Analysis on Optimal multicast Capacity and Delay Tradeoffs in MANET's

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***Abstract*—A Mobile Ad Hoc NETworks (MANETs) is a collection of wireless mobile nodes forming a self-configuring network. The mobility model plays a very important role in determining the performance in MANETs. Thus, it is essential to study and analyze various mobility models and their effect on MANETs. The purpose of this paper is to conduct analysis on the optimal multicast capacity-delay tradeoffs in MANETs using homogeneous mobile wireless networks. Four node mobility models are considered: Two-dimensional i.i.d mobility models, Two-dimensional hybrid random walk mobility models, one-dimensional i.id mobility models, and one-dimensional hybrid random walk mobility models. Two mobility time-scales are investigated: Fast mobility and slow mobility. This paper tries to present a fundamental and more general result compared to previous work.**

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Keywords— Multicast capacity and delay tradeoffs, Mobile Ad Hoc Networks (MANETs), independent and identically distributed (i.i.d.) mobility models, hybrid random walk mobility models.

I. INTRODUCTION

With the widespread rapid development of computers and the wireless communication, the Mobile computing has already become the field of computer communications in high-profile link. The main concept of Wireless Local Area Networks (WLANs) refers to MANETs which are also called either infrastructure-based wireless networks or a single hop network. MANETs is a completely wireless connectivity through the nodes constructed by the actions of the network, which usually has a dynamic shape and a limited bandwidth and other features. MANETs is a type of Ad hoc networks. Ad hoc network is a local area network or some other small network, especially with wireless, in which some of the network device are the part of networks only for the duration of a communication session. Ad hoc networks are auto-configurable network and self-configuring. Nodes are mobile and hence have dynamic network topology. Nodes in Ad hoc network play both the roles of router and terminals. MANETs can change locations and configure itself. Because MANETs are mobile, they use wireless connections to connect to various networks. This can be a standard Wi-Fi connection, or another medium.

This paper gives a general analysis on the optimal multicast capacity and delay tradeoffs in homogeneous MANETs.

Four mobility models are used.

1. One-dimensional i.i.d mobility models
2. One-dimensional hybrid random walk mobility models.
3. Two-dimensional i.i.d mobility models
4. Two-dimensional hybrid random walk mobility models

Two mobility time-scales are investigated:

1. Fast mobility.
2. Slow mobility

A. Background and Motivation

The capacity of wireless networks with randomly located nodes each capable of transmitting *W* at bits per second and employing a common range and each with randomly chosen and therefore likely far away destination is (1). Issue is how to improve the performance of network in terms of capacity and delay [1].

$$\Theta\left(\frac{W}{\sqrt{n \log n}}\right) \tag{1}$$

There has been significant recent interest within the networking research community to characterize the impact of mobility on the capacity and delay in mobile ad hoc networks [2]. In this correspondence, the fundamental tradeoff between the capacity and delay for a mobile ad hoc network under the Brownian motion model is studied.

The throughput/delay tradeoffs for scheduling data transmissions in a mobile ad hoc network are considered [3]. To reduce delays in the network, each user sends redundant packets along multiple paths to the destination. Capacity and delay were calculated under two particular algorithms, and the tradeoff derived from them was (2) where k was the number of destinations per source. In their work, the network is partitioned into Θ (n) cells similar to [3] and TDMA scheme is used to avoid interference.

$$\lambda = o\left(\frac{D}{nk\log k}\right) \quad (2)$$

The optimal tradeoffs have been established under some conditions on delay. When these conditions are not met, the optimal tradeoffs are still unknown in general [4]. Author comment that the key to establishing the optimal delay–throughput tradeoff is to obtain $P_{i,\ j}$ (D, L), the probability that node i hits node j in one of D consecutive time slots given a hitting distance L.

Many works have been conducted to investigate the improvement by introducing different kinds of mobility into the network, [2], [3], [4], [5] and [6]. Other works attempt to improve capacity by introducing base stations as infrastructure support [9], [10].

Introducing mobility into the multicast traffic pattern, [10] motioncast model is studied. Fast mobility was assumed. Multicast flows are expected to be predominant in many applications when demand of information sharing increases. In this paper [7] author proposed a hybrid wireless network, which is an integrated wireless and optical network, as the broadband access network. Specifically, we assume a hybrid wireless network consisting of *n* randomly distributed normal nodes, and *m* regularly placed base stations connected via an optical network. A source node transmits to its destination only with the help of normal nodes.

