OVERVIEW AND CHALLENGES OF ROUTING PROTOCOL AND MAC LAYER IN MOBILE AD-HOC NETWORK

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ABSTRACT:

Mobile Ad-hoc Network (MANET) are a new paradigm of wireless wearable devices enabling instantaneous person-to-person, person-to-machine or machine-to-person communications immediately and easily .In this paper an overview and history of MANET is given .We discuss the issues which should keep in mind for designing of MAC layer and Routing protocols at Network layer. All these issues can be taken into consideration for the improvement of MANET performance.

In mobile ad hoc networks, several interesting and difficult problems arises due to shared nature of the wireless medium, limited transmission power, limited transmission range, node mobility, and battery limitations, bandwidth limitation etc. The limited transmission range of wireless network coupled with the highly dynamic routing infrastructure need extra care. Mobility also create a lot of concerns. For communication, issues such as dynamic routing, efficient channel access and quality-of-service (QoS) support, bandwidth, synchronization, distributed nature, lack of central coordination should be considered. In this paper broadly we will discuss the above mentioned challenges at Network layer and MAC LAYER in mobile ad-hoc networks.

Key words: *MANET, MAC layer , Routing protocol*

1. INTRODUCTION:

An ad-hoc wireless network is a collection of wireless nodes that self organize into a network without the help of an existing infrastructure. Some or possibly all of these nodes are mobile. Since the network can be deployed rapidly and flexibly, it is attractive to numerous potential applications. Possible commercial applications of MANET include business associates sharing information during a meeting, students using laptop computers to participate in an interactive lecture, and emergency disaster relief personnel coordinating efforts in natural disasters. Mobile ad hoc networks also a good alternative in rural areas or third world countries where basic communication infrastructure is not well established.

A Mobile ad hoc network (MANET) is an autonomous collection of mobile users (nodes) that communicate over bandwidth-constrained wireless links as shown in fig 1. Due to nodal mobility, the network topology may change rapidly and unpredictably over time. The network is decentralized, where network organization and message delivery must be executed by the nodes themselves. Message routing is a problem in a decentralized environment where the topology fluctuates. While the shortest path from a source to a destination based on a given cost function in a static

network is usually the optimal route, this concept is difficult to extended in MANETs [1].

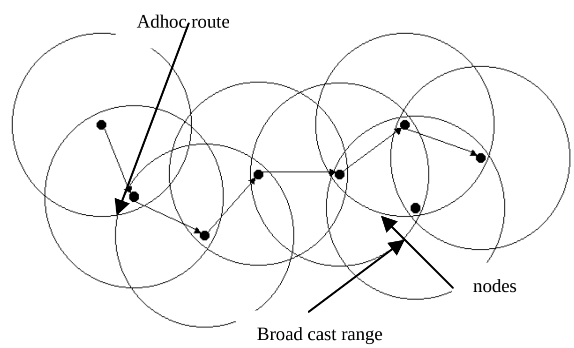

Fig. 1 An ad hoc wireless network

MANET adhoc nodes present in range of different areas. Factors such as power expended, variable wireless link quality, propagation path loss, fading, multi-user interference, and topological changes, limited bandwidth become relevant issues. The network should be able to adaptively alter routing paths to alleviate any of these effects.

2. HISTORY:

The concept of ad hoc networks is not new. Its history can be dated back to the Department of Defense (DoD)-sponsored Packet Radio networks (PRNET) research for military purpose in 1970s, which evolved into the Survivable Adaptive Radio networks (SURAN) program in the early 1980s [1]. The Defense Advanced Research Projects Agency's Strategic Technology Office wants DARPA[2] wants proposals that will help it to develop tactical wireless networks that have little centralized control or infrastructure and limited or no reliance on aerial relay nodes with a throughput of greater than 300 kilobits/sec for a network with 200 nodes.

