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Self-servicing mesh router for mobile mesh networks with missed node detection

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Abstract*— Wireless technology has been one of the most transforming and empowering technologies in recent years. In particular, mobile ad hoc networks (MANETs) are among the most popularly studied network communication technologies. In such an environment, no communication infrastructure is required. The mobile nodes also play the role of the routers, helping to forward data packets to their destinations via multiple-hop relay. This type of network is suitable for situations where a fixed infrastructure is unavailable or infeasible. Mobile ad hoc networks (MANETs) are ideal for situations where a fixed infrastructure is unavailable or infeasible. Today's MANETs, however, may suffer from network partitioning. This limitation makes MANETs unsuitable for applications such as crisis management and battlefield communications, in which team members might need to work in groups scattered in the application terrain. In such applications, intergroup communication is crucial to the team collaboration. To address this weakness, this project introduces a new class of ad-hoc network called Autonomous Mobile Mesh Network (AMMN). Unlike conventional mesh networks, the mobile mesh nodes of an AMMN are capable of following the mesh clients in the application terrain, and organizing themselves into a suitable network topology to ensure good connectivity for both intra- and intergroup communications.

***Index Terms*— Mobile mesh networks, dynamic topology deployment, client tracking**

I. INTRODUCTION

AMMNET is a wireless mesh network with autonomous mobile mesh nodes. In addition to the standard routing and relay functionality, these mobile mesh nodes move with their mesh clients, and have the intelligence to dynamically adapt the network topology to provide optimal service. In particular, an AMMNET tries to prevent network partitioning to ensure connectivity for all its users. This property makes AMMNET a highly robust MANET.

AMMNET is a mesh-based infrastructure that forwards data for mobile clients. A client can connect to any nearby mesh node, which helps relay data to the destination mesh node via multihop forwarding. For ease of description, in this paper we use the terms "mesh node" and "router" interchangeably. Like stationary wireless mesh networks, where routers are deployed in fixed locations, routers in an AMMNET can forward data for mobile clients along the routing paths built by any existing ad hoc routing protocols. Unlike stationary wireless mesh networks, where routers are deployed at fixed locations, routers in an AMMNET are mobile platforms with autonomous movement capability. They are equipped with positioning devices such as GPS, to provide navigational aid while tracking mobile clients.

Clients are not required to know their locations, and only need to periodically probe beacon messages. Once mesh nodes receive the beacon messages, they can detect the clients within its transmission range. With this capability, mesh nodes can continuously monitor the mobility pattern of the clients, and move with them to provide them seamless connectivity. Assume that each mobile mesh node is equipped with a localization device such as GPS.A mobile mesh node can detect mesh clients within its sensing range, but does not know their exact locations. For instance, this can be achieved by detecting beacon messages transmitted from the clients.

A Delay-Tolerant Network Architecture for Challenged Internets

The highly successful architecture and supporting protocols of today's Internet operate poorly when faced with operating environments characterized by very long delay paths and frequent network partitions. These problems are exacerbated by end nodes that have severe power or memory constraints. Often deployed in mobile and extreme environments lacking "always-on" infrastructure, many such networks have their own specialized protocols, and do not utilize IP. To achieve interoperability between them, we propose a network architecture and application interface structured around optionally-reliable asynchronous message forwarding, with limited expectations of end-to-end connectivity and node resources.

The architecture operates as an overlay above the transport layers of the networks it interconnects, and provides key services such as in-network data storage and retransmission, interoperable naming, authenticated forwarding and a coarse-grained class of service. The DTN architecture aims to address the desire to provide interoperable communications between and among a wide range of networks which may have exceptionally poor and disparate performance characteristics. The design embraces the notions of message switching with in-network retransmission, late-binding of names, and routing tolerant of network partitioning to construct a system better suited to operations in challenged environments than most other existing network architectures, particularly today's TCP/IP based Internet. The architecture represents a generalization of the Interplanetary Internet architecture to challenged networks other than space.

The previous work was closely tied to issues of deep space communications in particular, but contributed many key ideas toward the development of a networking architecture applicable for challenged internet works more generally. The design also derives in part from some interesting trends in the Internet: a move toward content-based naming, creation of administrative "regions", and alternative routing structures (e.g. network overlays).

