VCZRP: Enhancing Performance of Mobile Ad Hoc Networks Using Virtual Coordinates

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Abstract- **Ad hoc networks are wireless networks where mobile nodes relay on each other to keep network connected without help of pre-existing infrastructure or centralized control. These are characterized by dynamic topology caused by node mobility, multihop wireless connectivity and limited bandwidth, and potentially large scale makes routing as challenging problem in these systems. The key challenge in the design of ad hoc networks is the development of dynamic routing protocols that can efficiently find routes between two communicating nodes. To address these various routing protocols are existing like on-demand routing, geographical routing. These protocols require availability of location information and suffer from poor routing performance and severe dead end problems. Existing, Virtual Coordinate Systems perform routing without location information using virtual coordinate vector at each node which is calculated using predefine landmark nodes. But these systems have the problem of updating the virtual coordinates because of frequent topological changes causing considerable overhead. Proposed system uses virtual coordinate system with ZRP (Zone Routing Protocol) aspects. Also, by using VC Id instead of virtual coordinate vector for node updations can reduce wastage of network bandwidth.**

Index Terms: multihop, bandwidth, virtual coordinates, zone routing protocol

I. INTRODUCTION

Mobile Ad Hoc Networks (MANETs) are a group of mobile nodes which communicate with each other without any supporting infrastructure. The network is unstructured and nodes may enter or leave causes frequent topological changes. A node can communicate to other nodes which are within its transmission range. However, to communicate to nodes out of its range, node uses the help from other nodes as intermediary to receive and forward messages. Therefore, a node in a MANET acts as both a terminal and a router. There are many applications for MANET. For example, in a military field, search and rescue operations, or any remote geographical area where is no base station for communication.

Routing in MANET is extremely challenging because of MANETs dynamic features, its limited bandwidth and power constraints. Since nodes can move, join a network or leave it freely, the topology of the network changes quite often. Furthermore, the transmission range of each node is limited. In order to reach a destination, a message must pass through some intermediary nodes so that these networks are usually called multi-hop networks. One of the challenging problems in a mobile ad-hoc network is finding routes between nodes. A routing algorithm is called proactive if it calculates routes before they are needed and keeps routing-information to all nodes every time up-to-date. A reactive routing algorithm calculates a route only when it is needed.

Due to the constant node mobility, the network topology changes frequently a good route will probably be unavailable after a short while. This would result in having each node along the route update their routing table frequently, causing many control packets to flood through the network, consuming precious network resources. Therefore, to discover and maintain a route in the MANET environment is difficult.

Routing algorithms for a MANET can be classified into three categories: proactive, reactive and hybrid. In a proactive routing protocol, each node periodically broadcasts its routing table(s) to its neighbors, show that each of the nodes have a consistent network view. The advantage of this protocol is the short response time in determining a good route from source to destination due to the up to date network topology in each node. This short response time, however, is at the expense of consuming a large portion of network bandwidth for the non-productive control packets to maintain a network overview at each node. Moreover, most of the established routes are never used, wasting network resources. Protocols such as DSDV [15], Fisheye [4] fall into this category. In contrast, in a reactive routing protocol, a node does not need to periodically broadcast the routing table thereby improving network bandwidth. A node establishes a route to its destination, only on demand. However, a node may suffer from long waiting time before it can transmit the data packets since a node may not know which neighbor to select as the next hop to forward the packet due to the dynamic network topology. Consequently, the node has to find a new route to the destination on the fly. Protocols such as AODV [3], DSR [16], and TORA [17] fall into this category.