The PRNET used a combination of ALOHA and CSMA approaches for medium access, and a kind of distance-vector routing. SURAN employed routing protocols which were based on hierarchical link-state and were highly scalable. In the early 1990s ad hoc networks entered a new phase of development due to the popularity of notebook computers with communication equipments based on RF and infrared grew. The idea of an infrastructure less collection of mobile hosts was proposed, and the IEEE 802.11 subcommittee adopted the term "ad hoc networks". Novel non-military applications were suggested. At around the same time, the DoD continued to found programs such as the Global Mobile Information Systems (GloMo), and the Near-term Digital Radio (NTDR). The goal of GloMo was to provide office-environment Ethernet-type multimedia connectivity anytime, anywhere, in handheld devices. Channel access approaches were now in the CSMA/CA and TDMA, and several novel routing and topology control schemes were deployed. The NTDR used clustering and link-state routing, and self-organized into a two-tier ad hoc network. Presently, NTDR is the only "real" (non-prototype) ad hoc network is used by US Army. Since mid 1990s, a lot of work has been done on the ad hoc standards. Within the IETF, the mobile ad hoc networking (MANET) working group was born, and made effort to standardize routing protocols for ad hoc networks. The IEEE 802.11 subcommittee standardized a medium access protocol that was based on collision avoidance and tolerated hidden terminals.

3. MAC LAYER:

MAC protocol is used for Coordination and scheduling of transmissions among competing neighbors and its goal are Low latency, good channel utilization, best effort services and real time support. MAC protocol coordinates transmissions from different stations in order to minimize/avoid collisions. Various MAC layer protocols are available. Random Access is done in CSMA and MACA, Channel Partitioning is done in TDMA, FDMA and CDMA. The 802.11 standard specifies a common medium access control (MAC) Layer, which provides a variety of functions that support the operation of 802.11-based wireless LANs. Main functions of 802.11 MAC Layer are Scanning, Authentication, Association, WEP, RTS/CTS, Power Save Mode, and Fragmentation[4]

3.1 CHALLENGES IN MAC LAYER:

The main issues should be considered while designing a MAC layer protocol for ad-hoc wire less network are given below.

3.1.1BANDWIDTH EFFICIENCYAND OVERHEAD:

Since the radio spectrum is limited, the bandwidth available for communication is very limited. The MAC protocol must be designed in such a way that the scarce bandwidth is utilized in an efficient manner [5].The control overhead involved must keep as minimum as possible.

3.1.2 QUALITY OF SUPPORT (QoS):

The nodes are mobile most of the time, providing QoS support to data sessions in such networks is very difficult. Bandwidth reservation made at one point time may become invalid once the node moves out of the region where the reservation was made. QoS support is essential for supporting time critical traffic sessions [5].

3.1.3 SYNCHRONIZATION:

A MAC protocol must take into consideration the synchronization between nodes in the network and bandwidth reservation by nodes. The exchange of control packets may be required for achieving time synchronization among nodes .The control packets must not consume too much of work band width.

3.1.4 HIDDEN AND EXPOSED TERMINAL PROBLEMS:

The hidden terminal problem refers to the collision of packets at a receiving node due to simultaneous transmission of those nodes that are not within the direct transmission range of the sender, but are within the transmission range of receiver. Collision occurs when both nodes transmit packets at the same time [6]. The hidden and exposed terminal problems significantly reduce the throughput of a network when the traffic load is high. It is therefore desirable that the MAC protocol be free from the hidden and exposed terminal problems.

3.1.5 ERROR PRONE SHARED BROADCAST CHANNEL:

Because of broadcasting nature of transmission, collisions may occur. A MAC protocol should grant channel access to nodes in such a manner that collisions are minimized. Also, the protocol should that all nodes are treated fairly with respect to bandwidth allocation.

3.1.6 DISTRIBUTED NATURE/ LACK OF CENTRAL COORDINATION:

In MANET nodes move continuosly, therefore nodes must be scheduled in a dietributed fashion for gaining access to the channel. This may required exchange of control information. The MAC protocol must make sure that the additional overhead, in terms of bandwidth consumption, incurred due to this control information exchange is not very high.

3.1.7 MOBILITY OF NODES:

Nodes are mobile most of the time in wireless network. The bandwidth reservation made or control information exchange may end up being of no use if node mobility is very high. The MAC protocol has no role to play in influencing the mobility. The MAC protocol design must take this mobility factor into consideration such that the performance of the system is not significantly affected due to node mobility.

