The limit of ad hoc networks to commercial success
(Position Paper)

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Abstract

Mobile ad hoc networks have several advantages over traditional wireless networks including ease of deployment, speed of deployment, and decreased dependence on a fixed infrastructure. However, they have lots of challenges. To make matters worse, they seem to have some problems not to get overcame. The requirement of multihop traffic relay makes scalability to larger network the main drawback. In addition, they need the help of other node to reach the correspondent over one hop away from them. This could be one of the restrictions to commercial success. In the near future, MANET would be part of wider networks and cooperate to make the performance improvement of cellular networks.

1. Introduction

Networks have been evolved irrespective of what they are. Since Alexander Graham Bell invented a telephone in 1876, we have lived in a wired communication environment almost for one hundred years except for extremely rare cases such as aboard-ship communication with land. Since AT&T and Bell Labs constructed the first analog cellular system in 1977, 1.5 billion people globally now have digital mobile phones in short of 30 years. The users will be increased to 2 billion in 2007[1]. During the last decade, advances in both hardware and software techniques have made mobile nodes and wireless networking common and miscellaneous. So, what would come up next to lead communication arena?

Generally, there are two distinct approaches for enabling wireless mobile units to communicate each other. 1) Infra-structured. Wireless mobile networks have traditionally been based on the cellular concept and relied on good infrastructure support in which mobile devices communicate with access points like base stations connected to the fixed network. Typical examples of this kind of wireless networks are CDMA, WLL, GSM, etc. 2) As to infrastructureless approach, the mobile wireless network is commonly known as a Mobile Ad Hoc Networks(MANETS)[2,3]. A MANET is a collection of wireless nodes that can dynamically from a network to exchange information without using any pre-existing fixed network infrastructure. This is a very important part of communication technology that supports truly pervasive computing, because in many contexts information exchange between mobile units cannot rely on any fixed network infrastructure, but on rapid configuration of wireless connections on the fly. Significant examples include establishing survivable, efficient, dynamic communication for emergency/rescue operations, disaster relief efforts, and military networks.

In the side of cellular, they are developing the next generation system with goal for supporting above 100 Mbps throughput while the deployment and standardisation of 3G systems is still underway. For MANET, they have been the subject of significant research over the past several years, with numerous routing proposals and efforts to revise TCP to make applications operate well in the network since the MANET working group was born in 1997.

Since ad hoc networks are promising with strong price competence, will MANETS be winner? Otherwise, will they cooperate to make better networks? This paper approaches this question carefully beginning with addressing what MANET are and what problems MANET have, then examines what efforts MANET are being made to overcome these problems and what limit which they inherently have are. Finally it tries to sees where the wireless networks will go in the future.

2. A definition of MANETS

According to Murphy&al.[4], an ad hoc network is “a transitory association of mobile nodes which do not depend upon any fixed support infrastructure. […] Connection and disconnection is controlled by the distance among nodes and by willingness to collaborate in the formation of cohesive, albeit transitory community. Another definition is shown in [2], as follows:

A “ mobile as hoc network”(MANET) is an autonomous system of mobile routers(and associated hosts) connected by wireless links – the union of which form an arbitrary

graph. The routers are free to move randomly and organize themselves arbitrarily; thus the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet."

Since no base stations are required, ad hoc networks can be deployed quickly, without having to perform any advance planning or construction of expensive network infrastructure. Hence such networks are ideally suited for applications where such infrastructure are not available or unreliable.

Typical applications include military communications networks in battlefields, emergency rescue operations, undersea operations, environmental monitoring and space exploration. Because of its temporary deployment quality and relatively low cost of implementation, ad hoc networks are used in places where it is cheaper than its infra-structured counterparts. Examples of these applications consist of a network of laptop computers in conference rooms, network of digital electronic equipment and appliances(e.g VCR, television, computer, printer, remote control, etc.)[5]. Recently there is a growing interest of using ad hoc networks of wireless sensors to perform unmanned distributed surveillance and tracing operations[6].

Is there any problems underling in MANETS?

