Abstract: Multicast applications for large-scale Mobile Ad hoc Networks (MANETs) require an efficient and effective Quality of Service (QoS)-aware multicast model. The new requirements to guarantee QoS are high availability and good load balancing due to limited bandwidth and transmission power of Mobile Nodes (MNs). In this paper, multicast routing protocol namely Hypercube based Team Multicast Routing Protocol (HTMRP) has been proposed to address the scalability in mobile ad hoc networks. In HTMRP, team multicasting is proposed where the multicast group does not consist of individuals rather, member teams. This mechanism is common in ad hoc networks to accomplish collective tasks such as emergency recovery, battle field where team affinity model exist when the member teams has a common interest. In MANET, the link failures due to mobility is a big concern and is addressed in HTMRP by incorporating a logical hypercube model. The HTMRP also has a mesh layer on top of the hypercube for effective fault tolerance. In addition to scalability, HTMRP also guarantee the new QoS requirements namely high availability and good load balancing by incorporating team, hypercube and mesh tiers. The HTMRP has been simulated and extensively analyzed for scalability, delivery ratio and control overhead. HTMRP provides better performance for the above evaluation parameters than the existing multicast routing protocol.

1. INTRODUCTION

Ad hoc networks are self-organizing, rapidly deployable, and dynamically reconfigurable networks, which require no fixed infrastructure. Ad hoc networks in which the nodes are connected by wireless links and can be mobile are referred to as MANETs, where all the MNs function as hosts and routers at the same time. In this we introduce the Hypercube based Team Multicast Routing Protocol (HTMRP), which combines the features of team multicast and hypercube to provide scalability, robustness, high availability and good load balancing in MANET. The main aim of this project is to transfer the data from one network to other network by using the team lead node. Traditional unicast routing protocols designed for flat MANETs and hierarchical extensions, cannot scale well in large-scale MANETs. Similarly, traditional multicast routing protocols, e.g., flooding-based, tree-based, and mesh based, cannot scale well in large-scale MANETs either. In recent years, location-based unicast routing has attracted much attention because it scales quite well in large scale MANETs. Accordingly, researchers have proposed to use location information in multicast routing protocols. Ad hoc networks are self-organizing, rapidly deployable, and dynamically reconfigurable networks, which require no fixed infrastructure. Ad hoc networks in which the nodes are connected by wireless links and can be mobile are referred to as MANETs, where all the MNs function as hosts and routers at the same time. Two MNs communicate directly if they are within the radio transmission range of each other. Otherwise, they reach each other via a multi-hop route. Many existing and forthcoming applications in MANETs require the collaboration of groups of mobile users. Communications in battlefield and disaster relief scenarios, video conferencing and multi-party gaming in conference room or classroom settings, and emergency warnings in vehicular networks are example applications. As a consequence, multicast in MANETs becomes a hot research topic in recent years.

2. HTMRP

In this section, we introduce the Hypercube based Team Multicast Routing Protocol (HTMRP), which combines the features of team multicast and hypercube to provide scalability, robustness, high availability and good load balancing in MANET.

2.1 Landmark Tier

Landmark Tier (LT) is the bottom most layer where the actual nodes are formed into teams. These nodes have coordinated motion, i.e., they move together as a group. Each node in a team can randomly move within a bounded area. Each team dynamically elects a team leader called Landmark and is responsible for broadcasting the message to other team members.

2.2 Hypercube Tier

Hypercube Tier (HT) is the middle layer which comprises of logical three dimensional hypercube whose nodes are actually team leaders of the Landmark Tier. HT provides...
QoS factors such as good load balancing and high availability to the proposed protocol. There is a one-to-one mapping relation between a team leader and a hypercube node. The hypercube is logical in the sense that the logical link between two adjacent logical hypercube nodes possibly consists of multi-hop physical links.

