Study of Clustering and Neighbor Detection Protocol in MANET for Energy Efficiency

Minu Rani, Rekha Yadav, Suman Sehrawat

Abstract— Now a days for quick communication various of the communication protocol is being used . Out of them MANET mobile ad-hoc network is widely attracting all the research . Various protocol is being used for the detection methods and reducing the battery life . In this paper we are introducing a complete study and comparison of the modern MANET technology and clustering in case of mobile ad-hoc network . The analyzed result for the algorithm is given for the detection of neighbor detection algorithm . The studied result to insuring reduced energy consumption is by using color Petri net(CPN) tool. To calculate the weight node is also done to ensure research fruitful .

Index Terms- MANET , NDP , Clustering in MANET , CWP.

I. INTRODUCTION TO MODERN MANET

In the earlier versions of mobile ad hoc networks, the packet radios sponsored by DARPA were used for communication. However, currently three main communication standards with ad hoc capabilities are used to address a specific range of commercial applications. The deployment of a mobile ad hoc network is easy due to the absence of setting up any infrastructure for communication. Mostly such kind of network is required in militaly application and emergency rescue operations. But slowly it has been emerged into the areas of gaming, sensing, conferencing and collaborative and distributed computing[1]. This dynamic network is yet to capture most of the commercial applications. Research is still going on in this direction so that the MANET can be deployed in any area where a faster and cheaper network can be setup instantly for data communication. Mostly, the distributed applications where the entities are strongly coupled, are not adaptive to connection disruptions. In such regard the mobile ad hoc networks, where the nodes are at great extend dynamic in nature, which can be most suitable for the loosely distributed applications. In an ad-hoc network lacks any infrastructure for contrary network infrastructure. So , There are no base stations, no fixed routers and no centralized administration. All nodes may move randomly and which are connecting dynamically to each other. Therefore all nodes which are connected are operating as routers and need to be capable to discover and maintain routes to every other node in the network and to propagate packets accordingly. Mobile ad-hoc networks is most widely being used in the area with little or no communication infrastructure: think of emergency searches, rescue operations, or places where it is impotent to quick communication.

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Mrs. Meenu Rani, Department of Computer Science Engineering , S(PG)ITM, Rewari, India .
Ms. Rekha Yadav, Department of Computer Engineering , GITM Bilashpur MDU - Rohtak, India.
Mrs Suman Sehrawat, Department Of Computer Science Engineering , WCTM, Gurgaon, India.

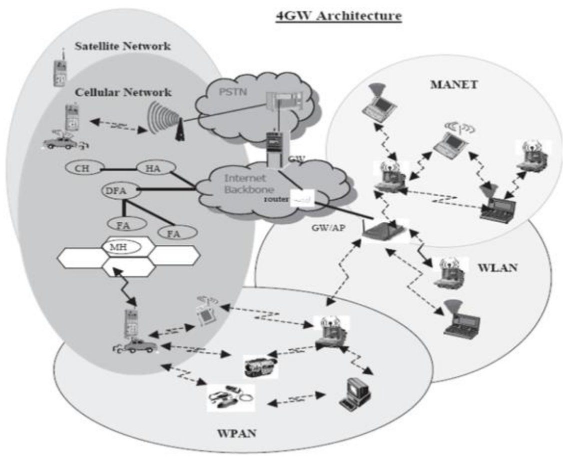

Figure 1: Current generation network [2]

In MANET, the available of node mobility changes the link of connectivity between the nodes very frequently. The classic Link State algorithms Existing conventional Bellman Ford routing algorithm are not applicable for such dynamic network where the topology changes with the free movement of the nodes. So new routing protocols are required for MANET that can be adaptive with the frequent neighbour change and topology changes. Scalability of a network can be express as the ability to provide an acceptable (threshold) level of service even with a large number of nodes. In MANET , the nodes are constrained with limited battery power, computation capability and storage capacity. When the network size increases, the number of packets forwarded by each node also increases. This ultimately affects the QoS of the network. This drains the node resources fast, making it dead in a short period. Similarly, topology maintenance overhead in a scalable dynamic network is another challenging issue.

II. CLUSTERING IN AD-HOK NETWORK

An ad hoc network is build up of mobile nodes with wireless interfaces, which communicate with each other by using multihop paths, So in the absence of any fixed infrastructure. For network traffic each mobile node in the network also acts as a router for the network traffic. The reason for most widely being used is the main advantages of such networks are dynamic reconfirmations and rapid deployment and dynamic reconfiguration, which make them the right candidate for military applications, rescue operations and disaster recovery.

