CHAPTER 5

IMPLEMENTATION OF MSRDMP FOR SCALABILITY

5.1 INTRODUCTION

A model developed for any system would evolve gradually ever and ever in order to face the challenges posed by its application in the environment. Similarly the proposed multicasting routing protocol MSRDMP has to adopt to various challenges. Scalability is one of the prominent issues that is to be addressed by the proposed MSRDMP for multicast routing for MANET. The previous chapter deals with how robustness and group management is achieved in MSRDMP. The scalability refers to the ability to accept the extendibility with existing one.

The protocols designed for MANET offer scalability but fail in achieving the effective performance. In the table driven proactive multicast routing approach the periodic updating of the table would increase the control overhead when scalability is increased. The following section of the chapter explains need for scalability. The transit table helps in achieving the better scalability performance. When group member is migrated from one group another, the intruder should be identified. When the new group is constructed it is let known to other existing group using the appendix packet. Finally the performance of proposed MSRDMP is compared with the other two existing protocol RSGM and SPBM.

5.2 NEED FOR SCALABILITY

The nodes operated in MANET do hardly place or stay in the same location because they are in dynamic topology. As far as multicast communication is concerned in mobile environment, the group membership of the group often changes its location; subsequently member jumps from one group to another. The node jumped from one group to another should be carefully managed and be allowed to join the new group. In many situations it will become very essential that a number of groups should be increased to achieve the effective group communication. When a new group is constructed it should be known by other existing groups.

The devised protocol for multicast routing should be capable of allowing the group members to join the new group and also capable of increasing the number of groups. Increasing the number of groups and the number of group members per group do not affect the performance of the system. The proposed MSRDMP ensures effective packet delivery ratio, minimized control overhead and joining delay.

5.3 ROLE OF TRANSIT TABLE FOR SCALABILITY

The proposed MSRDMP is the location aware table driven protocol. Each node maintains few tables for maintaining control data by individual nodes and leadership track node. The discussions about these two tables have been discussed in chapter three. In order to achieve the effective scalability in multicast routing, MSRDMP maintains one more table named Transit table. This transit table maintains and updates the information about virtual reference point.

As stated earlier the group is formed in MSRDMP with respect to the virtual reference point. Before group is constructed a virtual reference point is set in the area. The number of the virtual reference point set depends on the size of the area and transmission range of mobile nodes. The virtual reference point refers to a location in the area and acts as a center of radius for a particular group. If the range is R then R/2 of range from the virtual reference point forms the radius of the particular group. The Figure 5.1 depicts the number of groups formed with respect to VRP based on transmission range in a particular area. To avoid confusion in understanding, only few nodes are drawn inside the each group. In fact, each group contains a number of group members (GM), one group leader (GL), one leadership track node (LTN) and may contains many numbers of non participating nodes. All nodes maintain the transit table, including non participant node.

The Table 5.1 depicts the empty format of transit table. This transit table maintains a stack which stores the information about virtual reference point. If there are four groups then four values of virtual reference point would be stored in the transit table. The top pointer in a stack always holds the information about the virtual reference point with which a node has currently become a membership of the group. Once a virtual reference point is set in the area the information about the VRP is made known to all nodes. The Table 5.2 shows the transit table for all nodes. After leader for each group is selected by invoking persistence leadership algorithm, each node in the group updates stacks of transit table. For instance the Table 5.3 represents the transit table for group member GM_C for group named C. Clearly the top of the stack points to VRP_C because GM_C is the group member of group C and the group C is constructed with respect to virtual reference point $VRP_{C.}$

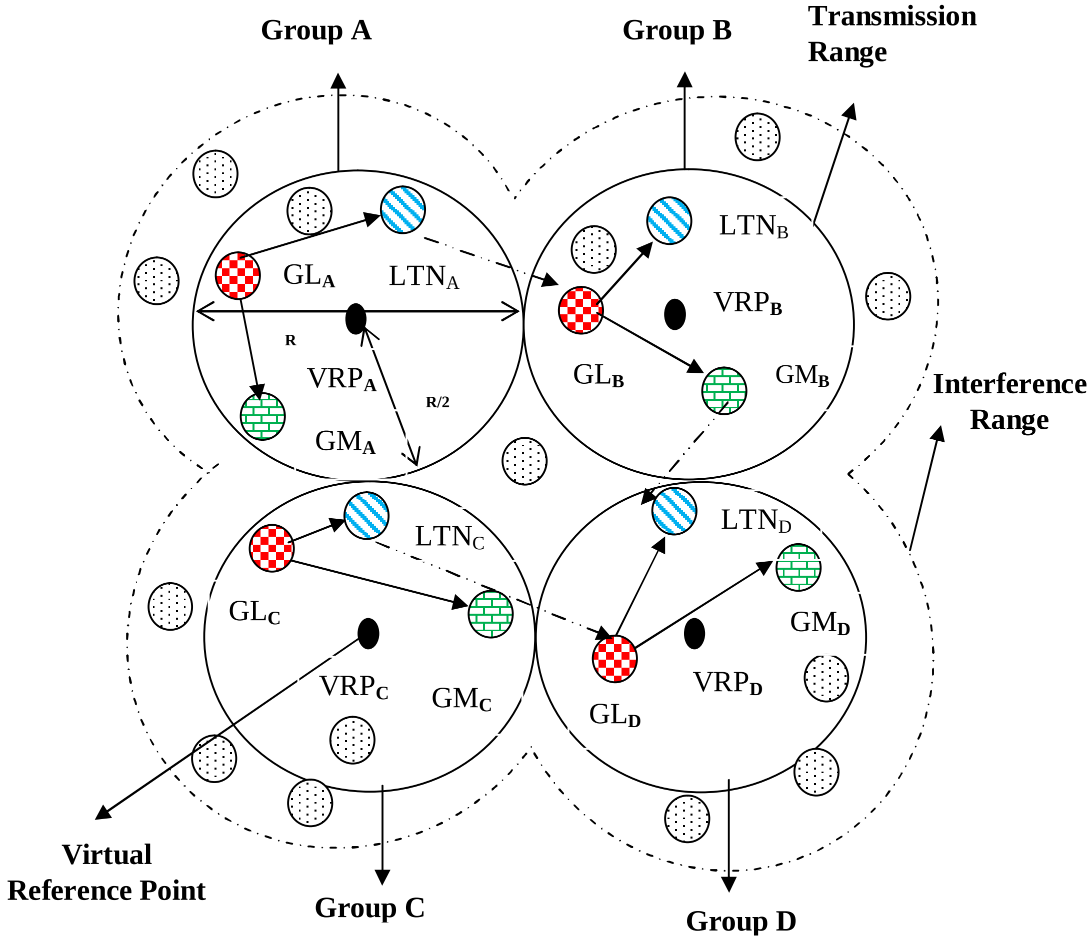

Figure 5.1 Group classification with respect to VRP

Table 5.1 Empty transit table

VRP_1
VRP_2
VRP_3
VRP_4
.
.
.
.
VRP_N

Table 5.2 Transit table before selecting GL

VRP_A
VRP_B
VRP_C
VRP_D

Table 5.3 Transit table of group member GM_C for group C

VRP_C
VRP_A
VRP_B
VRP_D

5.4 SECURED MIGRATION BETWEEN GROUPS THROUGH THP

As it is stated earlier group member of one group may move to another group either deliberately or accidentally. After the group member migrated to a new group, it may not communicate with its old group leader if it moves away from transmission range of old group leader. In such a situation the migrated group member would become a non participant node of the new group to which it has moved recently. If the migrated group member wants to take part in multicast group communication, it may flood a Transit Hello Packet (THP) in the new group.

