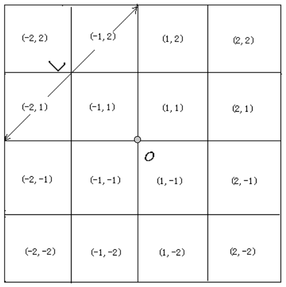
Overview

- The communication area is divided into non-overlapping square zones of the same size;
- There is a unique zoneID for each zone;
- There is a zone-head in every zone. Each zone-head is within the transmission range of all the zone-heads in its 8 neighboring zones;
- Every zone-head maintains the information of its member mobile hosts (MTs) ;
- The information is updated when timer comes and an MT moves to a new zone.

Partition of Fixed Zones



1.To guarantee that any two neighboring zone-heads are in the transmission range of each other and can communicate directly,

zone size is given by

$$(L/(2\sqrt{2}))\ X\ (L/(2\sqrt{2}))$$

2.Each zone has a unique zoneID=(i,j).

L: Transmission range

O: Origin

$$i=(Location\,x-Origin\,x)DIV(L/(2\sqrt{2}))$$

$$j=(Location\,y-Origin\,y)DIV(L/(2\sqrt{2}))$$

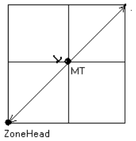
Fixed Zone Creation Protocol (1)

• Every member MT maintains the information concerning the location of origin, its IP number, its location from GPS, its zoneID, IP_number of its zone-head, transmission range L, status (1 for member MT).

• Every zone-head maintains the information of its *IP_number*, *location* from GPS, *zoneID*, transmission range L, *status*(0 for zone-head), *member_MTs_list* which consists of the IP numbers of its member MTs in its zone *neighbor_zone_heads_list* which consists of the IP_numbers of all the zone-heads in its 8 neighboring zones.

• Every MT should check its location information periodically to guarantee that every member MT is within the transmission range of its zone-head.

Timer.time <=L/(2*maximum_moving velocity)



Timer consideration for the worst situation

Fixed Zone Creation Protocol (2)

For every zone-head

If the timer arrives, it calculates its new zoneID. If it moves to another zone, it calls the hand_over() routine to transfer its information of the member MTs to its first member MT which becomes the new zone-head, then calls join() routine to send messages to its new zone-head, becomes its member MT or new zone-head if there is not zone-head in the new zone;

. **If it receives a join message from other MT** in its zone then it adds the MT to its member_MTs_list;

If it receives a dis_join message from its member MT ,it deletes the MT from its member_MTs_list;

If it receives an Inform_zone_head message, if it is in the neighbor zones, modifies the neighbor_zone_heads_list

Fixed Zone Creation Protocol (3)

For every member MT,

If the timer arrives, it calculates its new zoneID. If it moves to another zone, it sends join message to its new zone-head, becomes its member MT or zone-head, then calls the disjoin(zone_ID) routine to its old zone-head;

If it receives hand_over_Msg, it becomes a zone-head, updates its member_MTs_list and neighbor_zone_heads_list; informs others that it becomes the zone-head

Fixed-Zone-Based Routing Protocol

- Route Discovery

  Find a route from a source node to a destination node.
- Route Maintenance

  Correct a route when problems occur in the route when
  - Any MT in the route moves out of the transmission range of upstream or downstream MT along the route;
  - Any of the MTs along the route fails;
  - Any of the MTs along the route is power-off.

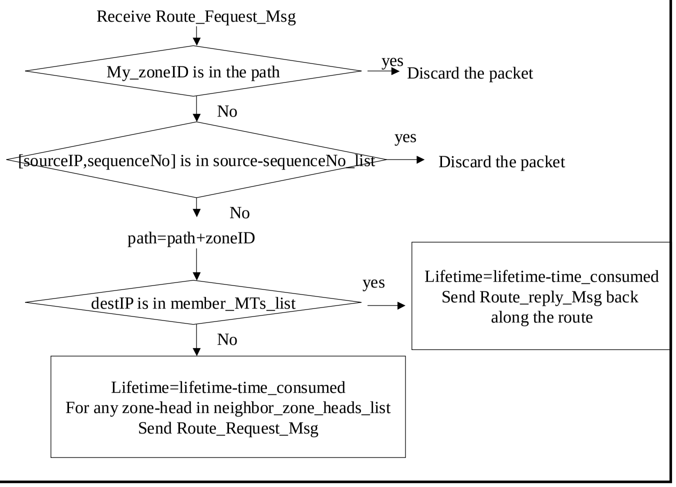
Route Discovery (1)