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Owing to their ability to provide a quick and cheap communication link without the need of wired infrastructure, they help in extending the limits of ubiquitous computing and information access for their users. Of late, there has been a need to support QoS and security in ad hoc networks owing to their varied usage scenarios and convergence of different applications' traffic. Clustering provides a solution to support QoS in ad hoc networks, which are usually constrained by low computational and bandwidth capacity of nodes, mobility of intermediate nodes in an established path, and absence of routing infrastructure. In a clustered network architecture, the whole network is divided into self-managed groups of nodes called *clusters*. All the nodes within a cluster are at most two hops away from each other. These clusters continually adapt themselves to the changing network topology and new cluster configurations that are feasible with the current network topology, are created dynamically. *Master* (or *Clusterhead)* is the node which is only one hop away from all the other nodes in the cluster, and carries certain extra responsibilities.

An overview of the CRESQ algorithm is as follows:

1. Initially all the nodes in the network are put in state *none*. Then the whole ad hoc network is clusterized using an initial clustering algorithm described in section II-C.
2. Once the initial clustering is done, then the cluster management algorithm takes over, which is described in section II-D.
3. Whenever a node S wants to establish a connection to a node D, S sends a ROUTE REQUEST packet to its master MS specifying the destination and required QoS levels. MS then broadcasts the packet to its bridges.
4. All the bridges of MS further broadcast the packet to all of their masters, which further broadcast to their bridges. This process continues till a master of D hears the request, which adds D's address in the *Addr List*1 of a ROUTE REPLY packet and sends it to the node from which it heard the ROUTE REQUEST.
5. Each of the nodes which receive the ROUTE REPLY packet, sends it to the node from which it heard the ROUTE REQUEST after checking the QoS constraints and adding in the *Addr List*, its own address (if it is a bridge*)* or a slave's address (if it is a master).
6. When S receives the ROUTE REPLY, it simply uses the path specified in *Addr List* to route its data packets. A data packet is routed by source routing at the intermediate nodes.

III. A STUDY AND ANALYSIS OF NEIGHBOR DETECTION PROTOCOL

In the MANET, the wireless nodes move freely while remaining reachable to each other. With fixed topology network, a connectivity matrix can be generated to identify the connections between the nodes. However, for MANET the generation of a connectivity matrix, where the frequent updation is required to reflect the changes in the network topology, is very difficult. Petri nets are promising graphical and mathematical modelling tools for describing and studying information processing systems. Petri Nets could be used to model any system that can be described graphically like flow charts and needs some means of representing parallel or concurrent activities [3].

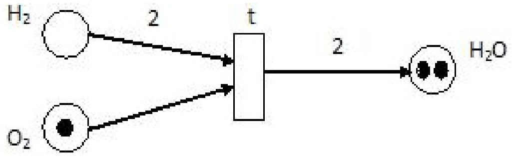

Figure 2: sample petri net model

Hierarchy in the CPNs shows that the models can be form e into number of related modules. This concept is based on the concept of hierarchical structuring of the programming language, that supports the bottom-up or top down style. Modules created can be reused in several parts of the CPN model and further sub-modules can be created from it. The modules of the CPNs are called *pages*. A complex model can have as many as hundreds of pages similar to a lengthy and complex program, that is divided into several modules. In hierarchical CPNs, a transition and its associated components make a link to another CPNs providing a more precise and detailed description of the activity represented by the transition. Such transitions are called the *substitution transitions*. The hierarchy inscription in the substitution transition defines the details of the substitution in separate modules called the *sub-pages*.[7] The places in a sub-page are marked with an input tag *In*-tag, output tag *Out*-tag or input/output tag *I/O*-tag. These places are called the *port places*. They constitute the interface through which the sub page communicates with its surroundings.

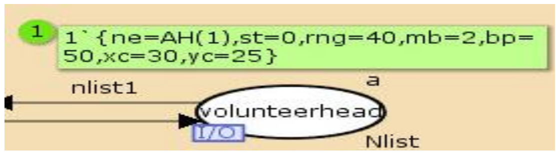

Figure 3: sample place in CPN

The port places of the sub pages are related to the socket places of the substitution transition by providing the port assignments [practitioner's guide][8]. When a port place is assigned to a socket place, the two places become identical. The port place and the socket place are two different representations of a single conceptual place, i.e. the port and the socket places have always identical markings. When an input socket receives a token from the surroundings of the substitution transition, that token also becomes available at the input port of the sub-page, and hence the token can be used by the transitions on the subpage. Similarly, the sub-page may produce tokens on an output port. Such tokens are also available at the corresponding output socket and hence they can be used by the surroundings of the substitution transition.[9-13]