The THP holds the information stored in the transit table. The information stored in transit table is sent as a packet is called the transit hello packet. This THP is used by the member who has migrated from one group to another and the non participant nodes who want to become the member of any group. Upon receiving the transit hello packet leadership track node of the new group would come to know that the group member has migrated from some group and would identify its previous or the old group by looking at top pointer of the stake of the transit hello packet.

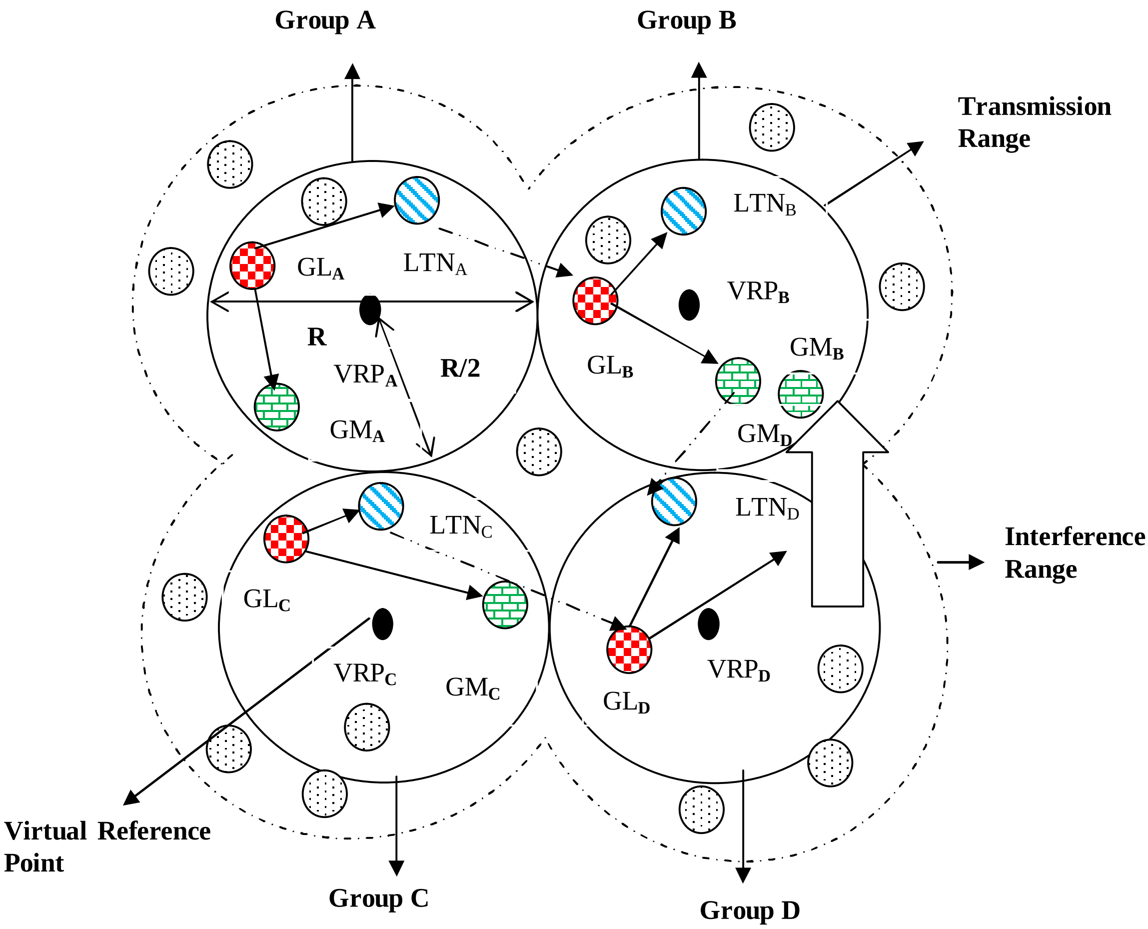

Figure 5.2 Member migration from group D to group B

Now leadership track node of that group makes a decision on whether to reply with address of the group leader of that group or not. If number of group members in that group does not exceed the permitted threshold value already set, leadership track node would reply the transit hello packet with the address of the group leader for that group. Then the migrated group member makes use of the address of the group leader and would send Joint Request (JR) to group leader and become the new group member of the group after receiving the Acceptance Reply (ARY) from the group leader. The Figure 5.2 represents migration of group member from the group D to the group B.

The group member GM_D is said to be migrated node after it reaches the group B. To become a group member of the group B, it has to flood the transit hello packet, after replied by the leadership track node of the group B; it would become the part of the group member of the group B after its join request is accepted by the group leader GL_B. Once it becomes the group member of the group B, it alters the transit table so that the top pointer of the stake points to virtual reference point VRP_B. The MSRDMP protocol paves the way that any stranger node or the node which has not been deployed during group construction can't take part in group communication. The node only posses the transit table is allowed to join the any group while moving between the groups.

5.4.1 Isolation of intruder

The group members that have migrated to new group must have to send the transit hello packet to become the member of the new group. The non participant node would also migrate from one group to another group. The enhanced MSRDMP identifies the node if it is migrated from another group or it is a non participant node on receiving the transit hello packet. Looking at top stake pointer, the migrated node can be identified from where it has migrated. If the migrated node does not possess the transit hello packet, MSRDMP ensures that it is the intruder that exploited the group construction and the node is not allowed to become the group member of that group.

5.4.2 Stale THP packet

Some nodes in the deployment area have not become the members of any group after the groups have been formed. They are said to be non participant nodes and would become the members of some group later using the stale transit hello packet. The stale transit hello packet does not have a top stake pointer, but the stake is filled with the information about virtual reference point.