A hybrid network is formed by placing a sparse network of base stations in an ad hoc network [8]. These base stations are assumed to be connected by a high-bandwidth wired network and act as relays for wireless nodes. They are not data Sources or data receivers. Hybrid networks present a tradeoff between traditional cellular networks and pure ad hoc networks in that data may be forwarded in a multi-hop fashion or through the infrastructure [14].

Author [11] studied the problem of determining the multicast capacity region of a wireless network of *n* nodes randomly located in an extended area and communicating with each other over Gaussian fading channels. Author defined multicast for ad hoc network through nodes mobility as motion-cast [12], and study the capacity and delay tradeoffs for it. Assuming nodes move according to an i.i.d pattern and each desires to send packets to *k* distinctive destinations, we compare the capacity and delay in two transmission protocols: one uses 2-hop relay algorithm without redundancy, the other adopts the scheme of redundant packets transmissions to improve delay while at the expense of the capacity.

Zhou and Ying [13] also studied the fast mobility model and provided an optimal tradeoff under their network assumptions. They considered a network that consists of n_s multicast sessions, each of which had one source and p destinations. They showed that given delay constraint D, the capacity per multicast session was (3).

$$O\left(min\left\{1, (\log p)(\log(n_s p))\sqrt{\frac{D}{n_s}}\right\}\right) \quad (3)$$

Then a joint coding/scheduling algorithm was proposed to achieve a throughput of (4). In their network, each multicast session had no intersection with others and the total number of mobile nodes was n = n_s (p+1).

$$O\left(min\left\{1, \sqrt{\frac{D}{n_s}}\right\}\right) \quad (4)$$

Capacity has been extensively studied in Wireless networks, most of the results are for homogeneous wireless networks where all nodes are assumed identical [15]. In this paper, author investigates the capacity of heterogeneous wireless networks with general network settings. In this paper [16], author study the contribution of network coding (NC) in improving the multicast capacity of random wireless ad hoc networks when nodes are endowed with multi-packet transmission (MPT) and multi-packet reception (MPR) capabilities. Author study the asymptotic networking-theoretic multicast capacity bounds for random extended networks (REN) under Gaussian channel model, in which all wireless nodes are individually power-constrained [17], [20].

Throughput capacity in mobile ad hoc networks has been studied extensively under many different mobility models [18]. Most previous research assumes global mobility, and the results show that a constant per-node throughput can be achieved at the cost of very high delay. Author studied the capacity scaling laws for the cognitive network that consists of the primary hybrid network (PhN) and secondary ad hoc network (SaN) [19]. PhN is further comprised of an ad hoc network and a base station based (BS-based) network. SaN and PhN are overlapping in the same deployment region, operate on the same spectrum, but are independent with each other in terms of communication requirements.

B. *Contributions and Organization*

In this paper, we give a general analysis on the optimal multicast capacity-delay tradeoffs in homogeneous MANETs. We assume a mobile wireless network that consists of n nodes, among which n_s nodes are selected as sources and n_d destined nodes are chosen for each. Thus, n_s multicast sessions are formed. Our results in homogeneous network are further used to study the heterogeneous network. The purpose of this paper is to conduct extensive analysis on the multicast capacity-delay tradeoff in mobile wireless networks. We study a variety of mobility models which are also widely adopted in previous works. The results obtained may provide valuable insights on how multicast will affect the network performance compared to unicast networks. By removing some limitations and constraints, we try to present a fundamental and more general result than previous works.

II. SYSTEM MODULE

We consider a mobile ad hoc network where *n* nodes move within a unit square. Among them, n_s nodes are selected as sources, and each node has n_d distinct destinations. We group each source and its n_d destinations as a multicast session. The definitions of capacity and delay are also similar to previous works.

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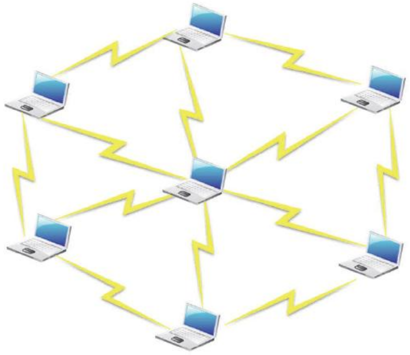
A. Homogeneous Networks

A MANETs can be either heterogeneous or homogeneous depending on the type of mobile nodes being involved. When all mobile nodes are of the same type of a MANETs, this is called a homogeneous MANETs. Homogeneous MANETs is shown in figure1. WLANs are used for wireless communication between nodes.

Figure 1: Homogeneous MANETs.



