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Sovereign Mobile Mesh Networks

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Abstract- Networks composed of mobile nodes inherently suffer from intermittent connections and high delays. Performance can be improved by adding supporting infrastructure, including base stations, meshes, and relays, but the cost-performance trade-offs of different designs is poorly understood. To examine these trade-offs, we have deployed a large-scale vehicular network and three infrastructure enhancement alternatives. 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, inter-group communication is crucial to the team collaboration. To address this weakness, we introduce in this paper a new class of ad-hoc network called *Autonomous Mobile Mesh Network* (AMMNET). We propose a distributed client tracking solution to deal with the dynamic nature of client mobility, and present techniques for dynamic topology adaptation in accordance with the mobility pattern of the clients. Our simulation results indicate that AMMNET is robust against network partitioning and capable of providing high relay throughput for the mobile clients.

Index Terms—Mobile Mesh Networks, Dynamic Topology Deployment, Client Tracking

I. INTRODUCTION

Ad hoc wireless networks are interconnected sets of mobile nodes that are self-organizing, selfhealing,survivable, and instantaneously available, without any need for prior infrastructure. Since Internet Protocol (IP) suite is now recognized as the universal interface or "glue" for interconnecting dissimilar networks, an IP-based ad hoc network has the potential to solve the interoperability problems faced by various conventional stovepipe networks that are designed for specific usage cases.

A multi-hop mesh network can be defined as a communications network that has two or more paths to any node, providing multiple ways to route data and control information between nodes by "hopping" from node to node until a connection can be established. Mobile mesh networks enable continuous efficient updates of connections to reconfigure around blocked or changed paths.

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.

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. We address this challenging problem in this paper by proposing a new class of robust mobile ad-hoc network called *Autonomous Mobile Mesh Networks* (AMMNET). In a standard wireless mesh network, stationary mesh nodes provide routing and relay capabilities. Such a network is scalable, flexible,and low in maintenance cost. When a mesh node fails, it can simply be replaced by a new one; and the mesh network will recognize the new mesh node and automatically reconfigure itself. The proposed AMMNET

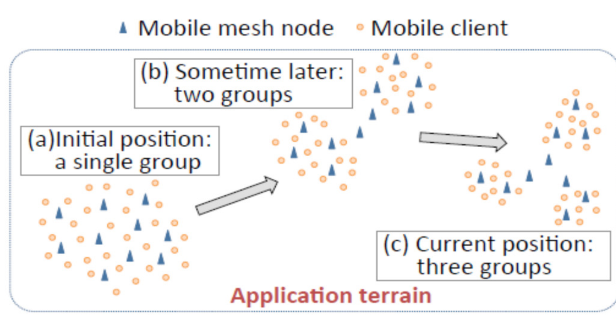

Fig. 1. Topology adaptation of the autonomous mobile mesh network under three scenarios

has the following additional advantage. The mobility of the mesh clients is confined to the fixed area serviced by a standard wireless mesh network due to the stationary mesh nodes. In contrast, an 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.

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

Fig. 1(a): 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. 1(b): The mesh clients move northwards and split into two groups. The mobile mesh nodes, in

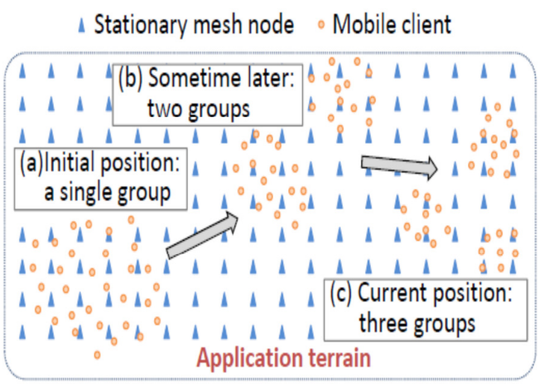

Fig. 2. Fixed grid-based square topology under three scenarios illustrated in Fig. 1

This case, reorganize themselves into a new topology not only to facilitate intra-group communications, but also to support inter-group communications effectively preventing a network partition. Fig. 1(c): 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. We note that it is not always feasible to replace a mobile mesh network with a standard stationary mesh network which is large enough to provide coverage for the entire application terrain as shown in Fig. 2. In this paper, we deal with application terrains that are too large and too expensive for such a deployment.Besides, pre-deployment of such a fixed mesh network might not even be possible for many applications such as disaster recovery and battlefield communications.Specifically, LTE [1] and WiMAX [2] might be able to support broadband access for a given application terrain.