2.3 Mesh Tier
The Mesh Tier (MT) is the top layer which is a mesh structure contains the hypercube as one mesh node. The link between two adjacent mesh nodes is logical and physically multi-hop. The Position-Based Multicast (PBM) protocol is proposed using only locally available location information about the destination nodes. This protocol provides a solution in order to approximate the optima for two potentially conflicting properties of the multicast distribution tree: (1) the length of the paths to the individual destinations should be minimal, and (2) the total number of hops needed to forward the packet to all the destinations should be as small as possible. If not properly handled, a greedy multicast forwarding may lead to a problem when a packet arrives at a node that does not have any neighbor providing progress for one or more destinations. This problem is solved in location-based unicast routing, such as using the right hand rule-based recovery strategy in [25]. This protocol extends the strategy to support the packet with multiple destinations.

2.4 Need for the project
The need for the project is to multicast the data from one node to another node using team leads of the nodes. We have proposed a HTMRP to support QoS-aware multicast in large-scale MANETs. The proposed model is derived from n-dimensional hypercube, which have many desirable properties, such as high fault tolerance, small diameter, regularity, and symmetry. The proposed model uses the location information of MNs and meets the new QoS requirements: high availability and good load balancing. Firstly, in an incomplete logical hypercube, there are multiple disjoint local logical routes between each pair of CHs, the high fault tolerance property provides multiple choices for QoS routing.

2.5 Multicast
Data communication in the Internet can be performed by any of the following mechanisms: unicast, broadcast, anycast and multicast. Unicast is point-to-point communication. Broadcast is when data is forwarded to all the hosts in the network. Anycast is when data is to be transmitted to any one of the members selected to be part of a group. Multicast is when data is to be transferred to only a group of hosts on a network. In the age of multimedia and high-speed networks, multicast is one of the viable mechanisms by which the power of the Internet can be further harnessed in an efficient manner.

2.6 Multicast Communications
The data transfer associated with a multicast group needs to be handled differently by the intermediate nodes, namely the routers involved in the routing of the multicast packets from the sender(s) to the receivers. The need to handle multicast data differently coupled with the different types of applications using multicast and their varied requirements has led to the development of various routing algorithms and protocols.

2.7 Efficiency of Multicast
Multicast provides efficient communication and transmission, optimizes performance and enables truly distributed applications. Copies of message are made only when paths diverge at a router, that is, when the message is to be transferred to another route in the path to the receiver or when a receiver is attached to the router. The optimal multicast path is computed as a tree or a group of trees. The quality of the tree is determined by low delay, low cost and light traffic concentration.

The first effort at quantifying the cost advantage in using multicast was by Chuang and Sirbu. It focuses on link cost such as bandwidth quantification and ignores node cost such as routing table memory, CPU usage. Where there is a direct relationship between the number of unicast packet hops and the number of receivers, the number of multicast packet hops remains nearly equal. It does increase with the increase in membership size, but at a slower rate than unicast.

2.8 Properties of Multicast Tree
It is a study on how the number of links in a multicast tree changes as the number of multicast users in a group change. It is shown that the stability of a tree tends to a Poisson the Waxman model, where nodes in the network are placed at random points in a two-dimensional grid. Links are added to the network by considering all possible pairs of nodes and then deciding whether a link should exist according to a probability function. The probability function is based on how far apart the two nodes are and how many links are expected to exist in the whole network.

3. MULTICAST ROUTING ALGORITHMS
The data transmitted needs to be transferred from the sender(s) to the receivers. The sender(s) and receivers are mostly end-hosts. Intermediate nodes are the routers, which route/direct the data from the sender(s) to the receivers. A spanning tree has been considered one of the most efficient and viable mechanisms to perform the data transmission in such a scenario, since it minimizes duplication of packets in the network. Messages are duplicated only when the tree branches and this ensures data communication is loop-free. An efficient multicast routing algorithm will aim to build a Minimal Spanning Tree (MST). The type of tree to be used depends on whether receivers are sparsely or densely distributed throughout the network; the number of receivers does not matter. The receivers might have a set of requirements like the cost or a given amount of delay that it can tolerate.
in the receipt of data. Different type of trees to handle such special cases has been proposed.