5.4.3 Secured Scalable Algorithm

The group member that migrated from one group to another can invoke the secured scalable algorithm to become the group member of the migrated group. The various symbols used by algorithm are described below

R	-	Transmission range of a node
N_i	-	Group member that migrated from any group
D_i	-	Current distance of group member from VRP_i
VRP_i	-	Virtual reference point for current group
VRP_j	-	Virtual reference point for migrated group
LTN_j	-	Leadership track node for migrated group
NGM_j	-	Number of current group member for migrated group
GL_j	-	Group leader for migrated group
GM_j	-	Group member for migrated group

TSP - Transit stack pointer

THP - Transit hello packet

TT - Transit Table

Threshold - The maximum group members that can be handled by GL_j

BEGIN

If (D_i>R/2) from current VRP_i then

N_i sends THP to LTN_j

LTN_j checks if NGM_j < Threshold

LTN_j sends GL_j address to N_i

N_i sends JR to GL_j

GL_j sends back ARY to N_i

GM_j= = N_i

Add Node to Mcast table (pkt.groupid, GM_j.id)

GM_j alters TT and TSP points to VRP_j

END

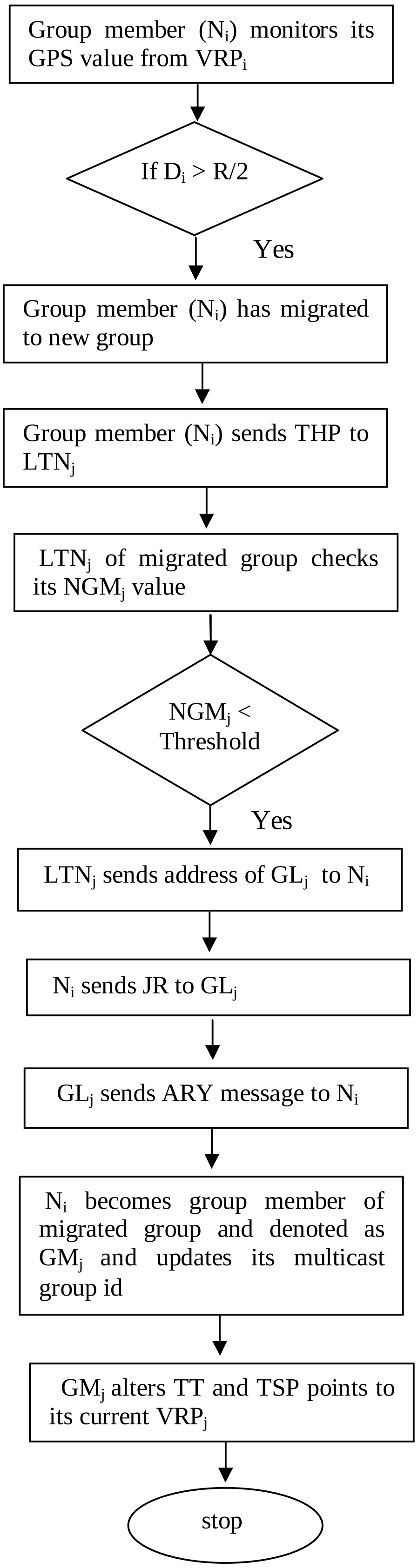

Figure 5.3 Secured scalable algorithm

5.5 NEW GROUP CONSTRUCTION

In order to stretch the communication to longer distance, a new group can be constructed and attached to the existing groups. To construct a new group it is necessary to set a new virtual reference point. The information about the new virtual reference point should be made known to all the nodes in the entire group.

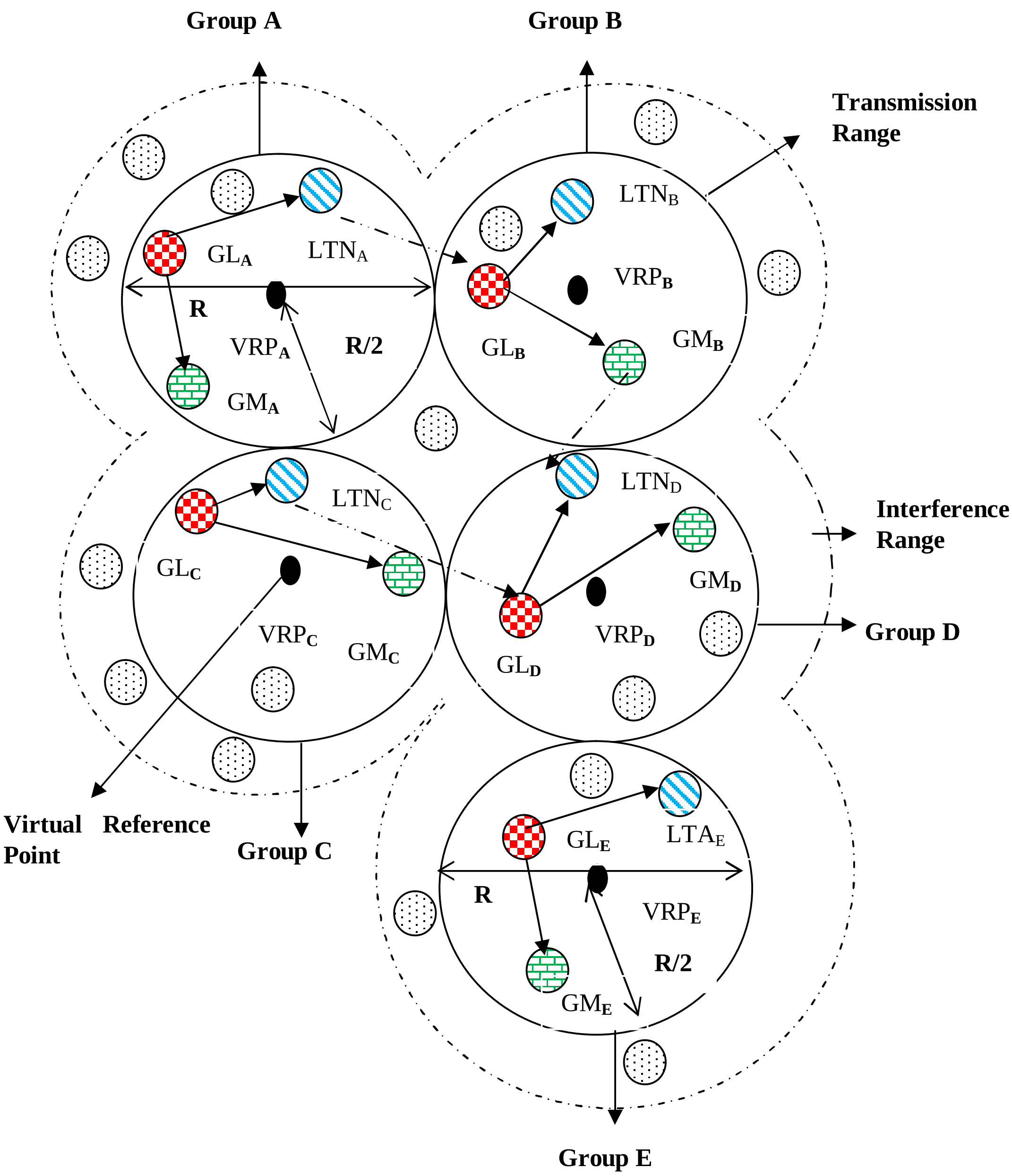

Figure 5.4 New group construction with existing groups

It is meant that all nodes have to update the transit table. Chiang et al (1998) introduced concept of forwarding group to update the group membership data in multicast routing. This transit table is used to generate the transit hello packet and help the group member, join the any group in the deployment area. The Figure 5.4 represents new group construction with existing groups, in which the VRP_E refers to the new virtual point set to construct the new group E. When the new group is constructed transit table of all the nodes in the group E are updated with the information about the existing virtual reference point along with new VRP_E.