Consider a mobile ad hoc network with n wireless mobile nodes. The following mobility models are used.

a. One-dimensional i.i.d. mobility model

Assume the mobile n nodes where n_s are the source node from which data is sent in one- dimension i.e. horizontally to the n_d destination nodes. Data is independent and identically distributed (i.i.d.) among nodes. Data is sent in order. The source and destinations in the multicast session are the same type of nodes.

b. One-dimensional hybrid random walk model

Assume the mobile n nodes where n_s are the source node from which data is sent in one- dimension i.e. horizontally to the n_d destination nodes. Data is sent randomly to the n_d destination nodes. Data is not i.i.d. The source and destinations in the multicast session are the same type of nodes.

c. Two-dimensional i.i.d. mobility model

Assume the mobile n nodes where n_s are the source node from which data is sent in two- dimensions i.e. horizontally and vertically to the n_d destination nodes. Data is independent and identically distributed (i.i.d.) among nodes. Data is sent in order. The source and destinations in the multicast session are the same type of nodes.

d. Two-dimensional hybrid random walk mobility model

Assume the mobile n nodes where n_s are the source node from which data is sent in two- dimensions i.e. horizontally and vertically to the n_d destination nodes. Data is sent randomly to the n_d destination nodes. Data is not i.i.d. The source and destinations in the multicast session are the same type of nodes.

B. Mobility time scales

a. Fast mobility

The mobility of nodes is at the same time scale as the transmission of packets, i.e., in each time-slot, only one transmission is allowed.

b. Slow mobility

The mobility of nodes is much slower than the transmission of packets, i.e., multiple transmissions may happen within one time-slot.

C. Scheduling Policies

Scheduling policy has the information about the current and past status of the network, and can Schedule any radio transmission in the current and future time slots. A packet is successfully delivered if and only if all destinations within the multicast session have received the packet. In each time slot, for each packet p that has not been successfully delivered and each of its unreached destinations, the scheduler needs to perform the following two functions:

a. Capture

The scheduler needs to decide whether to deliver packet to destination in the current time slot. If yes, the scheduler then needs to choose one relay node that has a copy of the packet at the beginning of the timeslot, and forward this packet to destination within the same timeslot. When this happens successfully, we say that the chosen relay node has successfully captured the destination of packet.

b. Duplication

For a packet p that has not been successfully delivered, the scheduler needs to decide whether to duplicate packet p to other nodes that does not have the packet at the beginning of the time-slot. The scheduler also needs to decide which nodes to relay from and relay to, and how.

III. SYSTEM DESIGN

Figure 2 shows the detailed architecture of the system. Architecture shows how source node n_s send data to the destination node n_d by using one-dimensional i.i.d. mobility model and one-dimensional hybrid random walk mobility model.

Figure 2: Overall Architecture of system.

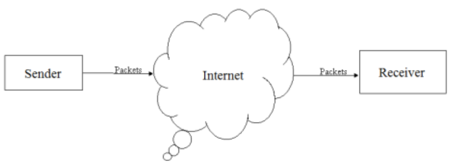


Figure 3 shows use case diagram of the system. Use case is composed of actors and use-cases. Actors are related to use cases by interactions. Use case of this project contains actors like sender, router-1, router-2, receiver and use-cases like select file, split file, selecting router, 1-dimensional, 2-dimensional, data stored, time-delay, merge

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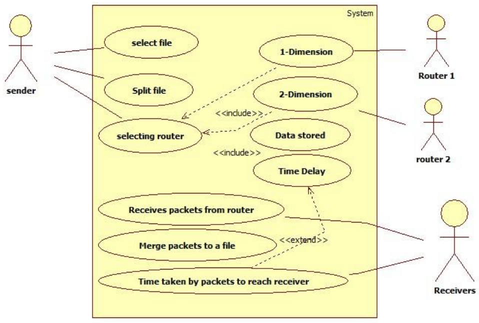
packets to a file. 1-dimensional and 2-dimensional use-cases are included in selecting router use case and time taken by packets to reach receiver is extended to time delay use-case. All use-cases are located inside the system as shown in figure 3.

Figure 3: Use Case Diagram of system



Use case is often refined into one or more sequence diagram. The interaction between objects is shown by sequence diagram of each mobility model. Use-cases interact with objects by requesting and responding each other. Interaction between objects is carried through sending packets and updating status.

Figure 4 shows the sequence diagram of one-dimensional i.i.d mobility model.