A hybrid protocol, such as zone routing protocol (ZRP) [18], combines the advantages of both proactive and reactive protocols. In ZRP, the network is divided into zones with each node belonging to one of the routing zones. Each node proactively maintains a routing table for nodes within its zone and reactively finds a route to its destination if the destination node lies beyond its zone. In ZRP [18], the zones can be configured to the changes in the network topology through a single parameter, zone radius. The zone radius plays a significant role in the ZRP schemes. For example, if the network consists of many slow moving nodes or the demand for routes is high, then large routing zones may be preferred. On the other hand, if some of the nodes in the network move fast or when the demand for routes is low, small routing zones may be preferred. These routing zones can be reset by adjusting the radius of the zones. By changing this parameter the balance of proactive and reactive contributions can be adjusted. Ad Hoc networks are characterized by dynamic topological changes would require frequent exchange of update information among the network nodes leading to increase in traffic. In proactive protocols, the update information is sent to all the nodes in the network. However, ZRP limits the scope of the proactive procedure only to the node’s local neighborhood (zone). ZRP is based on the idea that the changes in the network topology should have a local effect only. That is, if a node moves, or a new link is added, the entire network need not be informed of the change as in proactive protocols since this is a local event. Only the nodes within the nodes neighborhood need to be informed, thereby reducing the cost of topological updates. The key factor that determines how efficiently a multihop wireless network reacts to topology changes and node mobility is the routing algorithm that provides routes for every node in the network. Several routing protocols have been proposed in the past both of proactive and reactive nature as well as and some that take a hybrid approach.

Also for improving scalability geographical routing systems are adopted for wireless network routing. These routing schemes make use of nodes geographic location information for packet forwarding. In these protocol packets are forwarded greedily. Geometric routing [12] is a family of routing algorithms using the geographic coordinates of the nodes as addresses for the purpose of routing. One such algorithm is Euclidean greedy routing, which is attractive for its simplicity; each node forwards the packet to the neighbor that has the closest Euclidean distance to the destination address. Unfortunately, purely greedy routing sometimes fails to deliver a packet because of the phenomenon of voids nodes with no neighbor closer to the destination. To recover from failures of greedy routing, various forms of face routing have been proposed, in which the presence of a void triggers a special routing mode until the greedy mode can be reestablished.

Recently the concept of virtual coordinate routing is emerging. It is instead for geographic routing without location information. These schemes arise to cope those situations where it is not possible to make use of real node coordinates with GPS like systems. Virtual coordinates are calculated by using some landmark nodes that are selected from pool of available nodes in the network using landmark selection algorithms. Virtual coordinates serve as geographic locations for greedy forwarding. Virtual coordinates are based on connectivity information and not on physical positions and distances; therefore, VCR protocols are insensitive to voids and location errors. Moreover, a routing protocol may automatically adapt to network topology dynamics through a periodic refresh of virtual coordinates.

Virtual coordinate protocols such as BVR[10], LCR[8], Hop ID[2], VCap[9], and HGR[13] exists assign each node virtual coordinates –a multidimensional vector coordinate calculated using some reference nodes called landmark nodes which are identified by the pool of available nodes using some landmark selection algorithms[14]. These protocols address various problems that come across in traditional routing protocols but suffer with following problems.

1. Selection on number of landmark nodes has some restriction fewer may not evenly distributed or more number causes wastage of network bandwidth.
2. Maintaining virtual coordinate vector is vital in these schemes for these each node periodically flooding the coordinate vector with its neighbor nodes for updation.
3. In MANET node mobility is obvious, also node addition and deletions may occur which requires frequent updations which is costly affair in these systems.

We propose a new system VCZRP (Virtual Coordinate Zone Routing Protocol) to address the above problems considerably. In this protocol we introduce the concepts of zone routing into Virtual Coordinate system. The main idea here is by maintaining the VC Id (Virtual Coordinate Id) instead of nodes’ virtual coordinate vector through routing tables inside the nodes. These VC Id is used for updating the node with their neighboring nodes through frequent flooding of HELLO message packets.

VC Id has following merits over virtual coordinates:

The VC Id over head is much smaller than the actual Virtual Coordinate there by network bandwidth is utilized properly.

Network topological changes and node additions and deletions can cope effectively

Routing becomes faster

II. RELATED WORKS

In the context of routing using virtual coordinate recently some research on these schemes has been going on. The main motivation in these virtual coordinate systems are routing without location information by using virtual coordinates at each nodes. These protocols are addressed many problems that the traditional protocols have and improves network overall performance. Also, we propose VCZRP another protocol that uses zone routing aspects with virtual coordinates improves considerable performance gains over other virtual coordinate protocols. Before, we make related works in these regard.