3.1 Source Tree

Source tree algorithms (also known as shortest path trees) build a separate tree for each source. Reverse Shortest Paths (RSP) connects each of the receivers to the source. RSP is constructed by using Reverse Path Forwarding (RPF) at the intermediate routers, as mentioned in this is efficient for high data rate sources. It provides minimal delay at the expense of cost. It exhibits lesser traffic concentration. When source tree is used, a network with a large number of groups and with each group having a large number of sources, can stress the storage capability of the routers. Source trees consume more bandwidth for each individual multicast group. However their demands are more evenly distributed than the center based trees, especially in networks with high outdegree. Thus a network can support more high bandwidth multicast groups, if source trees are used instead of center based trees.

3.2 Shared Tree

Shared tree algorithm builds a single tree to be used by all the sources. The data communication in the tree can be one way or bi-directional. This is efficient for low rate sources and is efficient in the amount of state information that needs to be maintained at each router. However, it exhibits higher traffic concentration. Shared trees use a single location in the network called the core or the Rendezvous Point (RP) to which all packets from the sources are sent and from which packets are sent to all receivers. The paths from certain receivers to the source may be longer, which may cause additional delay. This will be a disadvantage for delay-sensitive and high bandwidth applications. The core is a potential bottleneck for data transmission. CBT and PIM-SM are examples of routing protocols making use of shared trees.

3.3 Steiner Tree

A minimal spanning tree is a tree that spans all the group members and minimizes the total weight of the tree. Steiner tree minimizes the total cost of a shared tree. It minimizes cost at the expense of delay. Finding such a tree in a network is a NP-Complete problem. Since it is NP-Complete in nature, it is not possible to find an exact solution for the same. A number of approximate and heuristic solutions have been proposed for the same. Kou, Markowsky and Berman (KMB) algorithm is an approximation of Steiner trees. A distributed version of KMB was proposed by Wall. The cost of a tree generated with the KMB algorithm is very close to the cost of a Steiner tree. KMB trees have higher delay for larger groups than center trees. It has higher variations in delay than center trees. When the Steiner tree consists of only group members, the KMB tree is a Steiner Minimal tree. Since KMB needs the complete network topology, it is not practical for wide area networks. Both KMB and Walls algorithm assumes that the group is statically configured. There are many networks in practice where the communication links are asymmetric and cannot be modeled by undirected edges. Such problems are modeled as directed Steiner tree problems. Multimedia communication can tolerate only a limited delay in the data transfer from the sender to the receiver. Delay bounded Steiner trees is a solution for the same. A tree that has minimal cost under a given delay constraint is called a delay bounded Steiner tree.

3.4 Reduced Trees

Reduced trees are proposed in as a solution for scalability of multicasting. The set of vertices in a tree can be partitioned into a set of members, relay nodes and duplicating nodes. A reduced tree is a tree that is modified such that there are no relay nodes. This leads to around 80% reduction in the amount of state information that is maintained per group.

3.5 Incremental Distributed Asynchronous Algorithm for MST

A distributed algorithm proposed for updating a MST when a new node joins the group. Recomputing the MST when changes are made to the underlying network is unnecessarily expensive when the new MST coincides with the old one. This incremental algorithm makes use of the existing structure to avoid computing from scratch. The algorithm runs asynchronously and processors at each vertex of the network is required to know only information concerning its adjacent edges. Each message exchanged contains at most an edge weight and a few bits.

3.6 Bounded Shortest Multicast Algorithm (BSMA)

BSMA starts by computing a least-delay tree rooted at a given source and spanning all group members. It iteratively replaces super-edges in the tree with cheaper super-edges not in the tree, while not violating the delay constraint until the total cost cannot be further reduced. Super-edge of a tree is the longest simple path whose internal nodes are relay nodes and each relay node connects exactly two tree nodes.

3.7 Bauer Algorithm

It imposes constraints on the number of outgoing links that can be used for a group. The tree construction begins with an arbitrary starting point and an edge that is closest to the partial tree is added, one at a time. The heuristic is repeatedly applied to the network graph for different starting points. It defines and monitors a damage index to the multicast tree as members join and leave, and triggers tree rearrangement when the index exceeds a certain threshold.

3.8 Delay Variation Multicast Algorithm (DVMA)

Buffering at the source, at the switching nodes and at the receiver may be used as a tool to combat delay variation. Buffering at the source and switching element would require the source and switching element respectively, to maintain additional information about all destinations.
Buffering at receiver is straightforward and cancels the effect of delay variation. However, providing bounds on delay variation while routing will result in a more efficient usage of buffering resources.