IV. ANALYZED NEIGHBOR DETECTION PROTOCOL

The mobile ad hoc network can be modeled as a unidirectional graph $G = (V,L)$ where V is a finite set of mobile nodes and L is a finite set of links that exist between the nodes. We create assumption that there lies a bidirectional link Lij between the nodes i and j when the gap in between the nodes $dij < trange$ (transmission range) of the nodes. In case of Dynamic the dynamic network the cardinality of the nodes $|V|$ remains constant, but the cardinality of links $|L|$ changes due to the mobility of the nodes. Each node v , V is uniquely identified by an integer identifier *ID* along with a wireless transmission range *vtrange*. When a node *v*1 is within the transmission range of *v*2, they are assumed to be connected by a unidirectional link *l*12 *L* , such that whenever *v*1 broadcasts a message, it is received by *v*2 via *l*12 .

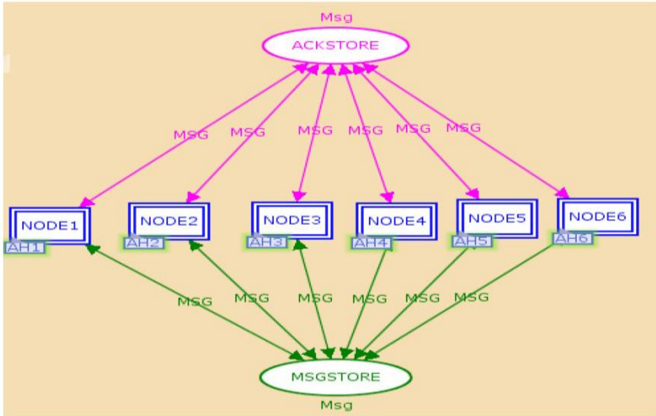

Figure 4: top level of the model [16]

Similarly, when *v*2 is within the transmission range. of *v*1 , they are assumed to be connected by an unidirectional link *l*21*L* , such that whenever *v*2 broadcasts a message, it is received by *v*1 via *l*21. Thus we say that there exists a bidirectional link between *v*1 and *v*2. The graph *G* representing the ad hoc network is assumed to be a simple graph. That is an un-weighted, un-directed graph containing no self-loops or no parallel links (when their end points are same). The neighbor detection protocol (NDP) has been designed to provide mechanism to detect the one-hop neighbours of the nodes in the ad hoc network. Here, the nodes use a special control packet called the *neighbour detection packet* (NDPAK) to realize their neighbors. The format of the packet is as:

If a node *u* wants to know about its existing neighbors, it should broadcasts a neighbor detection packet (NDPAK). The transmitter specifies it as a neighbor request (NRQ) type packet and keeps the receiver identification field (RID) as X. In this work it is imagined that the nodes can have either the role of cluster head or cluster member or an undecided state. Initially, the status of every node is undecided with a status value of 0 before the cluster is actually formed. The node(s) that is(are) within the transmission range of the sender *u*, receives the packet and send back acknowledgements to the sender. The packet being an acknowledgement packet has the type of packet as NAC and creates an unicast transmission to the source. Thus the RID field contains the identification number (NUM) of the source node that originally sent the NDPAK request. The node weight field WT is a non-negative number that is calculated by considering some node parameters to specify its ability to be selected as a cluster head. The STATUS field of the node indicates its current role in the network. Subsequently, as the node is chosen as cluster head or cluster member, this field is filled with appropriate values. The mechanism of the neighbor detection protocol (NDP) is listed step wise as follows[14]

Step 1: Node *u* broadcasts the Neighbour Detection Packet (NDPAK) to the network.

Step 2: Let the packet is received by node *v* which is within the transmission range of *u*. Node *v* sends back a Neighbor Acknowledgement (NAC) Packet to *u* along with its own information like ID, transmission range, weight and status enclosed in the packet.

Step 3: After receiving the acknowledgement NAC packet from *v*, node *u* updates its neighbor table (NTAB) by adding *v* as its immediate neighbor along with its information.

Step 4: Finally, *u* sends back a Neighbor Confirmation (NC) message so that *v* updates its own neighbor table and a bidirectional link is established between the two nodes.