The nodes in the existing group are not aware of the new group E unless they are informed by some way. The MSRDMP does not allow the nodes which do not have transit table value. The group leader GL_E of new group first inform about VRP_E to its neighbor group via leadership track node of that group. For the group E, the group D is a neighbor, the GL_E informs about VRP_E to LTN_D by sending an Appendix Packet (AP). The appendix packet is an informative packet that carries the information to the neighboring station about newly set virtual reference point for a new group. Once LTN_D receives the appendix packet and it updates its transit table and passes the appendix packet to its group leader GL_D. After GL_D receives the appendix packet, it multicasts the same to all of its group member $GM_{D\,(i-n)}$.

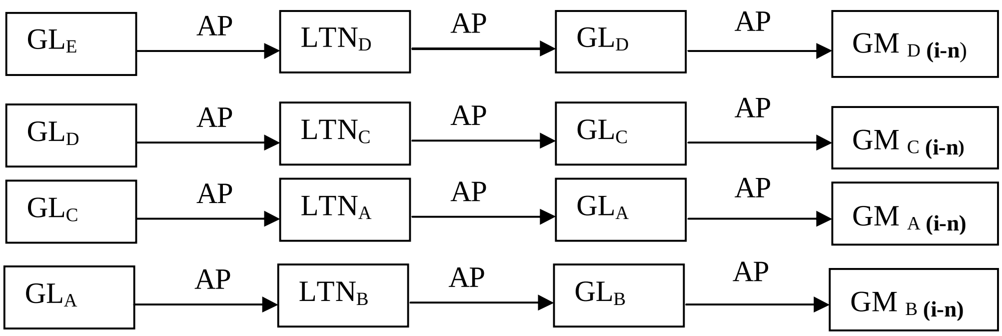

Figure 5.5 Communication flow of appendix packet

The serial way of communication takes place until all the nodes in the existing group are aware of the new group. The Figure 5.5 shows how appendix packet travels in informing the new virtual reference point.

The group leader of the new group initiates the passing of appendix packet to its neighborhood group. The group leader chooses a destination group in such a way that the LTN of the group has been just adjacent to it. The group leader of each group passes the appendix packet in the same way as done by the group leader for the new group. In the new group E shown in Figure 5.5, the GL_E initially passes the appendix packet to LTN_D of group D. The group D is very adjacent to the Group E.

The group leader GL_D may choose its LTN from either the group B or the group C. If GL_D has chosen the LTN from group C, the GL_C chooses the LTN of group A as its next destination. GL_C does not choose LTN of group B after the appendix packet reaches at the group C because the group B is not directly adjacent to the group C. This kind of passing avoids ambiguity in transforming appendix packet to existing groups.

5.6 LEADERSHIP DECLINATION

Group leader of each group takes responsibility to send the packet to all group members. The group leader is also moving across the group. The group leader of any group may decline its role as a leader either by volunteer declination or by accidental declination. The accidental declination is known by the leadership track node of the group using alert message.

The volunteer declination is made known to the members of the group by the group leader itself. Leadership track node of each group keeps monitoring the distance of group leader from its virtual reference point. The alert message exchanged between group leader and leadership track node plays a role in accidental declination of group leader. Leadership track node of any group makes its move, according to alert message.

The detail about alert message is discussed in section 4.4.3 of the chapter 4. When the group leader moves away from its current virtual reference point, LTN sends the alert message to GL. If the alert message is replied by GL then LTN assumes that GL roams around in its own group only. If a reply is not received from GL then LTN assumes that GL declines its leadership accidently.

As far as accidental declination is considered a movement of GL is monitored, but in volunteer declination the number of group members is considered. It is already stated that MSRDMP protocol is a table driven proactive active multicast routing protocols. The information about the table maintained by individual node and the leadership track node are narrated in the section 3.3.4 of chapter 3. Every node that takes part in the multicast group maintains a table, as group leader is also one of the nodes that maintains a table in it and update the table every time a change within the group occurs. Due to the dynamic topology nature of the mobile nodes, group members within a group may go out of transmission range.

Each time a node joins the group, one of the fields in the table' number of group membership in the group value increases by one. If a node goes out of transmitting range, NGM value decreases by one. If the value of NGM decreases to less than a half of the threshold value set, Group leader terminates its role as a group leader then a new group leader is elected to manage the group. The threshold value denotes the maximum group member that can be allowed in a particular group. Accidental declination can't be prevented when GL moves away the VRP deliberately, but volunteer declination can be postponed by changing threshold value.

5.7 RESULT AND DISCUSSION

The protocol MSRDMP designed for multicast routing ensures the scalability in increasing the number of nodes within a group as well as increasing the number of groups in a particular environment. In this performance evaluation, the proposed MSRDMP is compared with RSGM and SPBM. These three are location aware multicast routing protocols. Groups in these protocols are formed with respect to position. Every node that uses these protocols is equipped with global positioning system. In order to compare the result performance data set for RSGM and SPBM are extracted from a manuscript titled stateless multicasting in mobile ad hoc networks written by Xiaojing et al (2010).

Table 5.4 Simulation Parameter

Area Size	1000X1000m^2
Number of Nodes	50-500
Average Speed of Node	5-30 km/hr
Number of senders	2/Group
Number of receiver	25 to 150 per Group
Packet size	512 Bytes
Transmission Range	250m
Transmission Rate	54 Mbps
MAC Protocol	802.11b DCF

The global mobile information system simulation tool is used to implement the MSRDMP. The MAC protocol and radio parameters are configured according to the Lucent Wave LAN card that operates at a 11 Mbps and radio frequency 2.4 GHz and transmission range is 250 meters. MAC protocol that has been used for this simulation is 802.11bDCF. Each simulation lasted 500 simulation seconds. Each group leader sends CBR data packets at 8Kbps with packet length 512 bytes. Among three location aware protocols, the MSRDMP produces very good results and it can be applied to various emergency group communication systems.