. This is a comparatively radical approach; other approaches aim to "repair" underlying link performance problems or alter limited portions of the Internet architecture, such as routing, with additional protocols in an effort to keep the current service model and existing TCP/IP based protocols constant. Because it provides a different type of network service than Internet, the DTN design makes a different set of choices in the architectural design space: messages versus packets, a form of hop by hop reliability and security versus end-to-end, name based routing versus address based routing, and a routing abstraction of partially-connected rather than fully-connected network graph. Interestingly, DTN can be overlaid upon the TCP/IP based Internet easily, and therefore remains compatible. This is not the most interesting case, however, as its strength lies in its ability to tie together dramatically different types of net works with unusual connectivity properties. As such, in some ways it makes more limited assumptions on the underlying protocol layers than IP does upon its underlying link layers. Only time will tell what application interfaces and service semantics will most appropriately match applications to challenged networks, but we believe the DTN architecture puts forth several design decisions worthy of consideration. In addition, we believe it is timely to consider a very broad range of network characteristics in formulating a new network architecture, as it appears likely an ever increasing number of these features will have to be dealt with. Analysis and modeling of wireless networks greatly depend on understanding the structure of underlying mobile nodes.

In this paper we present two clustering algorithms to determine the number of groups and their identities: k-means chain and spectral clustering. Different from traditional k-means clustering, k-means chain can identify the number of groups in dynamic graphs, and the chaining process can also keep track of group trajectories over the entire trace. The second approach uses spectral clustering, which measures the similarities between each node pair to group nodes of similar behaviors. We show that critical information of a mobility trace, such as the number of groups and group members, can be precisely extracted with little or no prior knowledge of the properties of a trace. In this paper we set out to determine the groups as they emerge from a mobility trace.

Our goals were two-old:

1) to correctly develop a measurable method for group detection in the trace and the group membership as well, and

2) to identify the group trajectory followed by the group. Once groups are discerned, one can proceed to determine the group leader, or the relationship between different groups. In the performance evaluation of a protocol for an ad hoc network, the protocol should be tested under realistic conditions including, but not limited to, a sensible transmission range, limited buffer space for the storage of messages, representative data traffic models, and realistic movements of the mobile users (i.e., a mobility model).

This paper is a survey of mobility models that are used in the simulations of ad hoc networks. We describe several mobility models that represent mobile nodes whose movements are independent of each other (i.e., entity mobility models) and several mobility models that represent mobile nodes whose movements are dependent on each other (i.e., group mobility models). The goal of this paper is to present a number of mobility models in order to offer researchers more informed choices when they are deciding upon a mobility model to use in their performance evaluations.

Lastly, we present simulation results that illustrate the importance of choosing a mobility model in the simulation of an ad hoc network protocol. Specifically, we illustrate how the performance results of an ad hoc network protocol drastically change as a result of changing the mobility model simulated. The performance of an ad hoc network protocol can vary significantly with different mobility models.

The performance of one ad hoc network routing protocol with different mobility models. As shown, the performance of the protocol is greatly affected by the mobility model. The performance of an ad hoc network protocol can vary significantly when the same mobility model is used with different parameters. Figures 1 and 2 illustrate the widely different movement patterns that can occur with the Random Walk Mobility Model when different input parameters are used. When evaluated, these different movement patterns lead to widely different performance results.The selection of a mobility model may require a data traffic pattern which significantly influences protocol performance. For instance, if a group mobility model is simulated, then protocol evaluation should be done with a portion of the traffic local to the group. Intra group communication changes a protocol's performance dramatically, compared to the same mobility scenarios and all inter group communication . The performance of an ad hoc network protocol should be evaluated with the mobility model that most closely matches the expected real-world scenario

. In fact, the anticipated real-world scenario can aid the development of the ad hoc network protocol significantly. However, since the development of ad hoc networks is relatively new, we do not yet know what a realistic model is for a given scenario. In fact, we are just beginning to see realistic trace files for PCS or cellular networks. In [30], results are presented on how often MNs move and how far they move for the Metricom radio network. Traffic patterns and on-line behavior for wireless users of a high speed wireless access network are presented. If the expected real-world scenario is unknown, then researchers should make an informed choice about the mobility model to use.

The following list summarizes our conclusions:

1) seven synthetic entity mobility models for ad hoc networks. (see Figure 1 and Figure 3). The main difference between these two mobility models is thatMNs are more likely to cluster in the center of the simulation area with the Random Waypoint Mobility Model.

2) The Random Waypoint Mobility Model is used in many prominent simulation studies of ad hoc network protocols. It is flexible, and it appears to create realistic mobility patterns for the way people might move in, for example, a conference setting or museum (see Figure 3). One concern with this model is the straight movement pattern created by the MN to the next chosen destination.