V. STEPS TO CALCULATE WEIGHT IN PROTOCOL

The mobility of nodes changes the network topology frequently which in turn hampers the network stability. So, choosing the less mobile nodes for the formation of the virtual back bone is preferred. This ensures better backbone stability. Similarly the limited battery power devices consume their energy and become dead while routing the packets through them. This de-links the path for packet routing and demands for further establishment of routing back bone. In order to ensure the availability of routers in the routing backbone, nodes with more available battery power are chosen as the back bone forming nodes. Keeping these factors in mind, the node weights are calculated by considering the node mobility and its available battery power as the key values. Here δ is assumed to be the maximum permissible speed of a node in the network. Thus the mobility factor of every node is calculated by computing the difference of δ and its average speed during a certain time interval. A larger mobility factor indicates a node with less mobility and vice versa. The available battery power is the energy associated with the node at the instant of weight calculation. These two parameters are added with different weight factors to find the individual node weights. After the weight calculation of the nodes, the initial clustering algorithm is called upon to select the set of volunteer cluster heads. A pseudo-code segment of the algorithm is presented below.

```
Begin
...
for (every v ϵ V )
{
if Wv > Wi where i ϵ Γ(v)
Then Set head= v
for (every x ϵ Γ(v))
{
if STATUS(x) = 0 then
Set HEAD(x)= head
}
}
...
End
```

The algorithm indicates that a node having maximum weight out of its 1-hop neighbours declares itself as the volunteer cluster head. its 1-hop uncovered neighbors, (i.e., whose task is not decided yet) become the members of the volunteer head.

The set of covered nodes are exempted from taking part in subsequent selection procedure and this process is repeated till all the nodes are assigned with their role either as a cluster head or a cluster member. During the cluster head selection phase, every node broadcasts it's ID along with its weight *WTi* to the neighbors and

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stores the weights *WTj* that it hears from other nodes. It is understood that, every node has a neighbor table NTAB that stores the list of neighbors of the node which has been learnt by the execution of the NDP discussed in the last chapter. If a node does not hear another node with weight higher than its own weight, then it declares itself as a volunteer cluster head and its one-hop uncovered neighbor nodes become its family. For such case of a tie in the node weights the lower ID node is preferred for the role of cluster head. Unlike the re-affiliation issues of DMAC algorithm discussed by the authors of [5], where a node resigns its current head after finding any higher weighted node within its proximity, in the current algorithm a member node remains affiliated with a cluster head, unless either of them go out of the range of each other or the head drains out its energy consumption power . Which will reduces the number of re-affiliations lowering the cluster maintenance overhead. the wireless interfaces of the ad hoc network can be in any of the following operating modes:[15]

• **Transmit:** for transmitting data
• **Receive:** for receiving data
• **Idle:** a default mode when the node is ready to transmit or receive.

A simple linear model can be considered for the energy consumption cost of mobile nodes for sending or receiving packets. The authors of [4] have presented a linear model for the per-packet energy cost that consists of an incremental cost *m* associated with the size of the packet and a fixed cost *c* that is associated with the channel acquisition to represent broadcast communicationas

Energy = msend/receive + sizepacket + c broadcast

In a broadcast traffic, the sender listens briefly to the channel. If the channel is found to be free then the packet is sent and is received by all nodes in wireless range. The destination node processes the packet where as the non destination nodes ignore it. If the channel is found busy, the sender has no choice but to back off and retry later. In the current clustering algorithm, the cluster members send or receive the packets directly to/from their cluster head.

Due to the broadcasting environment, when a cluster member transmits, its neighbor non-destination nodes (called the exposed terminals) over hear the CTS message and data packets. Being the non-destination nodes they consume some amount of energy in discarding these overhear packets. Similarly, the nodes in the range of the destination node (called the hidden terminals) overhear the RTS message and the data packets. These nodes also consume some energy in discarding the overhear packets.

VI. CONCLUSION

This paper comes out with the detailed description of mobile ad-hoc network and to study the CPN approach for the neighbor detection protocol. the weight calculation model is also provided for the easy perception . the energy efficiency the objective is analyses and explain in the paper . The clustering issues regards the mobile ad-hoc network (MANET) is detailed for proper application. As this shows this paper's outcome for various energy consumption and protocol comparison. The detailed step by step node calculating model is also performed by expressing color Petri net model.

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AUTHORS PROFILE

Mrs Minu Rani is perusing her M.tech in Computer Science Engineering from Smonay Institute of Technology and Management . she is presenting her first review paper for clustering and energy efficiency in MANET . Her area of interest is to propose enerfy efficient algorithms .

Ms. Rekha yadav is a student of M.tech Final year under the Department Of Computer engineering from GITM Bilashpur affiliated to MDU Rohtak . her area of interest is biometric energy efficient devices .

Mrs. Suman Sehrawat had done her B.tech in CSE from SPGITM rewari now she is a student of M.tech first year from WCTM Gurgaon in Computer Science Engineering .