A tree that is bounded by both delay and delay variation is known as a delay variation-bounded multicast tree (DVBM). Whenever the size of the multicast tree is greater than two, DVBM is an NP-Complete problem. DVMA builds a DVMB spanning tree. It assumes that the complete topology is available at each of the nodes. The algorithm starts with a spanning tree satisfying the delay constraint, which may not include some members. Next the algorithm searches through the candidate paths satisfying the delay and the delay variation constraint from a non-tree member node to any one of the tree nodes. On finding such a path, it adds the members to the existing tree. The spanning tree built by DVMA satisfies the delay constraint. Further it either satisfies the variation constraint or has the smallest value of variation among the trees considered by the algorithm.

3. ARIES / GREEDY / Edge Bounded Algorithm (EBA)
A Rearrangeable Inexpensive Edge-based online Steiner Algorithm (ARIES) is a heuristic for updating multicast trees dynamically in large point-to-point networks. GREEDY and EBA are some more heuristics that have been proposed for the same purpose. ARIES monitors the accumulated damage to the multicast tree within local regions of the tree as nodes are added/deleted and triggers a rearrangement when the number of changes exceeds a certain threshold. It joins the new member to the existing tree by its shortest path to the tree. It uses a Geographic-Spread Dynamic Multicast Heuristic to decide the node to which the new member is joined. For each add request, it identifies the tree node closest to the new member and three nearby nodes in the existing tree.

4. MULTICAST ROUTING PROTOCOLS
The routing protocols are deployed at the intermediate nodes, namely the routers that make up the path from the sender(s) to the receivers. The routing protocols have two main responsibilities: to collect and maintain state information that can be used by the routing algorithms in selecting the best path to the receivers and to select the most appropriate path among the various paths available using a path selection procedure. Other than building the distribution tree, multicast routing protocols have the additional responsibility of group management. A multicast routing algorithm together with appropriate scheduling, forwarding and policing mechanisms can provide QoS guarantees for real-time multicast applications. The routing protocols are classified into dense and sparse mode protocols. PIM is one of the routing protocols that can operate in either of the modes. Sparse mode protocols offer better scalability and efficiency.

4.1 Distance Vector Multicast Routing Protocol (DVMRP)
DVMRP is a distance vector style algorithm that builds source based multicast trees. When a DVMRP router receives a multicast packet, it sends the packet to all attached routers and waits for a response. Routers with no group members return a prune message, which eventually prevents further multicast messages for that group from reaching the router. The prune state is soft, that is, it will time-out within a set time interval. If after sending a prune and before the state can time-out, the host wants to join the group, it has to send a graft message upstream. DVMRP is inefficient when the number of receivers in the group is sparsely distributed.

DVMRP builds its own routing table instead of using the existing unicast routing table for RPF checking of incoming packets. A packet is assumed to have arrived on the RPF interface if a router receives it on an interface that it uses to send unicast packets to the source. If the packet arrives on the RPF interface, then router forwards it out the interfaces that are present in the outgoing interface list of a multicast routing table entry. If it does not arrive on RPF interface, it is silently discarded to avoid loop-backs.

4.2 Multicast Open Shortest Path First (MOSPF)
MOSPF is a link state routing protocol that builds the map of the network topology, including location of domains and tunnels. It selects the best path to the required receivers using Dijkstra's shortest path algorithm. It is meant to be in use within an Autonomous System (AS). When there are multiple sources or many groups, it is CPU intensive. It is best used when relatively few sources or groups are active at any given time. It does not work well in presence of unstable links, as it leads to frequent state update and the associated computations. MOSPF does not support tunneling. The path is calculated only on-demand and cached for later use. It constructs source based multicast trees. It can also be considered as a QoS routing algorithm that minimizes delay. It is one of the dense mode protocols that requires explicit join from the receivers.