Routing is the way of forwarding packets from source node to destination node. While routing nodes make use of other nodes as intermediary if source and destinations are out of their radio range. Hence nodes in wireless network acts both as end systems and routers. Various metrics are for routing between nodes such as hop distance, geometric distance etc. Geometric routings make use of nodes location information for route discovery. It uses greedy algorithm for packet forwarding. However it suffers from severe dead end problems.

Brad Karp et al. [5], proposed GPSR for coping dead end problem. Greedy forwarding is used where ever possible and decisions made only using only information about the routers' immediate neighbors. Perimeter forwarding is used where Greedy forwarding not possible i.e. algorithm recovers by routing around the perimeter of the region. By keeping state only about the local topology, GPSR scales better in per-router state than shortest-path and ad-hoc routing protocols as the number of network destinations increases. Under mobility's frequent topology changes; GPSR can use local topology information to find correct new routes quickly.

Rao et al. [7] proposed a system routing without geographic location information. It makes use of virtual coordinates at each node instead of real geographic coordinates. Virtual coordinates are better for maintaining node identity as compared with real coordinates. Also, these are very effective in obstacles or holes and can be comparable with geometric coordinates in dense network environments. But, it performs badly under sparse networks and the problem of dead end can occur also greedy success rate effects badly.

Yao Zhao et al. [2] proposed Hop Id based virtual coordinate routing for Sparse Mobile Ad Hoc Networks. In that they use concept of virtual coordinate called as Hop Id. It is a multidimensional virtual coordinate assigned to each node and is calculated based on some landmark nodes randomly chosen among available nodes. It has the features that no geographic location information is needed and work well for sparse networks. Also, it scalable well for large ad hoc networks. It can effectively cope the dead end problem in sparse networks as well. It has some problem or maintaining Hop Id system. Each node broadcast periodically HELLO messages to neighbor nodes for node updations. System with N nodes and m landmarks consumes bandwidth of O(m.N) bytes/sec. So maintain of Hop Id in these involves considerable overhead.

III. DESIGN OF VCZRP

To cope some of the problems that are encountered in virtual coordinate routing systems in VCZRP we use zone concepts of the node network. It achieves good network bandwidth utilization and effectively improves routing performance under node addition and deletions. First by selecting some landmark nodes we find virtual coordinate vector. And entire network is made of zones of upto hop distance of two. Routing within zones make use of IARP Protocol and among zones by using IERP Protocol.

Its design mainly comprises into three modules.

A. *Landmark selection*

Selection of landmark nodes is vital for efficient routing performance in ad hoc networks. Various landmark selection algorithms are exists that are used by virtual routing systems. First of all landmark nodes has to choose for finding virtual coordinate. A simple way is to use some hash function to select landmarks randomly. For example, if we need m landmarks, we can simply generate m random IDs for landmark selection, called landmark IDs. Each node has its own unique ID that can be hashed from the IP address or any other unique number of a node. For each node, if its ID is the closest one to a landmark ID, it becomes a landmark. It is easier for ad hoc network develop from scratch. For deployed network we use the distributed algorithm as follows.

-Initialization: Each node initializes virtual coordinate of length m with two independent time periods with local neighbor exchange process and landmark selection process period. At this moment all nodes are equal and landmark nodes are select among themselves.
-Local Neighbor Exchange Process: Here each node broadcast periodically the beacon packets and discover their neighbors and to update connectivity information accordingly.
-Landmark Selection Process: In this process each node checks the time period for landmark selection. For a node if it is landmark or all landmarks are elected the process stops. If it does not know any landmarks it exists the process otherwise voting is done for others to select as landmarks.
-Find out virtual coordinate vector: After landmark selection each landmark node floods LANDMARK packet to the network with its landmark ID. Each node based on its hop distance metric from landmark node calculates its virtual coordinate.