4. ROUTING PROTOCOLS:

At network layer, routing protocols are used to find route for transmission of packets. Routing is the most fundamental research issue in ad hoc networking . The merit of a routing protocol can be analyzed through metrics-both qualitative and quantitative with which to measure its suitability and performance. These metrics should be independent of any given routing protocol. Desirable qualitative properties of MANET are Distributed operation, Loop-freedom, Demand-based operation, Proactive operation, Security, Sleep period operation and unidirectional link support. Some quantitative metrics that can be used to assess the performance of any routing protocol are End-to-end delay, throughput, Route Acquisition Time, Percentage Out-of-Order Delivery and Efficiency. Essential parameters that should be varied include: Network size, Network connectivity, Topological rate of change, Link capacity, Fraction of unidirectional links, Traffic patterns, Mobility, Fraction and frequency of sleeping nodes[5].

Routing protocols for ad hoc networks must deal with limitations such as high power consumption, low bandwidth, high error rates and arbitrary movements of nodes. Generally, current routing protocols for ad hoc networks can be categorized as: Proactive and reactive.

4.1 PRO-ACTIVE (table-driven):

The pro-active routing protocols are the same as current Internet routing protocols such as the RIP (Routing Information Protocol), distance-vector, OSPF (Open Shortest Path First) and link-state [6]. They attempt to maintain consistent, up-to-date routing information of the whole network. Each node has to maintain one or more tables to store routing information, and response to changes in network topology by broadcasting and propagating. Some of the existing pro-active ad hoc routing protocols are: DSDV (Destination Sequenced Distance-Vector, 1994), WRP (Wireless Routing Protocol, 1996), CGSR (Cluster head Gateway Switch Routing, 1997), GSR (Global State Routing, 1998), FSR (Fisheye State Routing, 1999), HSR (Hierarchical State Routing, 1999), ZHLS (Zone based Hierarchical Link State, 1999), STAR (Source Tree Adaptive Routing, 2000).

4.2 REACTIVE ROUTING PROTOCOLS (source-initiated on-demand driven):

These protocols try to eliminate the conventional routing tables and consequently reduce the need for updating these tables to track changes in the network topology

[6]. In contrast to pro-active routing protocols which maintain all up-to-date at every node, routes are created only when desired by the source node in re-active protocols. When a source requires to a destination, it has to establish a route by route discovery procedure, maintain it by some form of route maintenance procedure until either the route is no longer desired or it becomes inaccessible, and finally tear down it by route deletion procedure. Some of the existing re-active routing protocols are: DSR (Dynamic Source Routing, 1996), ABR (Associativity Based Routing, 1996), TORA (Temporally-Ordered Routing Algorithm, 1997), SSR (Signal Stability Routing, 1997), PAR (Power-Aware Routing, 1998), LAR (Location Aided Routing, 1998), CBR (Cluster Based Routing, 1999), AODV (ad hoc On-Demand Distance Vector Routing, 1999). In pro-active routing protocols, routes are always available (regardless of need), with the consumption of signaling traffic and power. On the other hand, being more efficient at signaling and power consumption, re-active protocols suffer longer delay while route discovery.

Both categories of routing protocols have been improving to be more scalable, secure, and to support higher QoS. Meanwhile, some protocols that combine the good properties of both pro-active and re-active protocols were proposed, such as ZRP (Zone Routing Protocol, 1999). Some of the above routing protocols have implementations for test.

A MANET protocol should function effectively over a wide range of networking contexts--from small, collaborative, ad hoc groups to larger mobile, multihop networks. The preceding discussion of characteristics and evaluation metrics somewhat differentiate MANETs from traditional, hardwired, multihop networks. The wireless networking environment is one of scarcity rather than abundance, wherein bandwidth is relatively limited, and energy may be as well.

The networking opportunities for MANETs are intriguing and the engineering tradeoffs are many and challenging. A diverse set of performance issues requires new protocols for network control.