4.3 Core Based Tree (CBT)
CBT builds a single bidirectional shared tree for the data transmission from the source(s) in the group to the receivers. When an intermediate node receives a packet meant for the group, it forwards it to the remaining members of the group that are downstream to the node. It does not need to forward it to the core. Core selection is one of the major issues in CBT and can be handled by the various heuristics proposed for core selection as in Section

4.4 Protocol Independent Multicast (PIM)
PIM operates in two modes dense mode (PIM-DM) and Sparse Mode (PIM-SM). PIMDM operates similar to DVMRP. Sparse mode protocols use explicit join messages to set up uni-directional shared distribution trees. Dense mode protocols use only source distribution trees and uses RPF checking to determine if a packet is to be forwarded. In PIM-SM a node is selected as the Rendezvous Point (RP) and all group communication takes places by sending the packets to it. It is not dependent on any particular unicast routing method. However, it uses existing unicast routing table for the routing decisions. Each of the sources in a PIM-SM multicast group send their packets to the RP. Since it builds unidirectional shared tree, only the RP can forward data to the members. Intermediate nodes should forward the data only to the RP. Any site interested in joining requests one of the RPs to set up a tunnel to the RP. All PIM-SM traffic is transported by unicast instead of multicast.

4.5 Simple Multicast

Simple multicast and EXPRESS multicast are based on the Root Addressed Multicast Architecture (RAMA) architecture. RAMA architecture is applicable in cases where multicast applications have a single source or have a single primary source, which can be used as the core of the tree. The address of the root is appended to the multicast group address, which is unique over the Internet. This eliminates the need for coordinated multicast address allocation across the Internet. These are two protocols that take care of address allocation along with routing of data. Most routing protocols assume that unique address has been allocated to the group.

4.6 Express Multicast

Like Simple multicast, EXPRESS multicast is based on the RAMA architecture. It builds a source tree with the root located at the source. Receiver sends join messages to the source along the reverse path to the source. The group is identified by the 8-byte address (Source Address, Group Address). Since the source address uniquely identifies the group, the protocol can only be used for single source group communications unlike Simple multicast (also based on RAMA architecture) that can support multiple sources per group. It assumes sources learn about receivers via some mechanism outside EXPRESS; it does not support IGMP. EXPRESS multicast using IP multicast channel have been assumed to give the most scalable solution for single source applications.

4.7 Source Specific Multicast (SSM)

The network must maintain knowledge about which hosts in the network are actively sending multicast traffic. In SSM the receiver informs the router to which it is sending the join request the list of source(s) of the group it is subscribing to. The receiver must subscribe or unsubscribe to (Source Address, Group Address) channels to receive or not receive traffic from specific sources. Receivers can receive traffic only from (Source Address, Group Address) channels that they are subscribed to. This is in contrast to IP multicast where receivers need not know the source(s) of the group to receive traffic from the group. The address range 232.0.0.0 through 232.255.255.255 has been reserved for SSM applications and protocols.

4.8 Centralized Multicast

Most routing protocols assume routers participate both in forwarding multicast packets and in control algorithms for routing, resource reservation and group management. Centralized Multicast separates data and control flow and centralizes control in distinct control elements. The control element gateway is introduced for each domain to construct the portion of the multicast tree inside the domain. Control element root controllers are introduced for the Internet to construct the inter-domain portion of a multicast tree. The tree in the domain can be a bidirectional shared tree or a source-specific shortest path tree. The inter-domain multicast tree is bidirectional shared tree.

4.9 Border Gateway Multicast Protocol (BGMP)

Border-Gateway Multicast Protocol (BGMP) is implemented at the border routers of a domain. It constructs inter-domain bi-directional shared trees using a single root, while allowing any multicast routing protocol to be used within the domains. The root is located at the domain whose address range covers the group address; which is typically the group initiator’s domain. BGMP requires strict address allocation.

4.10 Multiprotocol Extensions to BGP (MBGP)

This protocol proposes using the BGP to setup and forward multicast routing state. This is to enable faster deployment of multicast, as BGP is widely in use in the current Internet.