They however are not flexible enough to adapt to topology changes for the dynamic applications considered in this work, and hence might require a much higher deployment cost, including the costs of equipments, manpower and rewiring. In other words, they are a cost effective technology only when there is a high density of users in a fixed and known application terrain, like in urban or suburban residential networks, to justify the expensive deployment cost.

However, when this condition is not satisfied, such as a large temporary and uncertain application terrain in battlefield communication or disaster management applications, AMMNET is a good candidate because it can adapt to a very dynamic environment. Delay tolerant network (DTN) [3] is another option to support opportunistic communications for mobile networks. However, there is no guarantee of finding a routing path to forward data. In contrast, the goal of our design is to provide such mobile networks a robust infrastructure with persistent connectivity. We note that if the number of mesh nodes in AMMNET is not enough to support full connectivity for the entire terrain, DTN can be used to improve the probability of data delivery. We leave the integration of AMMNET and DTN as our future study.

Fig. 3. Autonomous airborne mesh networks for crisis management

We assume that each mobile mesh node is equipped with a localization device such as GPS. In addition, 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. Alternatively, RFID has been proposed for location-based applications [4].Similarly, mesh clients can be tagged with an inexpensive RFID and mobile mesh nodes are equipped with an RFID reader to detect the presence of mobile nodes within their sensing range.

Our challenges in designing the proposed AMMNET are twofold. First, the mesh clients do not have knowledge of their locations making it difficult for the mobile mesh nodes to synthesize a global map of the user locations.Second, the topology adaptation needs to be based on a highly efficient distributed computing technique in order to keep up with the dynamic movement of the mobile users. These challenges are addressed in this paper.The remainder of this paper is organized as follows.We introduce the framework of an AMMNET,and present how to realize mobile client tracking in a distributed manner in Section 2. In Section 3, a number of network topology optimization methods are discussed.Our performance evaluation results are given in Section 4. We summarize some related work in Section 5, and conclude this paper in Section 6.

II. EXISTING SYSTEM

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. They are also a cost effective solution because the same ad hoc network can be relocated, and reused in different places at different times for different applications.

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.

III . PROPOSED SYSTEM

In this project we propose a new class of robust mobile ad hoc network called Autonomous Mobile Mesh Networks (AMMNET).In a standard wireless mesh network, stationary mesh nodes provide routing and relay capabilities. They form a mesh-like wireless network that allows mobile mesh clients to communicate with each other through multihop communications. Such a network is scalable, flexible, and low in maintenance cost. When a mesh node fails, it can simply be replaced by a new one; and the mesh network will recognize the new mesh node and automatically reconfigure itself. The mobility of the mesh clients is confined to the fixed area serviced by a standard wireless mesh network due to the stationary mesh nodes.In particular, an AMMNET tries to prevent network partitioning to ensure connectivity for all its users. This property makes AMMNET a highly robust MANET.

IV . TOPOLOGY ADAPTATION

The protocol discussed so far ensures that the mesh nodes maintain the connectivity for all clients. The resulting networks, however, might incur long end-to-end delay with potentially many unnecessary intergroup routers because the bridging networks are constructed independently. As the example shown in if a client in group G2 wants to communicate with another client in group G3, this must be done through a long path over the router b1 at group G1 although groups G2 and G3 are near each other. Another potential drawback is the excessive use of the intergroup routers. To improve this condition, we propose two topology adaptation schemes, namely local adaptation and global adaptation, each with a different resolution of location information to shorten the relay paths between groups.

