



## Energy Efficient Clustering Based Approach for Selecting of Neighbour Head in MANET: A Survey

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**Abstract**— Today, quick communication several of the communication protocol is being used. In Which MANET mobile ad-hoc network is widely attracting all the research. Several protocols are being used for the detection methods and saving the battery life. In this paper we are calculating a complete study Work and comparison of the modern MANET technology and clustering in case of mobile ad-hoc network. The Assumed result for the algorithm is given for the detection of neighbour detection algorithm. The studied result to insuring reduced energy consumption is by using colour Petri net (CPN) tool. To calculate the weight node is also done to ensure research fruitful.

**Keywords** — MANET, NDP, Clustering in MANET, CWP.

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### I. INTRODUCTION

In the latest 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 military application and emergency rescue operations. But slowly it has been included 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 network 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.

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 needed 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.

### II. CLUSTERING IN AD-HOC NETWORK

The research is still going on to meet the above challenges in mobile ad hoc network. Routing in MANET can take place either in a flat structure or in a hierarchical structure [2]. It has been proved that the packet delivery delay is reduced in a hierarchical structure than that of in the flat structure resulting in a better routing efficiency [3]. In large networks, the flat routing structure produces excessive information flow which can saturate the network. Hierarchical routing is an interesting solution for handling such a scalable network where only selected nodes take the responsibility of routing [4]. Thus, topology management plays a vital role prior to the actual routing in MANET. Cluster based structure, which is a typical synonym of the hierarchical structure in network topology, has become popular since last few decades to improve the routing efficiency in a dynamic network. This process deals with the formation of a virtual cellular backbone (VCB), where the cluster heads map to the base stations in cellular architecture [5]. Qualitative information flow among various nodes is the prime goal of any communication network.

In cellular network, the mobile nodes communicate directly with the fixed base station reducing the wireless part of communication to a single hop problem. A number of solutions have been proposed for handling of mobility of the nodes by this base station. Thus, the mapping of cellular architecture into peer-to-peer network leads to the concept of

clustering [6]. In such a virtual cellular architecture (VCA), cluster heads are selected to play the role of base stations of the cellular structure. The cluster head along with its one-hop members form the virtual cells retaining the merits of cellular architecture. Scalability and bandwidth utilisation in an ad hoc network have considerable effect on routing efficiency. Keeping track of neighbours in a dynamic network for efficient routing, further increases the storage cost in a flat structure. The spatial reuse of major resource like bandwidth is also reduced in case of a scalable network. Clustering is a proven solution for such situations. The cluster heads being responsible for storing and forwarding the packets need to keep the information regarding their neighbour heads or gateways within their close proximity. This enables to increase the scalability of the network. The bandwidth utilisation is also increased as limited nodes take part in transmitting the packets. Energy issue is still an unsolved problem for wireless nodes [7]. Specially, in a wireless sensor network limited battery power is a major constraint. The cluster control structure provides solution for efficient energy management [8]. Here, limited nodes are selected as communication centres for forwarding data of other nodes. At that time, the remaining nodes can save their battery power as they don't take part in packet forwarding.

1. Initially all the nodes in the network are put in state none. Then the whole ad hoc network is cauterized 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 List1 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 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 [9].

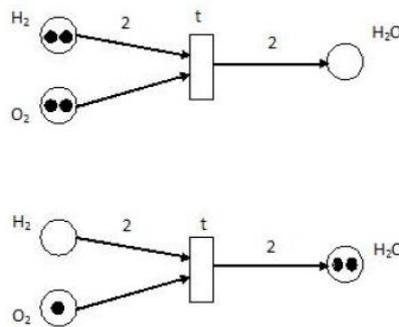


Figure 1: sample Petri net model (10)

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.[11] 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.

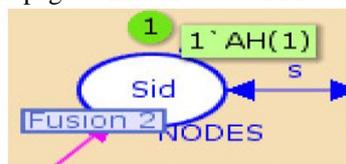


Figure 2: sample place in CPN [12]

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][13]. 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.[14-18]

#### IV. ANALYZED NEIGHBOR DETECTION PROTOCOL

The mobile ad hoc network can be modelled 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  $L_{ij}$  between the nodes  $i$  and  $j$  when the gap in between the nodes  $d_{ij} < \text{trange}$  (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  $v\text{trange}$ . 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  $l_{12}$ .

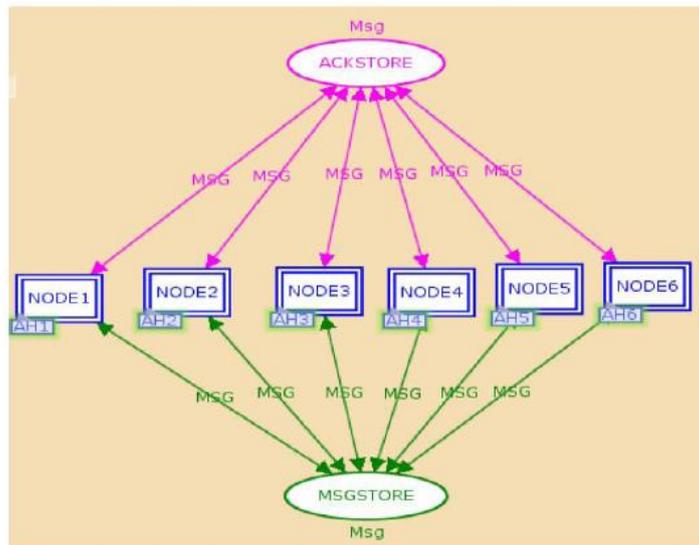


Figure3: top level of the model [19]

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 neighbour 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 neighbours. The format of the packet is as: If a node  $u$  wants to know about its existing neighbours, it should broadcasts a neighbour detection packet (NDPAK). The transmitter specifies it as a neighbour 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 neighbour detection protocol (NDP) is listed step wise as follows [20]

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 Neighbour 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 neighbour table (NTAB) by adding  $v$  as its immediate neighbour along with its information.