3) The Random Direction Mobility Model an unrealistic model because it is unlikely that people would spread themselves evenly throughout an area (a building or a city). In addition, it is unlikely that people will only pause at the edge of a given area. The Modified Random Direction Mobility Model allows MNs to pause and change directions before reaching the simulation boundary; this version, however, is identical.

4) Random Walk Mobility Model with pause times. The Boundless Simulation Area Mobility Model provides movement patterns that one might expect in the real world (see Figure 4). n addition, this model is the only one that allows MNs to travel unobstructed in the simulation area, thus removing any simulation edge effects from the performance evaluation. One concern, however, is the undesired side effects that would occur from allowing the MNs to move around a torus. For example, one static MN and one MN that continues to move in the same direction become neighbors again and again. In addition, a simulation area without edges would force modification of the radio propagation model to wrap transmissions from one edge of the area to the other.

5) The Gauss-Markov Mobility Model also provides movement patterns that one might expect in the real-world (see Figure 10), if appropriate parameters are chosen. In addition, the method used to force MNs away from the edges of the simulation area (thus avoiding undesired edge effects) is of note. While the Probabilistic Random Walk Mobility Model also provides movement patterns that one might expect in the real-world choosing appropriate parameters for the probability matrix may be difficult. This model could become useful, however, when we have scenario trace data that we want to model. The City Section Mobility Model appears to create realistic movements for a section of a city, since it severely restricts the traveling behavior of MNs; MNs do not have the ability to roam freely without regard to obstacles and other traffic regulations. Further development of this model (e.g., to use realistic city maps) is desired. The Exponential Correlated Random Mobility Model appears to theoretically describe all other mobility models. However, selecting appropriate parameter values is (almost) impossible. The Column, Nomadic Community, and Pursue Mobility Models are useful group mobility models for specific realistic scenarios.

The movement patterns provided by these three mobility models can be obtained by changing the parameters associated with the Reference Point Group Mobility Model. The Reference Point Group Mobility Model (RPGM) is a generic method for handling group mobility. An entity mobility model (or models) needs to be specified to handle both the movement of a group of MNs and the movement of the individual MNs within the group. The input parameters of the RPGM model allow the flexibility to implement the Column, Nomadic Community, and Pursue Mobility Models. The results of DSR presented in Figures 21–25 differ greatly from the results presented in [4] and [15]. As an example, all the data packet delivery ratios presented in [4] for DSR (using the Random WaypointT. Camp, J. Boleng, and V. Davies: Survey of Mobility Models 26 Mobility Model) are over 95%. Their results are not comparable to ours because of the differences in our simulation environments. (For example, the maximum average speed considered in [4] is only 10 m/s; our maximum average speed is 20 m/s.) Furthermore, the metric used for the x-axes in [4] is pause time, rather than speed. As discussed in Section2.2.2(see Figure 5), speed has a much greater impact than pause time on link breakage rates [3].. See [6] for more details on the differences between the simulation environments in [4], [15], and herein. Further research on mobility models for ad hoc network protocol evaluation is needed. One avenue of future work is to devote further effort in examining the movements of entities in the real world to produce accurate mobility models. A second avenue is to develop a new model that combines the best attributes of some of the models. For example, a new model could handle edges via the method.

Gauss-Markov Mobility Model and then combine the movement patterns of the Boundless Simulation Area Mobility Model and the Random Waypoint (or Random Walk) Mobility Model. A third avenue is to develop a minimum mobility model standard for performance evaluation. This minimum standard would allow us to evaluate different mobility models more thoroughly. Lastly, we should examine the method used to choose a future MN location. In other words, the similarities and differences between mobility models that randomly select directions and mobility models that randomly select specific locations should be analyzed. The existing TCP/IP based Internet operates on a principle of providing end-to-end inter-process communication using a concatenation of potentially dissimilar link-layer technologies. The standardization of the IP protocol and its mapping into network-specific link-layer data frames at each router as required supports interoperability using a packet-switched model of service. Although often not explicitly stated, a number of key assumptions are made regarding the overall performance characteristics of the underlying links in order to achieve smooth operation: an end-to-end path exists between a data source and its peer(s).

In this paper, we argue that to achieve interoperability between some networks, especially those engineered for xtreme environments or that often suffer from frequent network partitioning, link-repair approaches alone will not suffice and network-specific proxies are undesirable. Instead, we suggest a general purpose message-oriented reliable overlay architecture as the appropriate approach to tie together such networks, forming an "internetwork of challenged internets." The approach, which provides the service semantics of asyn-hronous message delivery, may be used in combination with TCP/IP where appropriate. Its design is influenced by the interoperability properties of the classical Internet design, the robust non-interactive delivery semantics of electronic mail, and a subset of the classes of service provided by the US Postal System. These networks have all evolved to become highly successful communication networks supporting millions of daily users.

