a centralized infrastructure. MANET networks are formed through interconnected devices communicating wirelessly within a relatively limited and shared area. Mobile devices in MANETs can typically move in any direction and therefore the shared media between the mobile devices may frequently change. In MANETs, all nodes that have messages (packets) to exchange must transmit their packets concurrently if there is no interference that can affect their communication. In other words, to achieve high network efficiency in MANETs, parallel transmissions on more than one link must be considered by routing and scheduling protocols. Interference in MANETs is a result of concurrent transmissions taking place in the neighborhood (asynchronous) and is also associated with collisions (which produce corrupted data) arising from nodes outside the range of each other transmitting to a common receiver at the same time (synchronous). However, in MANETs, when con-

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1877-0509
Peer-review under responsibility of the Conference Program Chairs
doi:10.1016/j.procs.2015.05.015

sidering interference, the route from the source to the destination in a specific path may not be the optimal choice. That is, to minimize communication interference, the selected path may not be the shortest path or may increase the number of hops in the routing path. In previous work [1], as discussed later in the Subsection 3.3, we studied the idea of using a Conservative Neighborhood Range (CNR) which eliminate the need to establish backup paths while maintaining stability, a routing protocol we called Greedy-based Backup Routing Protocol with Conservative Neighborhood Range (GBR-CNR). Without the requirement of backup paths to maintain stability, we expect it can be modified to reduce the interference better than the previously studied protocols where backup path mechanisms or multi-paths are used to maintain path stability. In the context of this paper, we introduce an approach based on GBR-CNR [1], a version of the original Greedy-based Backup Routing Protocol (GBR) [2], to establish the interference-aware stable paths.

The rest of this paper is organized as follows. In Section 2, we review specifically related work including giving a brief description of different approaches to studying the interference in MANETs. We provide details of related stable routing protocols in Section 3. In Section 4, we propose our developments to improve a network throughput by minimizing communication interference in MANETs. Experimental results are given in Section 5. Finally, concluding remarks are made in Section 6.

2. Related Works to Minimize Interference in MANETs

Interference limits the throughput of communication in MANETs by corrupting some of the packets that are exchanged among the mobile devices. Therefore, it is of critical importance to study the interference that affect the receivers in the MANETs environment. Pyun et al. [3] proposed a distributed topology control scheme in MANETs where the transmission power of each node was adaptively adjusted based on both the number of its neighbor nodes and the amount of interference that the node generated for its neighbors. De Rango et al. [4] considered a protocol that introduced the concept of interference in the choice of optimum routes in order to improve wireless system performance. Two distinct metrics were proposed: the first one was based on global interference perceived by nodes involved in the communication. The second one was based on the interference perceived only on the links belonging to the route from the source to the destination. The proposed metrics were not based on the minimum hop number, such as in the AODV protocol, but on the global interference perceived by nodes (the first metric), and on the interference affecting the link involved in the transmission (the second metric).

Role of multiple antennas to void such strong interference was studied by Huang et al. [5]. The study focused on canceling strongest of interference by using receivers which zero-forcing beamformed. This method zero-forcing beamforming interference management method is widely used many Media Access Control (*MAC*) protocols which effectively created an interference-free area around each receiving node through carrier sensing. This interference free area is usually called a guard zone. Optimizing this guard zone area can results in significant transmission capacity increase when a single-antenna in MANETs are used. Such a guard zone which can help with interference cancelation and hence would allow nearby transmitters to continue transmitting. For example a network with Poisson distributed transmitters and independent Rayleigh fading channels, the transmission capacity is derived, which gives the maximum number of successful transmissions per unit area. Mathematical analysis from stochastic geometry are applied to obtain the asymptotic transmission capacity scaling and to characterize the impact of inaccurate Channel State Information (CSI). The effective interference model resulting from perfect interference cancelation is illustrated in Figure 1a. Also, as illustrated in Figure 1b, CSI estimation errors result in additional interference with respect to the case of perfect CSI.

Also, in previous work, Gu and Zhu [6] presented the Interference Aware Cross Layer Routing protocol (IA-CLR), an interference aware routing protocol based on a node's sending and receiving capacities. IA-CLR builds the routes with the minimum bottleneck link interference by using the new routing metric that can comprehensively reflect the real network condition. Also, Zhou et al. [7] tackled the challenges of localized link scheduling posed by complex physical interference constraints. By integrating the partition and shifting strategies into the pick-and-compare scheme, they presented a class of localized scheduling algorithms with provable throughput guarantees subject to physical interference constraints. The basic pick-and-compare scheme works as follows: at every time slot, it generates a feasible schedule that has a constant probability of achieving the optimal capacity region. If the weight of this new solution is greater than the current solution, it replaces the current one.