Step 4: Finally,  $u$  sends back a Neighbour Confirmation (NC) message so that  $v$  updates its own neighbour 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  $\delta$  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  $\delta$  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
...
While (every  $v \in V$ )
{
If  $W_v > W_i$  where  $i \in \Gamma(v)$ 
Then SH=  $v$ 
While (every  $x \in \Gamma(v)$ )
{
If STATUS( $x$ ) = 0 then
SH( $x$ ) =H
}
}
...
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 neighbours, (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 its ID along with its weight  $WT_i$  to the neighbours and stores the weights  $WT_j$  that it hears from other nodes. It is understood that, every node has a neighbour table NTAB that stores the list of neighbours 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 neighbour 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 [21], 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 reduce 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:[22]

- 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 [23] 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 communications  $\text{Energy} = m \cdot \text{size packet} + c$  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 neighbour 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 neighbour 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 colour Petri net model.

## REFERENCES

- [1] C Siva Ram Murthy and B S Manoj. Ad Hoc Wireless Networks. Pearson Education, 2005.
- [2] C. E. Perkins. Ad Hoc Networking. Addison Wesley, 2000. Prentice Hall PTR, 2002.
- [3] C. C. Chiang, H.K. Wu, W.Liu, and M. Gerla. Routing in clustered multihop, mobile wireless networks with fading channel. In Proceedings of IEEE Singapore International Conference on Networks SICON' 97, pages 197–212, 1997.
- [4] I. Chlamtac, M.Conti, and J.-N. Liu. Ad hoc networking: imperatives and challenges. Ad Hoc Networks, 1:13–64, 2003.
- [5] I. Chlamtac and A. Farago. A new approach to the design and analysis of peer-to-peer mobile networks. Wireless Networks, 5:149–156, 1999.
- [6] S. Basagni, I. Chlamtac, and A. Farago. A generalized clustering algorithm for peer-to-peer networks. In Proceedings of Workshop on Algorithmic aspect of communication (satellite workshop of ICALP), July 1997.
- [7] A Ephremides. Energy concerns in wireless networks. IEEE Wireless Communications, pages 48–59, 2002.
- [8] J. H. Chang and L. Tassiulas. Energy conserving routing in wireless ad hoc networks. In Proceedings of Workshop on Algorithmic aspect of communication (satellite workshop of ICALP), pages 22–31, Tel-Aviv, Israel, March 2000.
- [9] Kurt Jensen. Coloured Petri Nets. Springer Verlag, 1992.
- [10] I. Chlamtac and A. Farago. A new approach to the design and analysis of peer-to-peer mobile networks. Wireless Networks, 5:149–156, 1999.
- [11] C K Toh. Ad Hoc Mobile Wireless Networks: Protocols and Systems. Prentice Hall PTR, 2002.
- [12] C. C. Chiang, H.K. Wu, W.Liu, and M. Gerla. Routing in clustered multihop, mobile wireless networks with fading channel. In Proceedings of IEEE Singapore International Conference on Networks SICON' 97, pages 197–212, 1997.
- [13] I. Chlamtac, M.Conti, and J.-N. Liu. Ad hoc networking: imperatives and challenges. Ad Hoc Networks, 1:13–64, 2003.
- [14] T. Ohta and S. Inoue and Y. Kakuda. An adaptive multi-hop clustering scheme for highly mobile ad hoc networks. In proceedings of sixth international symposium on autonomous decentralized systems (ISADS'03), Pisa, Italy, April 2003
- [15] C. R. Lin and M. Gerla. A distributed control scheme in multi-hop packet radio networks for voice/data traffic support. In Proceedings of IEEE GLOBECOM, pages 1238–1242, 1995.
- [16] S Bandyopadhyay and E J Coyle. An energy efficient hierarchical clustering algorithm for wireless sensor networks. In Proceedings of INFOCOM 03. IEEE, April 2003.
- [17] S. Basagni, I. Chlamtac, and A. Farago. A generalized clustering algorithm for peer-to-peer networks. In Proceedings of Workshop on Algorithmic aspect of communication (satellite workshop of ICALP), July 1997.
- [18] S.Basagni. Distributed and mobility adaptive clustering for multimedia support in multi-hop wireless networks. In Proceedings of vehicular technology conference VTC, volume 2, pages 889–893, 1999.
- [19] A Ephremides. Energy concerns in wireless networks. IEEE Wireless Communications, pages 48–59, 2002.
- [20] L. M. Feeney. An energy consumption model for performance analysis of routing protocols for mobile ad hoc networks. Journal of Mobile Networks and Applications, 6(3):239–249, 2001.
- [21] C Siva Ram Murthy and B S Manoj. Ad Hoc Wireless Networks. Pearson Education, 2005.
- [22] suchismita chnara , “analysis and design of protocol for clustering in mobile ad hoc network” submitted dissertation for doctorate at NIT Rourkela 2011 .
- [23] <http://trends-in-telecoms.blogspot.com/2011/05/4g-wirelessarchitecture-and.html>