A Local Adaptation

A star topology generally provides shorter relay paths, and, as a result, requires fewer intergroup routers. To construct a star topology, we let the bridge routers exchange their location information opportunistically, and perform local adaptation as shown in Algorithm 1 when some bridge routers detect that they are close to each other.

Algorithm 1. Topology Adaptation (initiated by router r).input: (Collected in Algorithm 1) Rb: set of bridge routersknown by r opportunistically; Lb: location of router b 2 Rb; Ri: set of intergroup routers connecting all known bridge routers b 2 Rb

1: if number of free routers in r's group < _ then
2: Call Algorithm 3 to perform global adaptation;
3: else
4: Compute the single star topology S for Rb;
5: Build a bridge network B connecting to any bridge router b0 62 Rb;
6: N0 i number of intergroup routers needed for
S and B;
7: if N0 i _ _jRij then
8: Trigger the assigned intergroup routers to adapt
their topology to S [B after a three-way
handshaking;
9: Reclaim the rest of intergroup routers to the
free-router poor;
10: end if
11: end if
12: return

Specifically, when clients in different groups are communicating with each other, the corresponding bridge routers can exchange their location information by piggybacking such information in the data packets. For instance,when client c1 transmits a data packet to client c2 through

B Global Adaptation

Local topology adaptation provides local optimization. It is desirable to also perform global topology adaptation to achieve global optimality. The motivation is to achieve better overall end-to-end delay and free up intergroup routers for subsequent local adaptation. A simple option for global optimization is to apply Algorithm 1 to construct a star network for all the bridge routers in the AMMNET.Such a star network, however, would be inefficient and require more intergroup routers than necessary, particularly when there are a significant number of groups in the network as in Ideally, an AMMNET should use as few intergroup routers as possible to minimize the number of mobile routers required and deliver good end-to-end delay for the application. This optimization problem can be formulated as the connected set cover problem, which has been proved to be NP-hard . In this paper, we propose a hierarchical star topology, which is a near-optimal technique based on R-tree [as shown in Algorithm 1. The Rtree is a multidimensional tree structure that aggregates at most M objects into a minimum-bounding rectangle. M of such rectangles are further aggregated into a larger bounding rectangle at the next higher level in the tree. This clustering process is repeated recursively at the higher levels until there is a single minimum-bounding rectangle left at the root of the R-tree. To determine a suitable value of M, we can apply k-means clustering or affinity propagation to cluster the bridge routers in the network. The latter does not require a specified number of clusters k. After clustering, each bridge router is associated with a distinct cluster based on its Euclidian distance with the centroid of the cluster. M is etermined as the average size of all the clusters, i.e., M ¼ Pk i¼1 jCij=k, where k is the number of clusters and jCij is the number of bridge routers in the ith cluster Ci.

V. Performance of Network Coverage

We start by examining the performance of the network coverage under different network scenarios as follows:

A Impact of Router Moving Speed

We first determine how many clients can be covered by mobile mesh nodes when the number of available mesh nodes is not enough to cover all the clients in the simulation terrain. To meet this constraint, we deploy only 100 available mesh nodes in this simulation. Each simulation includes 100 clients classified into five mobile groups. We vary the moving speed of routers from the mean speed of clients to six times of the mean speed of clients. We note that the number of routers might appear excessive for the number of users in the network. However, the cost of the network should be considered from the view point of the area of the application terrain (not the number of users)
in the context of AMMNET.

B Coverage Area Given a Finite Number

Routers We next check how many clients can be served by different comparison schemes under the same simulation setting, yet

VI. Stationary Node Placement

Intuitively, there are two strategies for stationary node placement based on regions in the mobile network.

• Uniform placement: place the nodes uniformly across the entire network limited only by the placement constraints described above.
• Non-uniform: place more nodes in the network core, while still following the placement constraints. We use a simple heuristic for such a placement. The number of nodes in each square (see Figure 3) is proportional to the amount of time mobile nodes spend in that square.