The first question to answer is whether the popular Internet protocols and application interfaces (or modest modifications to them) could be used straight forwardly as the solution. We first examine the operation of several specific Internet protocols without enhancements, followed by effects of link-repair methods and the use of proxies. Developing network-based applications has always been a more challenging undertaking than developing applications for local execution. To lessen the burden on the programmer, network access is often "hidden" below some other common abstraction (e.g. remote procedure calls or method invocation, remote file system access, etc). These systems are designed with a certain general understanding of network performance in mind. Challenged networks stress these assumptions, and reveal a number of the problems detailed below. While one cannot fault these systems for not contemplating challenged networks, in order to operate over such networks, some change in programming methodology would be needed. These changes are not extremely radical, and carefully-designed application libraries could help to minimize the burden on the programmer. These approaches most frequently elicit particular end station behavior by actively modifying the TCP data stream contents or timing relationship.

Approaches range from local connection termination, modification of the TCP ACK stream, retransmitting lost TCP packets without end-system interaction, and general data stream modification (e.g. compression or encryption). The approaches differ primarily in their respective levels of transparency. That is, to what extent they modify end-to-end semantics. Generally, more transparency is preferred to less, with the overall trade-off being between transparency and degree of performance improvement.

Analysis and modeling of wireless networks greatly depends on understanding the underlying models that mobile nodes follow:

First of mobility model is that of group-oriented or leaderoriented movement, in which the set of moving nodes, or units, can be divided into several disjoint sub-sets where the movement of units within each sub-set is highly correlated. By separating out the groups from each other, more precise analysis of intra-group behavior can be achieved, and inter group mobility correlation can be observed and analyzed. In this work we present several tools for analyzing mobility traces and determining the number and identity of these groups. We describe these tools in detail and compare their performance over both real and synthetic traces. In order to thoroughly simulate a new protocol for an ad hoc network, it is imperative to use a mobility model that accurately represents the mobile nodes (MNs) that will eventually utilize the given protocol. Only in this type of scenario is it possible to determine whether or not the proposed protocol will be useful when implemented. Currently there are two types of mobility models used in the simulation of networks: traces and synthetic models [28]. Traces are those mobility patterns that are observed in real life systems. Traces provide accurate information, especially when they involve a large number of participants and an appropriately long observation period. However, new network environments (e.g. ad hoc networks) are not easily modeled if traces have not yet been created. In this type of situation it is necessary to use synthetic models. Synthetic models attempt to realistically represent the behaviors of MNs without the use of traces. In this paper, we present several synthetic mobility models that have been proposed for (or used in) the performance evaluation of ad hoc network protocols.

A mobility model should attempt to mimic the movements of real MNs. Changes in speed and direction must occur and they must occur in reasonable time slots. For example, we would not want MNs to travel in straight lines at constant speeds throughout the course of the entire simulation because real MNs would not travel in such a restricted manner.

In Section 2, we discuss seven different synthetic entity mobility models for ad hoc networks In Section 4, we illustrate that a mobility model has a large effect on the performance evaluation of an ad hoc network protocol. In other words, we show how the performance results of an ad hoc network protocol significantly change when the mobility model in the simulation is changed. The results presented prove the importance of choosing an appropriate mobility model (or models) for a given performance evaluation. In addition, implementations of all the mobility models described in this paper The Random Waypoint Mobility Model includes pause times between changes in direction and/or speed [16]. An MN begins by staying in one location for a certain period of time (i.e., a pause time). Once this time expires, the MN chooses a random destination in the simulation area and a speed that is uniformly distributed between [minspeed, maxspeed]. The MN then travels toward the newly chosen destination at the selected speed. Upon arrival, the MN pauses for a specified time period before starting the process again. shows an example traveling pattern of an MN using the Random Waypoint Mobility Model starting at a randomly chosen point or position (133, 180); the speed of the MN in the figure is uniformly chosen between 0 and 10 m/s. We note that the movement pattern of an MN using the Random Waypoint Mobility Model is similar to the Random Walk Mobility Model if pause time is zero and [minspeed, maxspeed] = [speedmin, speedmax].

The Random Waypoint Mobility Model is also a widely used mobility model (e.g., [4, 8, 11, 15]). In addition, the model is sometimes simplified. For example, [18] uses the Random Waypoint Mobility Model without pause times. In the following, we present three possible solutions to avoid this initialization problem. First, save the locations of the MNs after a simulation has executed long enough to be past this initial high variability, and use this position file as the initial starting point of theMNs in all future simulations.