B. IntrA Zone Routing Protocol

The IntrA Zone Routing Protocol (IARP) is used for routing within a zone. The IARP is a simple timer-based LS routing protocol. To track the topology of zone, each node periodically broadcast its link state for a depth of hops upto zone radius which is controlled by a Time-To-Live (TTL) field in the update messages. The nodes after receiving the IARP packets transmit them to the neighbor nodes until the Hop Counter (HC) number becomes the same as zone radius. However, if the HC in the IARP packet is bigger than the HC recorded in a node routing table, it is considered that packets are coming from the routing loops. Also the table maintains VC Id for each node to represent the neighbor virtual coordinate. This procedure is carried out periodically for all nodes and the routing tables are updated. When a request comes from nodes inside the zone radius, the routing table is checked and the packets are sent immediately to the destination node. The following Table 1 shows the node routing table which has Source VC and its neighbor VC and corresponding VC Id and HC (hop count) which is equal to hop distance to the corresponding node. Table 2 shows packet format of IARP.

SN-VC	DN-VC	VC Id	HC

Table. 1

VC Id	Packet Type	HC

Table. 2

Each node maintains a routing table for neighboring nodes of hop distance two. For each neighbor node it calculates VC Id which is send periodically for node updations.

C. IntEr Zone Routing Protocol (IERP)

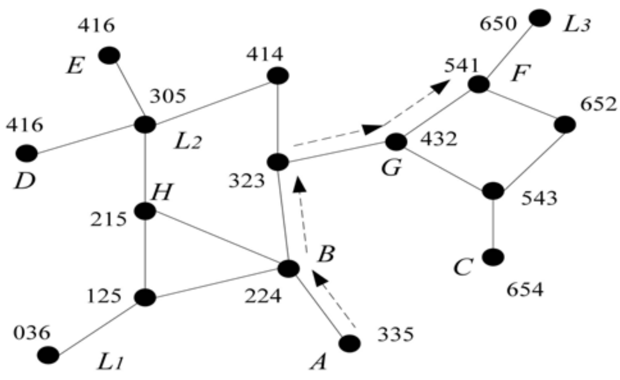
If the routing table not matches the virtual coordinate for destination node it uses for IERP packet. It has the format as shown in following table.

SN-VC	BN-VC	VC Id	HC

If the node not found within zone it makes use of IERP Packet table. It uses Border Node Virtual coordinate which is suited to the destination. The HC in the table is of two which means it maintains boarder nodes.

VC Id: Virtual Coordinate Id (VC Id) is an identity to each node which is used to identify it among the network of nodes. For 3200 nodes in a network we use the corresponding number of VC Id’s. Each node for periodic exchange of messages for updations use these VC Id’s instead of multidimensional coordinate vector which is of O(N.m) bytes for entire network flooding causes more wastage of bandwidth. If the VC Id not matches because of topological changes corresponding coordinate is updated in the table.

Example using VCZRP:



In the above figure we suppose to send packet to Source Node A to Destination F. Node A is maintaining IARP and IERP Routing tables as follows.

SN-VC	DN-VC	VC Id	HC
335	125	1	2
335	224	2	1
335	215	3	2
335	323	4	2

IARP Routing Table

SN-VC	BN-VC	VC Id	HC
335	125	1	2
335	215	3	2
335	323	4	2

IERP Routing Table

For packet forwarding node A looks for destination node virtual coordinate. Above in IARP table it did not matches. So it goes for IERP table. And here it chooses as node with VC 323 which is appropriate. Here the same happen to take packet to route the destination to F.

Improvements in proposed VCZRP:

1. The better network bandwidth utilization is achieved using only the VC Id for periodic updations of node with its neighbors instead of entire node virtual coordinate dimension vector.
2. Routing becomes faster because of routing tables as compared to greedy forwarding methods.
3. With VC Id it can be easy to manage node mobility (Topological Changes) and node updations and deletions.
4. Security is essential when sensitive information is passed between the nodes, and malicious nodes are constant threat. For better security unauthorized nodes should be excluded from route computation and discovery.

VI. CONCLUSION

Virtual coordinate routing is used for routing in ad hoc networks by using some land mark nodes in the network. Virtual coordinate vector is calculated for each node using these landmarks. It is improved to cope some of the drawbacks in geographic routing like dead-end problem. However Virtual coordinate system has problem for addressing node mobilities and their updations. So Zone Routing Protocol aspects are implementing along with it to improve overall performance. Network made of zones of each node of hop distance of two and routing with in zones made proactively by using IARP protocol and among zones uses virtual coordinate vector for packet forwarding. It makes routing with in zones faster also node updations effectively.

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