4.3 ROUTING CHALLENGES:

Being one of the most popular fields of study during the last few years, almost every aspect of ad hoc networks has been explored in some level of detail. Yet, no ultimate resolution to any of the problems is found or, at least, agreed on. On the contrary, more questions have arisen than been answered [7]. The major challenges are shown in figure -3.

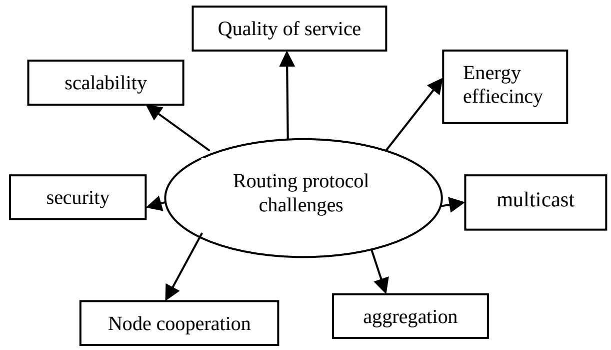

Figure -3 Routing challenges

4.3.1 SCALABILITY:

Scalability can be broadly defined as whether the network is able to provide an acceptable level of service even in the presence of a large number of nodes in the network. It is one of the most important open issue of ad hoc networks. Firstly, ad hoc networks suffer, by nature, from the scalability problems in capacity. In a non-cooperative network, where omni-directional antennas are being used, the throughput decreases at a rate, where N is the number of nodes [8]. That is, in a network with 100 nodes, a single device gets approximately one tenth of the theoretical data rate of the network interface card at maximum. This problem, however, cannot be solved except by physical layer improvements, such as smart antennas.

Routing protocols also set some limits for the scalability of ad hoc networks. Route acquisition, service location and encryption key exchange is examples of tasks that will require considerable overhead, which will grow rapidly with the network size. Pro-active routing is not applicable in a dynamic environment, due to huge amount of broadcast message of topology changes. Re-active protocols allow deploying large networks in the expense of increased route acquisition latency. The minimum route acquisition latency is the product of maximum network diameter and minimum node traversal time for route request. Correspondingly, demands for short latencies for route acquisition limit the network size drastically. There is still much work to be done to optimize the trade-off between capacity and scalability in different scenarios and applications separately for a general solution.

4.3.2 QUALITY OF SERVICE :

Quality of Service (QoS) is being developed to meet the emerging requirements of heterogeneous applications in the Internet which is able to provide only best-effort service. QoS is a guarantee by the network to provide certain performance for a flow in terms of the quantities of bandwidth, delay, jitter, packet loss probability etc. QoS of fixed wireless networks is still an open problem[8]. Moreover, ad hoc networks make the QoS appear an even more challenging problem than ever before, despite some of re-active routing protocols can be configured to return only paths that comply with certain desired QoS parameters. RF channel characteristics often change unpredictably, along with the difficulty of sharing the channel medium with many neighbors, each with its own potentially changing QoS requirements. Routes are using links with different quality and stability, which are often asymmetrical. There are numerous multi-layer attempts to improve the QoS problems from the service contracts to the MAC layer. A promising method for satisfying QoS requirements is a more unified approach of cross-layer or vertical-layer integration. The idea is different from many of the traditional layering styles to allow different parts of the stack to adapt to the environment in a way that takes into account the adaptation and available information at other layers. QoS routing policies, algorithms and protocols with multiple, including preemptive, priorities are to be researched in the future[9].

Due to the nature of ad hoc networks, QoS cannot be guaranteed for a long time because of the link quality variation. Methods to detect and report changes in the connection quality should be investigated in the future. For example, Perkins suggested an addition of a new ICMP message (QOS_LOST) to be defined to inform the end point that a new route discovery should be initiated.