- When source node **S** wants to communicate with destination node **D**, it sends route_request_Msg to its zone-head, then the zone-head sends the route_request_Msg to its neighboring zone-heads until the destination node is in its member_MTs_list, then it sends the Route_Reply_Msg back along the path to the source node;
- If S does not receive Route_Reply_Msg from D during the waiting period, it resends route_request_Msg;
- If S gets several routes during waiting period, it saves the path in its route cache , then uses pathselect( ) to select one route that satisfies the user's QoS requirement, then sends data from S to D along the route.
- Route_request_Msg consists of

  1. Source_IP - IP number of source node S
  2. destIP - IP number of destination node D
  3. SequenceNo - to guarantee loop freedom
  4. ZoneHead - ZoneID of the zone-head to which the message will be sent
  5. path - collection of ZoneIDs in the route discovered
  6. lifetime - to guarantee that the discovered route is fresh enough

Route Discovery (2)

For intermediate zone-heads:


Receive Route_Fequest_Msg
My_zoneID is in the path
yes
Discard the packet
No
[sourceIP,sequenceNo] is in source-sequenceNo_list
yes
Discard the packet
No
path=path+zoneID
destIP is in member_MTs_list
yes
Lifetime=lifetime-time_consumed
Send Route_reply_Msg back
along the route
No
Lifetime=lifetime-time_consumed
For any zone-head in neighbor_zone_heads_list
Send Route_Request_Msg

Route Maintenance

```
Path_maintenance(path[I]) // path[I] means node I in the path
{
  if    path[I+1] is reachable
            path[I]=path[I+1]  // bypass the failed zone-head
  else
     if    ∃ ZoneHead ∈ ( path[I-1].neighbor_Zone_heads_list &&
path[I+1].neighbor_Zone_heads_list)
      // if there is another zone-head in the neighbor_ Zone_Heads
      // _List of the  previous and the  following zone_head of the failed node
          path[I]=ZoneHead;
     else
          send Error_Msg(source_IP, sequenceNo, destIP,
error_sender, path)
            // it sends Error_Msg back to source node.
}
```

Advantages

- Since zones are fixed and any MT can get its zoneID through calculation, the overheads for maintaining clusters and selecting clusterheads are considerably reduced
- Both time-driven and event-driven:

  Only when timer comes and an MT moves to a new zone, it transmits its information to its zone-head and its neighboring zones. The required bandwidth, CPU time, and power consumption for zone maintenance are reduced
- A path is a collection of ZoneIDs instead of IP numbers. When a zone-head moves to another zone, there will be a new zone-head in the zone. Therefore, the probability for links to be broken is reduced, prolonging the lifetime of exsisting routes

Advantages(Cont.)

- Use route cache to keep route information for a period of time
- Use a route maintenance protocol to maintain a route when there are small changes in the route, avoiding the overheads for rediscovering a new route;
- Route_ Request_Msg is sent to specific ZoneID so a zone-head only receives and process messages that are sent to it, reducing the transmission overheads as compared to broadcasting Route_ Request_Msg to all MTs;
- If we add QoS metric to the route request packet, we can consider QoS in route discovery, and find a route that satisfies user’s QoS requirements.

Conclusion

- Fixed-Zone-Based Routing Protocols adapt to large-scale, high-density, high-mobility wireless ad hoc networks.
- The largely reduces the overheads in calculation and communication for maintaining clusters , electing cluster heads, and discovering routes.
- The algorithm is simple and efficient.