4.11 Multicast Internet Protocol (MIP)

MIP constructs both group-shared and shortest-paths multicast trees. The operations can be sender or receiver initiated or both. It is independent of the underlying unicast routing algorithms used. Instead of using soft state, MIP uses diffusing computations to the network must maintain knowledge about which hosts in the network are actively sending multicast traffic. In SSM the receiver informs the router to which it is sending the join request the list of source(s) of the group it is subscribing to. The receiver must subscribe or unsubscribe to (Source Address, Group Address) channels to receive or not receive traffic from specific sources. Receivers can receive traffic only from (Source Address, Group Address) channels that they are subscribed to. This is in contrast to IP multicast where receivers need not know the source(s) of the group to receive traffic from the group. The address range 232.0.0.0 through 232.255.255.255 has been reserved for SSM applications and protocols.
5. HTMRP ALGORITHM

In HTMRP, the network nodes are divided into several teams $T_n$ based on the commonality of interest of the nodes. The node which comes first into the team acts as team leader TL. The number of nodes and their ids in a team are maintained in In-list. A link from node i to node j is said to be present if node j lies within the transmission range of node i, i.e., $\text{link}(i,j) = 1$, if $\text{dist}(i,j) \leq \text{Trange}(i)$.

We assume that all nodes in the team have uniform Trange and use omni-directional antennas. As and when a message is received, the TL broadcasts the same to the members of the team. Based on the number of team and team leaders, a logical hypercube is constructed. Let TL, $T_n$ denotes the team leader, TLS may be the source. Team Leader which is the multicast source and TLR, TLR $T_n$ is the set of receiver Team Leaders. Since the team leaders are the members of the hypercube, each team leader has a minimum three direct links to other team leaders. This arrangement helps in providing a better fault-tolerance through redundant path. As the multicast teams increase, the protocol needs to construct many such hypercube to accommodate all team leaders. In such case, a mesh is constructed to connect all the hyper cubes. Mesh structure inherently provides fault tolerance as it has alternate paths. For the entire multicast, the tree is constructed at hypercube and mesh level based on the number of teams involved. The entire protocol has been implemented using three different algorithms at three different tiers.

**Landmark tier team construction algorithm:**

```java
// Nodes with common interest forms a team T; the node in the team acts as team leader TL;

1. For each team $T_i$ in $T_n$, $1 \leq i \leq T_n$, where $T_n = \{T_1,T_2,T_3, \ldots, T_n\}$;
2. in-list = {} for each node $C_j$ in $T_i$, $1 \leq j \leq |T_i|$ do in-list := in-list + $\{C_j\}$;
3. list of neighboring nodes of A is $\{B_1, B_2, \ldots, B_x\}$;
   for each neighboring node $B_k$, $1 \leq k \leq x$ do Compute the distance $d_k$ between A and $B_k$;
4. if $d_k \leq \text{Trange}$ then A and $B_k$ are neighbors else find a multi-hop route between A and $B_k$
5. for each node $C_j$ in in-list do TL broadcasts the message;
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Figure 1: Main Screen

Figure 2: Displaying hypercube nodes and team leads

Figure 3: Data transmission from source to source team leads

Figure 4: Formation of mesh tier
5. CONCLUSION

The data from the transmitter is transmitted to the nodes by using the team leads and the three tiers. The three tiers are Landmark Tier, Hypercube Tier, and Mesh Tier. The data transmission is done in a hierarchical manner. The traffic congestion can thus be decreased while transmission. The team leads are much important in this project as the data transmission will be done by them. We have proposed a HTMRP to support QoS-aware multicast in large-scale MANETs. The proposed model is derived from n-dimensional hypercube, which have many desirable properties, such as high fault tolerance, small diameter, regularity, and symmetry. The proposed model uses the location information of MNs and meets the new QoS requirements: high availability and good load balancing. Firstly, in an incomplete logical hypercube, there are multiple disjoint local logical routes between each pair of CHs, the high fault tolerance property provides multiple choices for QoS routing. This paper thoroughly analyses the problems of scalability in large scale multicast routing with more nodes and large number of multicast sessions. Based on that, HTMRP is proposed and implemented. From the experimental results, it is proved that HTMRP outperforms the existing multicast routing protocols in terms of delivery ratio and control overhead. HTMRP also implements a combination of both team multicast and hypercube structure to provide high scalability and reliability.

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