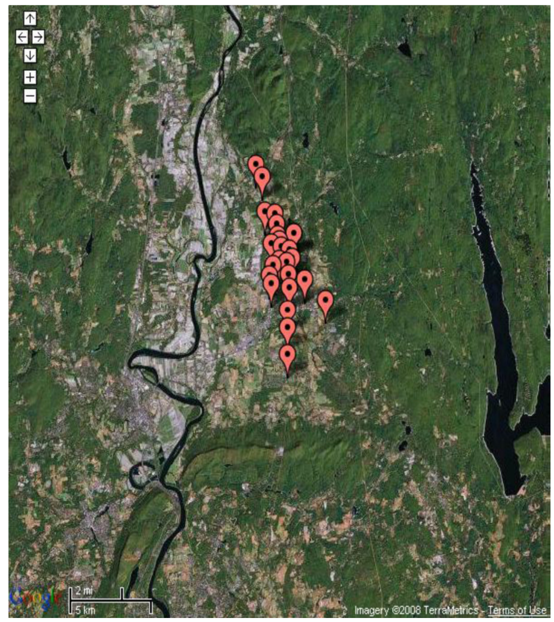

Figure 4: Placement of 25 base stations nonuni for across the mobile network.

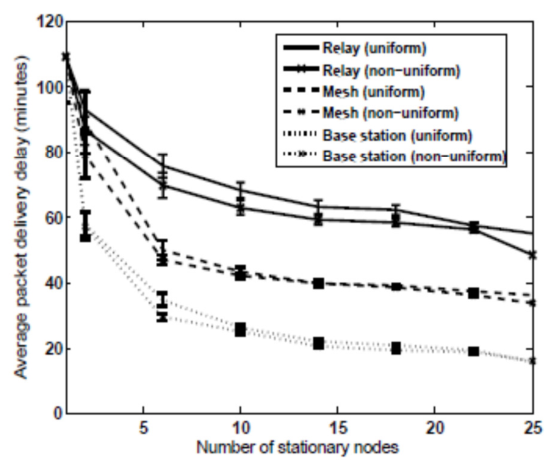

Figure 5: The average packet delivery delay with a varying number of stationary nodes for uniform and non-uniform placement.

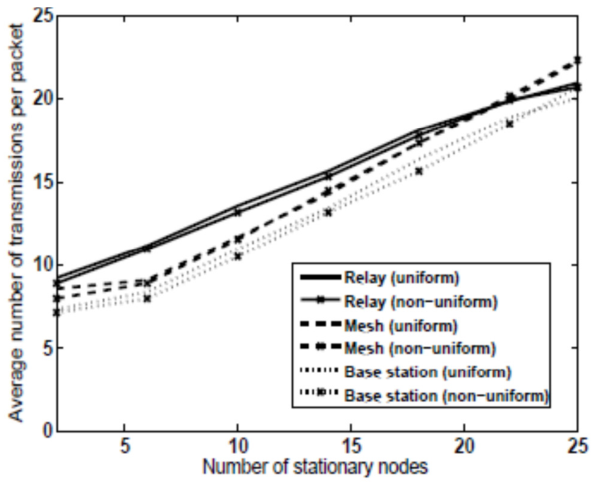

Figure 6: The average number of transmissions per packet with a varying number of stationary nodes for non-uniform and non-uniform placement.

VII. RELATED WORK

There is a large body of research on analyzing hybrid networks.These include studies on the effect of placing a sparse set of well connected base stations in an ad hoc wireless network , improving performance of sparse mobile networks using autonomous agents [10], and adding relays in a purely mobile network [4]. Measurement studies on throughput capacity of vehicular networks show the feasibility of Internet-based applications from mobile nodes [7]. Similarly, systems of base stations, called Infostations, have been designed to provide intermittent coverage and connectivity in mobile networks.Although, augmenting a mobile network with stationary nodes is a well studied area, there is little or no work that analyzes different hybrid network configurations under one unified framework.