The following metrics were studied to show the scalability of MSRDMP under varying group size and number of groups. Packet delivery ratio is the ratio between the number of packets received and the total number of packets sent. Normalized control overhead is the total number of control messages transmitted divided by the total number of received data packets. Average Path length is the average number of hops traversed by each delivered data packet. Joining delay is the time interval between a member joining a group and starts receiving of the data packet from that group after becoming the member of the group.

5.7.1 Impact of Group Size

In the dynamic environment the number of group members in a multicast group can't be same for a longer period of time. The nodes are moving between the groups. Every multicast group supports some number of group members. If the number of group member increases there must be a performance variance in the functionality of the group. The Figure 5.6 represents the graph for packet delivery ratio versus group size. The group size varies from 25 to 150 group members per group.

All protocols show good packet delivery ratio, while increasing the group members per group. The SPBM gives very minimum packet delivery ratio when a number of group members per group are low. The graph shown in the Figure 5.6 clearly represents the performance curve for packet delivery ratio. The blue line for MSRDMP flows above the yellow for SPBM and red for RSGM.

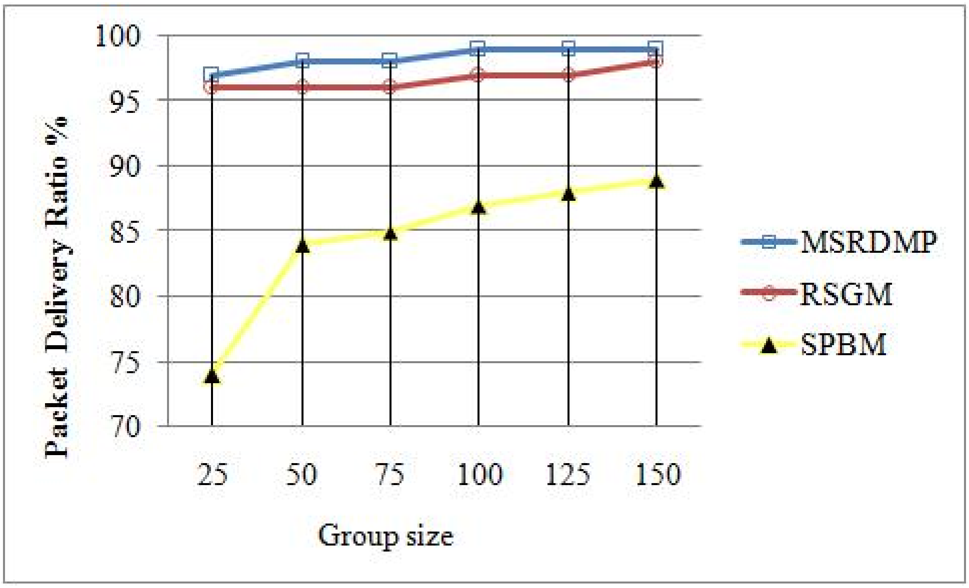

Figure 5.6 Packet delivery ratio versus group size

The Figure 5.7 shows the graph for control overhead versus group size. SPBM incurs high degree of control overhead than RSGM. SPBM floods the join query message periodically it is of no use when group size is low. RSGM uses multilevel control message, it produces unnecessary control overhead when the fewer zone leader is available. The MSRDMP uses very few control messages in assisting the node to become the member of the group and transferring the data packets to group members that already became the members of the group.

The graph shown in Figure 5.7 indicates the graph for control overhead for three protocols. The yellow line for SPBM flows downwards when the group size increases. The red line for RSGM and the blue line for MSRDMP coincidences each other when group size increases. In MSRDMP there must be a group leader in every group, control messages are easily passed in managing the group members.

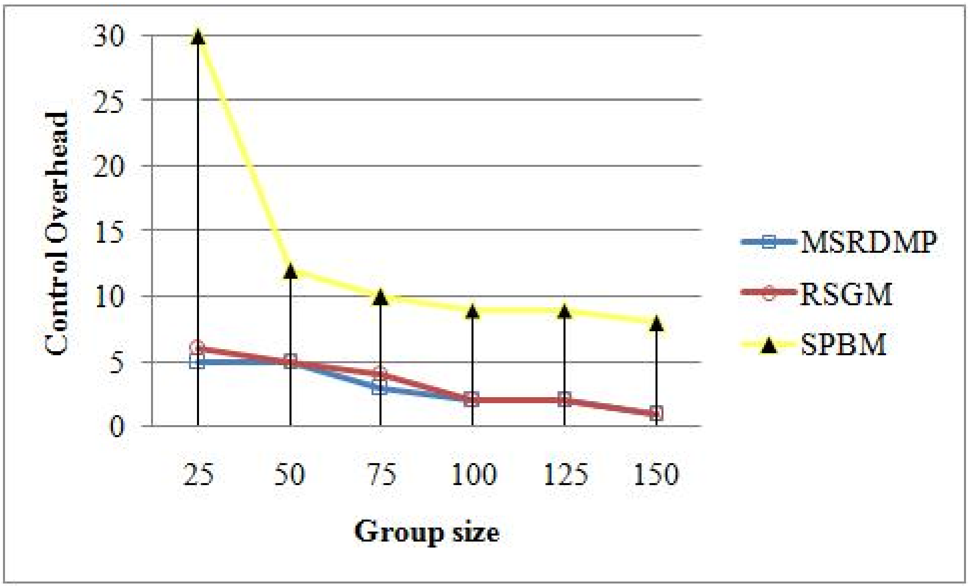

Figure 5.7 Control overhead versus group size

The Figure 5.8 shows the graph for average path length versus group size for three location aware protocols. RSGM and SPBM give almost equal average path length. In SPBM, zone is divided into a number of groups with hierarchical level. The information passed from one group to another is first transferred to its adjacent group level and later transferred to the top level group, this results in significant increases in path length. In MSRDMP path length is confined to optimum level. Only if data losses occur the number hops taken by a data packets increases.

Each group leader is assisted by a leadership track node in transferring the data packets to its adjacent group. The graph depicted in Figure 5.8 shows curvature line for each protocol. The blue line for MSRDMP flows down when group size increases. The red and yellow line travels almost parallel to each other when group size increases.