4.3.3 ENERGY CONSERVATION:

Without a fixed infrastructure, ad hoc networks have to rely on portable, limited power sources. A node in an ad hoc network has to relay (and, hence route) messages for other nodes in the same network. The issue of energy-efficiency therefore becomes one of the most important problems in ad hoc networks. Despite of approaches to develop better batteries and hardware with lower power consumption, from the networking point of view, most existing solutions for saving energy in ad hoc networks revolve around the reduction of power used by the radio transceiver (the device's network interface), which is often the single largest consumer of power[10]. At the MAC layer and above, this is often done by selectively putting
the receiver into a sleep mode, or by using a transmitter with variable output power. Recently, much work has been done with energy-aware routing protocols and applications, especially with the idea of vertical layer integration. Protocol design at the networking layer (i.e., layer 3) in conjunction with transmission power awareness at the physical and the MAC layers offers the possibility of substantial performance improvement .This is a cross layer issue. From the energy management standpoint, power control and multiple antennas at the link layer are coupled with power control and scheduling at MAC layer, and with energy-constrained and delay-constrained routing at network layer.

4.3.4 SECURITY :

Security is a critical issue of ad hoc networks that is still a largely unexplored area. Since nodes use the open, shared radio medium in a potentially insecure environment, they are particularly prone to malicious attacks, such as denial of service (DoS). Lack of any centralized network management or certification authority makes the dynamically changing wireless structure very vulnerable to infiltration, eavesdropping, interference etc. Security is often considered to be the major "roadblock" in commercial application of ad hoc network technology [11]. Traditional methods of protecting the data with cryptographic methods face a challenging task of key distribution and refresh. Accordingly, the research efforts on security have mostly concentrated on secure data forwarding. However, many security risks are related to peculiar features of ad hoc networks. The most serious problem is probably the risk of a node being captured and compromised. This node would then have access to structural information on the network, relayed data, but it can also send false routing information which would paralyze the entire network every quickly [11]. One of the current approaches to the security problems is building a self-organized public-key infrastructure for ad hoc networks cryptography. Key exchange, however, raise again the scalability issue. Another common approach is secure routing, which has an appealing idea of dividing the data on N pieces which are sent along separate routes and, at the destination, the original message is reconstructed out of any (M – out – of - N) pieces of the message. Nevertheless, security is indeed one of the most difficult problems to be solved. Having received only modest attention so far, its "golden age" of research can be expected after the functional problems on the underlying layers have agreed on. Another challenging issues on ad hoc networks are node cooperation, interoperation with the Internet, aggregation, multicast, as well as the theoretical limitation of ad hoc networks. Technologies such as smart antennas, software radios also bring new research problems along with impetus to ad hoc networks.

5. CONCLUSION AND FUTURE SCOPE:

We discussed main issues of MAC layer and Routing protocols of network layer. These two layers play most important role in improving the performance of MANET. The future is PERVASIVE MANET[12]. cross-layer policies is a very promising direction, which can be further explored. Cross-layering can tackle the traffic in better manner on ad hoc networks by sharing information from different layers . Moreover, information collected at a particular layer (e.g., a route failure) can be exploited by different layers to tune the protocol behavior.

The future of ad hoc networks is really appealing, giving the vision of "anytime, anywhere" and cheap communications. Before those imagined scenarios come true, huge amount of work is to be done in both research and implementation. At present, the general trend in MANET is toward mesh architecture and large scale. Improvement in bandwidth and capacity is required, which implies the need for a higher frequency and better spatial spectral reuse. Propagation, spectral reuse, and energy issues support a shift away from a single long wireless link (as in cellular) to a mesh of short links (as in ad hoc networks). Large scale ad hoc networks are another challenging issue in the near future which can be already foreseen. As the evolvement goes on, especially the need of dense deployment such as battlefield and sensor networks, the nodes in ad hoc networks will be smaller, cheaper, more capable, and come in all forms.

In all, although the widespread deployment of ad hoc networks is still year away, the research in this field will continue being very active and imaginative. Future research makes it possible to Imagine a wireless mesh of rooftop-mounted ad hoc routers; an ad hoc network of cars for instant traffic and other information; sensors and robots forming a multimedia network that allows remote visualization and control; multiple airborne routers (from tiny robots to blimps) automatically providing connectivity and capacity where needed like in a football game; in an ad hoc network of spacecraft around and in transit between the Earth and mars .These may seem like science fiction, but a lot of work is in process seriously by the ad hoc research community.

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