Our study offers a general analytical model and a more constrained real-world deployment study comparing the performance of different hybrid networks.The analytical model in the paper derives from a body of work on using Markov chains to model mobile networks. The ODE model as a fluid limit of Markov chains was first introduced to study epidemic routing in sparse mobile networks. Markovian models have been used to study various routing protocols: epidemic routing, 2-hop routing , and Spray and Wait. More fundamental work on modeling inter-meeting time between nodes following common mobility models was performed by Kurtz .

A recent work by Ibrahim et al. uses the Markov model to analyze a single region network with untethered relays and relays connected through a wired infrastructure. That paper derives asymptotic expressions using the fluid limit of Markov chains for a simple MTR routing protocol. We build on their work and present a more general model for epidemic routing for mobile networks with infrastructure based on ordinary differential equations. We argue that epidemic routing is more general than MTR routing since most routing protocols for sparse mobile networks are variants of epidemic routing.

Moreover, their work lacks a deployment which is important for understanding the effect of practical issues like dynamic routing protocols, node placement, and real world propagation.More recent work by Balasubramanian et al. [2] confirms our results that a significantly sized base station infrastructure can quickly overwhelm the benefits of add mobile-to-mobile DTN routing in the context of web search and retrieval on DieselNet.

VIII. CONCLUSION

We have performed an experimental and analytical study of mobile networks enhanced with relays, meshes, and wired base stations.We first explore the trade-offs with each type of infrastructure experimentally in the context of a deployed vehicular testbed. However, since the number of mobile and stationary nodes in the deployment is small, we complement this effort by developing analytical models of large-scale networks in the presence of different infrastructures.Based on the model and the deployment, our study draws three main conclusions. (1) We need less than 5–7 times as many relays and 2–3 times as many mesh nodes as base stations for a similar enhancement in performance. Considering the high cost of deploying base stations, it is often a better choice to deploy untethered relays or mesh nodes; however, when extremely small delays are sought,base stations are required. (2) The addition of infrastructure often obviates the need for mobile-to-mobile routing. For example, simple two-hop forwarding provides excellent performance for base station and mesh networks. (3) The number of mobile nodes required to influence performance given a fixed number of base stations is very large. From these results, we can conclude that a small amount of infrastructure in certain cases is vastly superior to even a large number of mobile nodes capable of routing data to one another.

REFERENCES

[1] E. Dahlman, S. Parkvall, and J. Sko¨ ld, 4G LTE/LTE-Advanced for Mobile Broadband. Academic, **2011**.
[2] L. Nuaymi, WiMAX: Technology for Broadband Wireless Access. John Wiley & Sons, **2007**.
[3] K. Fall, “A Delay-Tolerant Network Architecture for Challenged Internets,” Proc. ACM Special Interest Group on Data Comm., **2003**.
[4] A. Petkova, K.A. Hua, and S. Koompairojn, “Processing Approximate Rank Queries in a Wireless Mobile Sensor Environment,”Proc. 11th

Int'l Conf. Mobile Data Management (MDM), **2010**.
[5] "Quadrocopter LLC," http://quadrocopter.us/, **2013**.
[6] R. Roy, Handbook of Mobility Models and Mobile Ad Hoc Networks.Springer, **2010**.
[7] Y.-C. Chen, E. Rosensweig, J. Kurose, and D. Towsley, "Group Detection in Mobility Traces," Proc. Sixth Int'l Wireless Comm. And Mobile Computing Conf. (IWCMC '10), **2010**.
[8] T. Camp, J. Boleng, and V. Davies, "A Survey of Mobility Models for Ad Hoc Network Research," Wireless Comm. and Mobile Computing, vol. 2, no. 5, pp. 483-502, **2002**
[9] X. Hong, M. Gerla, G. Pei, and C. Chiang, "A Group Mobility Model for Ad Hoc Wireless Networks," Proc. Second ACM Int'l Workshop Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWiM '99), **1999**.
[10] K. Blakely and B. Lowekamp, "A Structured Group Mobility Model for the Simulation of Mobile Ad Hoc Networks," Proc. Second Int'l Workshop Mobility Management & Wireless Access Protocols (MobiWac), **2004**.

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