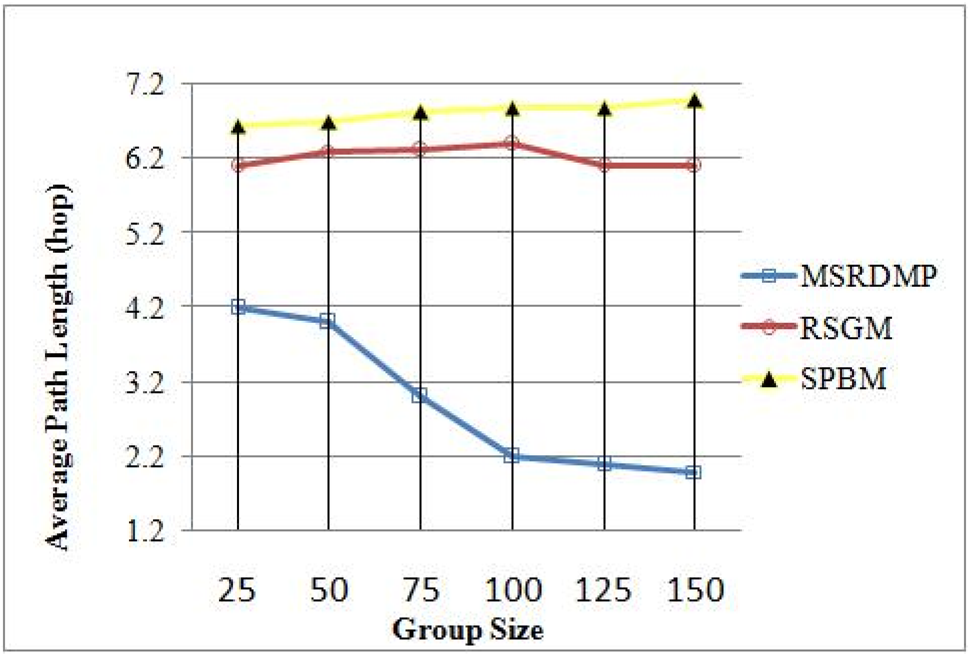

Figure 5.8 Average Path length versus group size

The Figure 5.9 shows the graph for average joining delay versus group size. The average joining delay for SPBM is more when group size increases. Number of zone leader is low when group size decreases. The node wants to become a group member has to wait for long time when a number of leaders is low. If the group size increases the joining delay will decrease because the membership would become stable in the larger group size. In MSRDMP the joining process is assisted by leadership track node.

In RSGM refresh message is often conveyed to zone leader, the leader position is piggybacked so that new member can easily join the group.

The graph shown in Figure 5.9 depicts curvature line for average joining delay for three protocols. The blue line for MSRDMP travels just below the red for RSGM. Among three protocols the MSRDMP incurs very optimum joining delay for the new member joining the group.

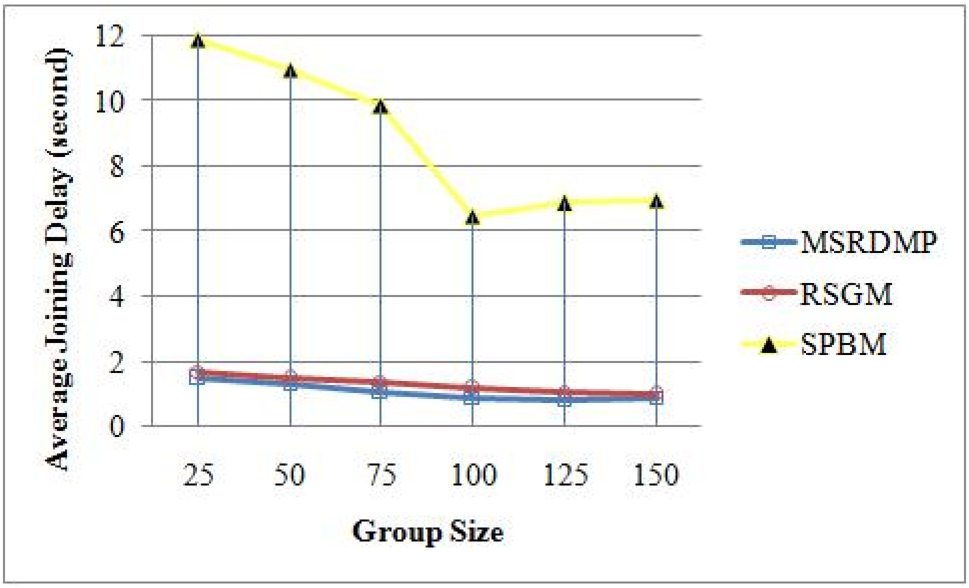

Figure 5.9 Average joining delay versus group size

5.7.2 Impact of Number of Groups

When network size increases, whole area can't be covered by fewer groups. It is necessary to scale the number of groups so that nodes deployed in the area can communicate each other. The protocol designed for multicast routing should be capable of offering scalable to the number of groups. The MSRDMP is very much scalable to the number of groups. To analyze the impact of the number of groups, the number of the group increases from 2 to 12 groups in the network area and total number of members are fixed as 120. If the number of groups is 2, the number of members per group is 60.

If the number of groups is 4, then the number of members per group is 30. The Figure 5.10 shows the graph for packet delivery ratio versus number of groups. The packet delivery ratio for all protocols diminishes when the number of the group increases. The SPBM gives a very low delivery ratio of only 62% when the number of groups is 12. The MSRDMP gives better packet delivery ratio than RSGM when the number of groups is 12. When the amount of group increases the control overhead as well as the packet transmission overhead increases therefore the packet delivery ratio decreases for all location aware protocols. The graph shown in Figure 5.10 represents the performance of packet delivery ratio. The blue line for MSRDP flows above the lines for RSGM and SPBM. The yellow line falls drastically down when the number of the group increases.