Second, initially distribute the MNs in a manner that maps to a distribution more common to the model. For example, initially placing the MNs in a triangle distribution may distribute nodes in the Random Waypoint Mobility Model more accurately than initially placing the MNs randomly in the simulation area [5].

II. EXISTING SYSTEM

One great challenge in designing robust MANETs is to minimize network partitions. As autonomous mobile users move about in a MANET, the network topology may change rapidly and unpredictably over time; and portions of the network may intermittently become partitioned. This condition is undesirable, particularly for mission-critical applications such as crisis management and battlefield communications. To address this challenging problem, the existing system proposes a new class of robust mobile ad hoc network called Autonomous Mobile Mesh Networks (AMMN).

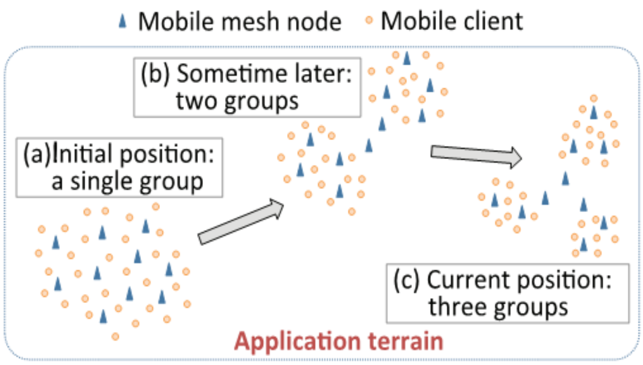
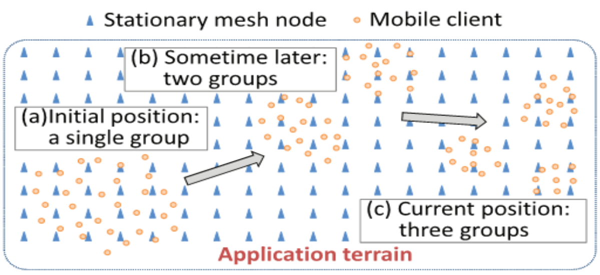


Fig 1. Topology adaptation of the autonomous mobile mesh network under three scenarios.



The topology adaptation of an AMMNET is illustrated in Fig. 1:

Fig. 1a: The mesh clients initially concentrate in one group. All the mesh nodes position themselves within the same proximity to support communications inside the group.

Fig. 1b: The mesh clients move northwards and split into two groups. The mobile mesh nodes, in this case, reorganize themselves into a new topology not only to facilitate intragroup communications, but also to support intergroup communications effectively preventing a network partition.

Fig. 1c: The same mesh clients now move southeast and form three groups. The mobile mesh nodes adapt their topology accordingly to archive full connectivity for all the mesh clients.

Drawbacks

- Searching for disappearing mobile clients is not carried out.
- Minimizing routing paths in not considered.

III. PROPOSED SYSTEM

In proposed system, all the existing system approaches are carried out. In addition, the following options are provided. A separate node searching logic is given to all the neighbor nodes of the disappeared node. The past communication path is kept in memory of all intermediate nodes for given time period so that during successive communication, the previous partial path information is used.

Advantages

- Tracks the users and dynamically adapt the network topology to seamlessly support both their intragroup and intergroup communications.
- Searching for disappearing mobile clients is carried out.
- Minimizing routing paths is considered.

IV CONCLUSION

The project need to work in dynamically formed groups that occupy different parts of a large and uncertain application terrain at different times. There is currently no cost-effective solution for such applications. Since the user groups occupy only a small portion of the terrain at any one time, it is not justifiable to deploy an expensive infrastructure to provide network coverage for the entire application terrain at all time. Other challenges are due to the potentially hostile environment and the uncertainty in how the application terrain unfolding with time.

In this proposed system introduced a mobile infrastructure called AMMNET. Unlike conventional mobile ad hoc networks that suffer network partitions when the user groups move apart, the mobile mesh routers of an AMMNET track the users and dynamically adapt the network topology to seamlessly support both their intra-group and inter-group communications. Since this mobile infrastructure follows the users, full connectivity can be achieved without the need and high cost of providing network coverage for the entire application terrain at all time as in traditional stationary infrastructure. The project describe a separate node searching logic is given to all the neighbor nodes of the disappeared node. The past communication path is kept in memory of all intermediate nodes for given time period so that during successive communication, the previous partial path information is used. In future still many change and interesting issues examined searching for disappearing mobile clients, minimizing routing paths, and utilizing non overlapping channels.

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