3. The problem of MANETS

One of what MANET differs from other network comes from a combination of device motion and interactions with the environment. Wireless links are quite susceptible to time varying statistical behavior caused by many factors, including the physics of propagation medium, inner city fading characteristics and shadowing (e.g. a person walking by a device). Even when two persons are closer to each other than another person, the both cannot be connected via radio because there is an environmental obstacle like metal building or hill, etc. So, their views of the network is different, As they move, or as their environment changes around them, this view of the network will also change. Hence, the network topology, that is defined by the set of physical communication links in the network(wireless links between all pairs of nodes that can directly communicate with each other) can frequently and unpredictably. This implies that the multihop path for any given pair of source and destination nodes also changes with time.

Mobility also causes unpredictability in the quality of an existing wireless link between neighbors. Another difference is the absence of centralized control. All networking functions, such as determining the network topology, multiple access, and routing of data over the most appropriate multihop paths, must be performed in a distributed way. In other words, all nodes may function as router. These tasks are particularly challenging due to the limited communication bandwidth available in the wireless channel. Many of proposed routing algorithm[7,8] use a broadcast route discovery mechanism whereby a route request is flooded across the entire network. While the impact of such route discovery floods may be limited in small networks, the impact, the impact will be significantly greater for larger networks. When a link break in an active route occurs, many of these protocols require that an error notification be sent to nodes that were using that link. Again, for small networks with limited network diameters, this route error message can be propagated back to a source node relatively quickly, and some repair action can be taken. However, as the network diameter and average path length increase, the error message may have to propagate across tens of hops to reach the source nods. For a large networks, or even smaller networks with rapidly moving nodes, it is likely that the source node will be unable to make a repair before another link in the route breaks.

Internet routing protocols, such as RIP, OSPF and BGP have always been developed on the assumption that networks have some degrees of instability while networks proceed from a converged state to a converged state through epochal transitions such as changes to router configurations, loss or restoration of links or loss or restoration of routers. Due to node mobility and constantly changing neighbor interconnectivity, MANETS must displays more severe convergence problem than wired network.

Common routing protocols depend on bi-directional connectivity. Distance vector protocols, for example, advertise what might be considered to be statements that "you can reach [this prefix] with [these attributes] via me, on the interface that you receive this message. OSPF explicitly refuse to use links that lack bidirectional connectivity while not making statements of that form. In a ad hoc network, a given relationship can be unidirectional. Node A may be able to hear node B, but B not hear A, and it may make operational sense to allow A to B.

In addition to the common vulnerabilities of wireless connection, an ad hoc network has its particular security problems, due to nasty neighbor relaying packets. The feature of distributed operation requires different schemes of authentication and key management. Further, wireless link characteristics introduce also reliability problems, because of the limited wireless transmission range, the broadcast nature of the wireless medium(e.g.

hidden/exposed terminal problem), mobility-induced packet losses and data transmission errors.

Providing different quality of service level is a constantly changing environment will be a challenge. The inherent stochastic feature of communications quality in a MANET makes it difficult to offer fixed guarantees on the services offered to a device. An adaptive QoS must be implemented over the traditional resource reservation to support the multimedia services

Some or all of the nodes in a MANET may rely on batteries or other exhaustible means for their energy. As a result of energy conservation, or some other need to be inactive, nodes of a MANET may stop transmitting and/or receiving for arbitrary time period. A routing protocol should be able to accommodate such sleep periods without overly adverse consequences.

4. The status of MANETS

There are a number of ways to solve these problems as the number of proposals made to the MANET working group attests. They commonly broken down into two broad classes: reactive protocols, which determine what route to use when the route is needed, and proactive protocols that predetermine routes on the assumption that they may be needed.

Reactive protocols follow approaches such as source routing or some form of on demand. These are designed with the premises that most active routes are topologically local, within one or two hops and the application can work around occasional routing glitches if recovery is expedited. The Ad hoc On-Demand distance Vector(AODV) and DSR(Dynamic Source Routing)[] belong to a reactive protocol. Proactive protocols generally follow some form of link-state algorithm, such as SPF(Dijkstra) or of map-based explicit routing. These are designed with the premises that routes of any length may be commonly used or not at all and the constant route changes that happen globally may materially affect the correct operation of individual nodes. Topology Multicast Reverse Path Forwarding(TBRPF) and Optimized Link State Routing(OLSR) are SPF- based protocols.

Security is an issue that none of these protocols has directly addressed, although some general analyses have been floated. Security flaws exist in many of them, which could be exploited; for example, DSR is subject to man-in-the-middle attacks.