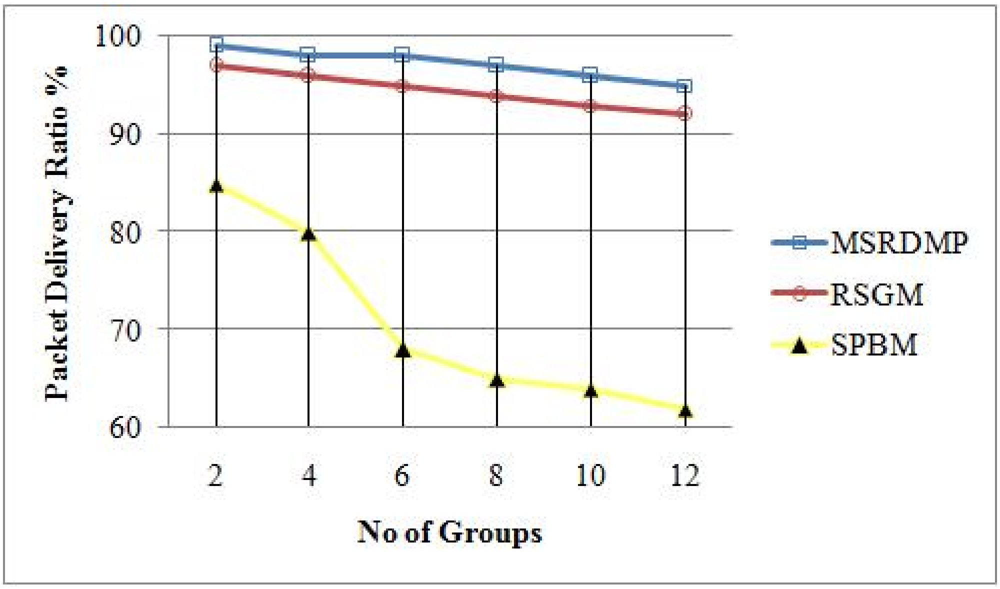

Figure 5.10 Packet delivery ratio versus number of groups

The Figure 5.11 presents the graph for control overhead versus number of groups. All protocols exhibit the higher control overhead when number of group increases. The number of groups is 2, the 60 members per group poses the low control overhead because fewer exchanges of control messages are passed within the members of the two groups. When the number of groups increases the group members are also sparsely deployed hence control messages can be dropped. The SPBM incurs the very high control overhead because the control message has to be passed in predefined tree structure only.

In RSGM only zone leader takes responsibility to ensure the membership criteria in a group, whereas MSRDMP makes use of leadership track node per each group, it subsequently reduces the control overhead. The graph shown in the Figure 5.11 clearly portraits that the performance curves for control overhead. The control over head for RSGM and MSRDMP is more or else the same. The blue and red lines overlap each other. The yellow line for SPBM goes upward when the number of the group increases.

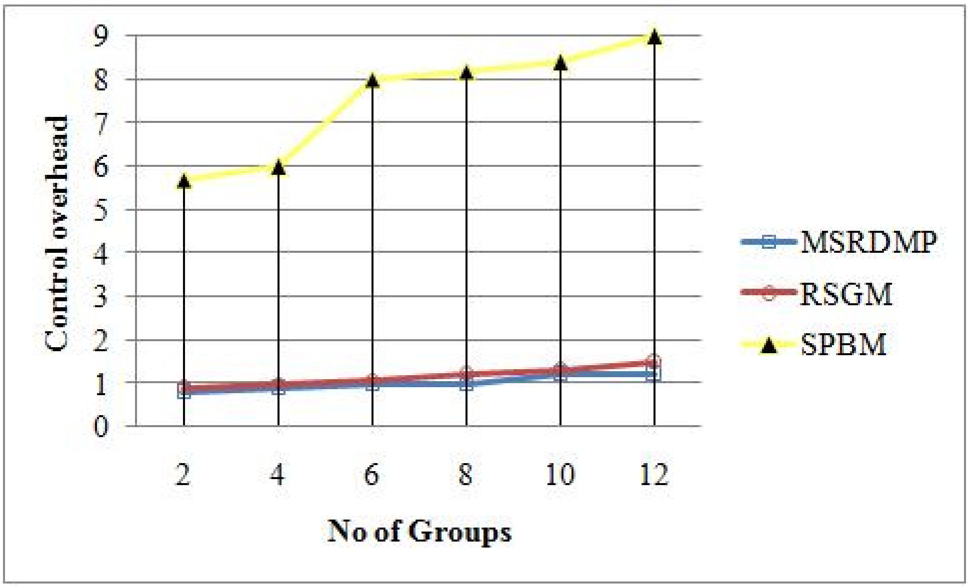

Figure 5.11 Control overhead versus number of groups

The Figure 5.12 shows the graph for average path length versus number of groups for three multicast routing protocols. The average path length is almost constant for each protocol when the number of the group increases. The RSGM and SPBM incur more average path length than MSRDMP. The increasing in a number of groups makes a little effect on the average path length. A leadership track node in MSRDMP helps the adjacent group leader so that the average path length is low compared to RSGM and SPBM.

The graphical representation showed in the Figure 5.12 displays the line flow for average path length for three protocols. The blue line for MSRDMP goes below the lines for RSGM and SPBM. Among three protocols SPBM incurs high average path length when increases the scalability in terms of number of groups.

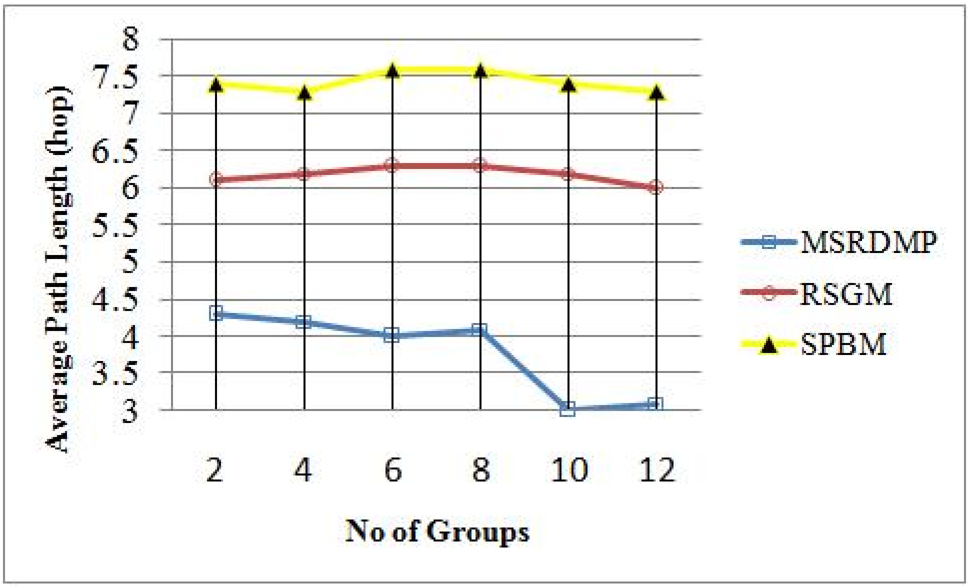

Figure 5.12 Average path length versus number of groups

The Figure 5.13 shows the graph for average joining delay versus number of groups. The joining delay for SPBM increases drastically when the number of the group increases. The joining query is usually managed by the group leader of the group in SPBM. There is more number of group members per group, but only a few group leaders could not manage the entire joining query made by the newly joining node. This leads to extreme delay in joining the group. The joining delay for MSRDMP and RSGM is considerably low when the number of the group increases. In MSRDMP the new node is helped by a leadership track node in getting the address of group leader for the particular group. The task of group leader is equally distributed so that the new member is responded without delay.

The graph displayed in the Figure 5.13 marks the average joining delay curve for three location aware protocols. The yellow line for SPBM goes upwards while an increase in the number of groups. The blue color for MSRDMP flows down the line for RSGM. The above discussed results ensures that the MSRDP offers better performance as scalability of groups and the number of group members per group is increased.