Figure 4: one-dimensional i.i.d mobility Model

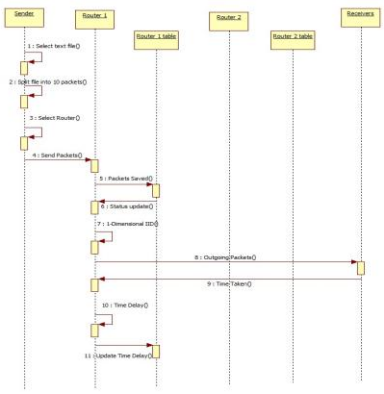


Figure 5 shows the sequence diagram of one-dimensional hybrid random walk mobility model.

Figure 5:One-dimensional hybrid random walk

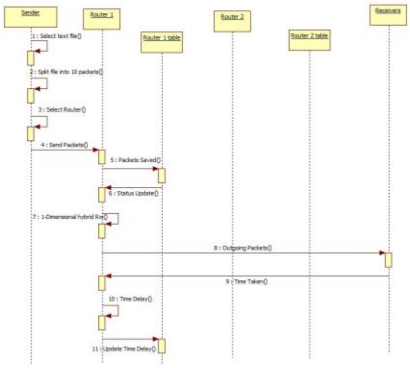


Figure 6 shows the sequence diagram of two-dimensional i.i.d mobility model.

Figure 6: Two-dimensional i.i.d mobility model

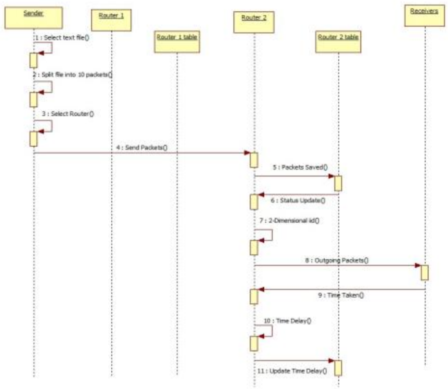


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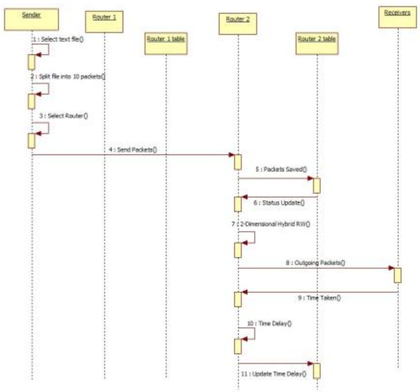
Figure 7 shows the sequence diagram of two-dimensional hybrid random walk mobility model.

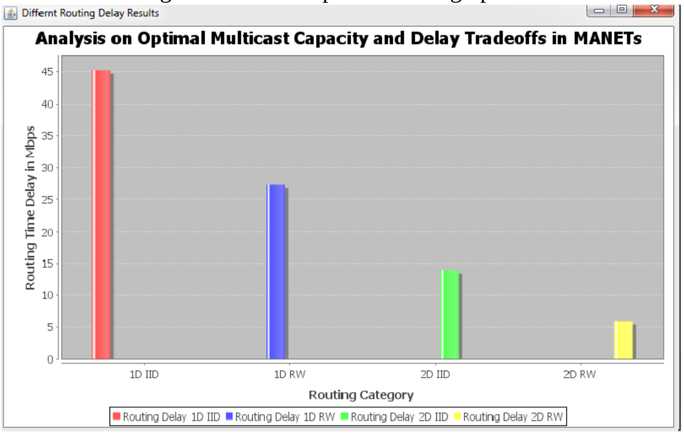
Figure 7:Two-dimensional hybrid random walk mobility model



IV. RESULT

In this project, as there is comparison for the capacity and delay tradeoffs in MANETs, it is showed that one-dimensional mobility model has more capacity compared to two-dimensional mobility model and two-dimensional mobility model has less time delay compared to one-dimensional mobility model. This is shown in real time systems and comparison is plotted on to a graph in figure 8.

Figure 8: Result is plotted on to graph.



V. CONCLUSIONS

In homogeneous networks, we analyzed the optimal multicast capacity-delay tradeoffs under two-dimensional i.i.d mobility models, two-dimensional hybrid random walk mobility models, one-dimensional i.i.d. mobility models, one-dimensional hybrid random walk mobility models and Fast mobility and slow mobility time-scales are investigated. We find that though the one dimensional mobility model constrains the direction of nodes' mobility, it achieves larger capacity than the two dimensional model since it is more predictable. Also, slow mobility brings better performance than fast mobility because there are more possible routing schemes.

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