Quality of Service is not addressed except AODV. There is a draft that describes QoS use of routing protocol, which would have it seek a path in which certain bandwidth and delay bound are met, and in which the request for a route would fail if its conditions cannot be satisfied. QoS routing is, of course, seen as a research topic by much of the IETF community, due to a lack of commercial demand and the difficulty of the problem in a destination-routed connectionless network[14].

From the perspective of the marketplace, there is little commercial demand for MANET-style protocols. While interactive automotive mapping services are common in Japan and some European countries, these use direct-connect short-reach radio technologies or third generation wireless, rather than packet networks. Sensor networks remain the realm of research, and military uses are in research.

5. The limit of MANET

It is the distance among nodes or rather their proximity that defines the boundaries of the network. It does not imply that all nodes within the network are within their reach each other. The collection of several nodes within a certain distance is not a necessary but not sufficient condition to form a ad hoc network. In addition, collocated nodes need to be willing to collaborate. If one node is out of the range of their correspondent, other nodes that are intermediate between two could help them to communicate each other. If network get bigger in this way, could it be extended to contain infinite nodes?

For MANET to be used in commercial networks, it would require a routing algorithm to support scalability to large network of millions to billions nodes. There have been many recent proposals of unicast routing protocols for ad hoc mobile networks[7, 8]. Many of these publications include simulations of the protocols they describe, illustrating the performance of the protocol. To determine the relative merits and strengths of the various protocols, studies have been performed which simulate the protocols under various input conditions[9, 10]. While these simulations and studies are informative in evaluating the performance of the protocols for relatively small number of the protocols for relatively small number f nodes(i.e., 50 nodes), they do not show how any of the protocols scales to larger node populations. AODV and the zone routing protocol(ZRP), respectively for networks as large as 1000 nodes[8].

Clustering and hierarchical addressing methods have long been known for attempting to increase protocol scalability[11, 12]. Clustering protocols group nodes into clusters based on their proximity to each other. Cluster-based protocols, however, have their drawbacks. They require periodic messaging from each network node in order to maintain the clusters. This periodic messaging results in higher processing and control packet overhead,

as well as increased bandwidth utilization and longer delay. Moreover, if the protocol constrains routes to traverse cluster leaders, longer path lengths will be required. Also, there may be complications when the cluster leaders fail or give up their cluster leader status.

With combination of modifications that may be incorporated into virtually any on-demand protocol, the simulation shows scalability improvement up to maximum as large as 10,000 nodes[14].

And will one node sacrifice his/her limited power to help other nodes that have not any kind of favorable relationships? I think it's not likely to share his/her precious resource without the common interest or the members belonging to the same organization where devices are not private, for example, a company or university, etc.

6. The future of MANETS

Ad Hoc Networks is an area that is being widely researched these days and is a very fast growing area. Much work still is left done in this field for it to be commercially viable.

In addition, ad hoc routing requires that nodes cooperate to forward each other' packets through the network. This means the throughput available to each single node's applications is limited not only by the raw channel capacity, but also by the forwarding load imposed by distant nodes. This effect could seriously limit the usefulness of ad hoc routing. The simulated chain capacity that the 802.11 MAC of ad hoc mode achieves with a greedy sender is about 1/7 because nodes early in the chain starve later nodes[15]. This proves that the network scalability in ad hoc networks is limited. It remains question that the node could cooperate to forward traffic for other nodes when there is no benefit. MANETS are not seen as networks in their own right any more than local area networks are networks in their own right. Instead, MANETS are seen as localities within networks, much as LANs operate as the local access to a wider area Internet. The operation of MANETS in isolation is a special case of their operation as part of a larger network. The low scalability and the unwillingness of nodes in commercial network would limit the application of ad hoc network.

How will the next generation of system evolve?

In recent years, intrastructure-based wireless data networks have made tremendous progress with both the worldwide upgrade of cellular networks to support wide-area data access and the widespread deployment of IEEE 802-11 based local area networks. Recent research has been done to combine two networks synergistically. One of them is to increase the throughput of wide area cellular wireless networks through opportunistic use of ad-hoc local area wireless networks through the integrated card to offer both IEEE 802.11b and 3G wireless interface[16]. This is one way that ad hoc networks could contribute to next generation networks with its own exclusive realm.

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