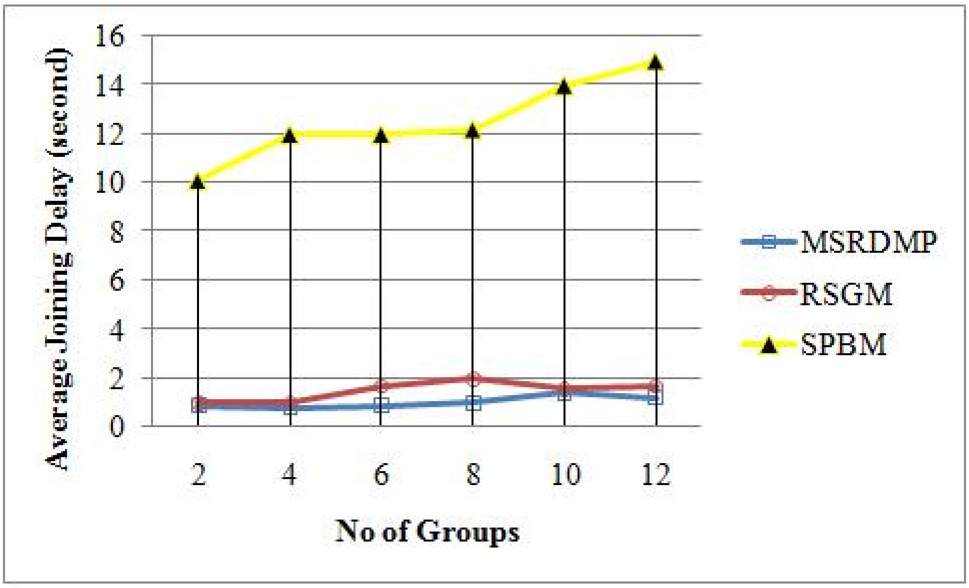

Figure 5.13 Average joining delay versus number of groups

5.8 NUMERICAL INVESTIGATION AND DISCUSSION ON GROUP SIZE

The test on scalability feature of the proposed multicast protocol MSRDMP is compared with the RSGM and the SPBM under varying group size. The Table 5.5 shows the result data for four performance parameters packet delivery ratio, control overhead, average path length and average joining delay for three protocols. The average performance shows that the packet delivery ratio for the MSRDMP is 98.33%, which is 1.67% more than the RSGM and 13.83% more than the SPBM. The control overhead for the MSRDMP is 3 and 3.33 for the RSGM and 13 for the SPBM.

The average performance of path length is optimized in the MSRDMP. The packet in the MSRDMP takes the 2.91 hops on an average, whereas the RSGM takes the 6.22 hops. The SPBM takes 6.22 hops on an average. The average performance of joining delay for the MSRDMP is 1.08 seconds, which is seven times lower than the SPBM and 0.23 second less than the RSGM.

5.9 NUMERICAL INVESTIGATION AND DISCUSSION ON NUMBER OF GROUPS

Apart from number of group members per multicast group, the number of multicast group also increases depending on the environment. The proposed multicast routing protocol MSRDMP is scalable in terms of group size as wells as number of groups. The performance parameters packet delivery ratio, control overhead, average path length and average joining delay is analyzed and compared with the other two location aware protocols the RSGM and the SPBM.

The Table 5.6 shows the average performance of those protocols for six set of values under number of groups. The packet delivery ratio for the MSRDMP is 97.16% and 94.5% for the RSGM. The SPBM offers 70.66% packet delivery ratio. The control overhead for the MSRDMP is 1.01 on an average and 1.16 for the RSGM. The control overhead for the SPBM is more and the average value is 7.55. The average performance of joining delay for the MSRDMP is 50% less than the RSGM and 75% lesser than the SPBM. The MSRDMP, RSGM and the SPBM claim 3.78 hops, 6.18 hops and 7.43 hops respectively. The average performance of joining delay for the MSRDMP is 1.03 seconds on an average, whereas the RSGM takes 1.5 seconds on an average for a node joining a multicast group. The SPBM takes more delay about 12.55 seconds for a node joining a multicast group. It is observed that the MSRDMP offers better performance than the other two location aware protocols.

Table 5.5 Numerical investigation and discussion on group size

Group Size	Packet delivery ratio %			Control overhead			Average path length (hop)			Average joining delay (second)		
	MSRDMP	RSGM	SPBM	MSRDMP	RSGM	SPBM	MSRDMP	RSGM	SPBM	MSRDMP	RSGM	SPBM
25	97	96	74	5	6	30	4.2	6.1	6.65	1.5	1.7	11.9
50	98	96	84	5	5	12	4	6.3	6.7	1.3	1.5	11
75	98	96	85	3	4	10	3	6.32	6.83	1.1	1.4	9.9
100	99	97	87	2	2	9	2.2	6.4	6.9	0.9	1.2	6.5
125	99	97	88	2	2	9	2.1	6.1	6.9	0.8	1.1	6.9
150	99	98	89	1	1	8	2	6.1	7	0.9	1	7
Average Performance	**98.33**	**96.66**	**84.5**	**3**	**3.33**	**13**	**2.91**	**6.22**	**6.83**	**1.08**	**1.31**	**8.86**

Table 5.6 Numerical investigation and discussion on number of groups

Number of groups	Packet delivery ratio %			Control overhead			Average path length (hop)			Average joining delay (second)		
	MSRDMP	RSGM	SPBM	MSRDMP	RSGM	SPBM	MSRDMP	RSGM	SPBM	MSRDMP	RSGM	SPBM
2	99	97	85	0.8	0.9	5.7	4.3	6.1	7.4	0.9	1	10.1
4	98	96	80	0.9	1	6	4.2	6.2	7.3	0.8	1	12
6	98	95	68	1	1.1	8	4	6.3	7.6	0.9	1.7	12
8	97	94	65	1	1.2	8.2	4.1	6.3	7.6	1	2	12.2
10	96	93	64	1.2	1.3	8.4	3	6.2	7.4	1.4	1.6	14
12	95	92	62	1.2	1.5	9	3.1	6	7.3	1.2	1.7	15
Average Performance	**97.16**	**94.5**	**70.66**	**1.01**	**1.16**	**7.55**	**3.78**	**6.18**	**7.43**	**1.03**	**1.5**	**12.55**

5.10 SUMMARY

This chapter of the thesis explains the need for scalability and role of the transit table for achieving the better scalability performance. How secured migration of nodes between groups is handled by THP is explained. The new group construction facilitated by appendix packet is narrated. The performance of proposed MSRDMP under varying number of nodes per group and number of groups in a deployment area is analyzed and compared with the existing location aware protocol RSGM and SPBM and also numerical investigation and discussion on group size and number of groups are quantified and tabulated.