ISSN No. 0976-5697

Volume 5, No. 3, March-April 2014

International Journal of Advanced Research in Computer Science

REVIEW ARTICAL

Available Online at www.ijarcs.info

Protocols Governing Clustering in MANETS

Piyush Makani, Saumya Srivastava and Saurabh Gupta
Computer Science and Engineering
Pranveer Singh Institute of Technology Kanpur, India

Abstract: This paper discusses about various protocols which govern communication in an infrastructure-less Mobile Ad-hoc network. Also efficient protocols and algorithms are proposed for the effective communication in MANET. The existing protocols which basically govern the process of clustering are not very apt for communication and have certain drawbacks. Analysis of results has provided a direction to move on by proposing new protocols and algorithms for clustering. This has been an area of interest among the scientist and the researchers for a long time as there is no fixed infrastructure or architecture in MANET for communication purpose as against in a fixed infrastructure based cellular system. Therefore while implementing communication in MANET by simply mapping the concepts of base station (fixed infrastructure cellular system), various issues may crop up like limited battery power, scalability, available band width etc. This study introduces the topic of clustering and the various protocols involved with clustering in order to establish communication in MANET.

Keywords: Manet, Cluster, Coloured Petri Nets(CPN), Critical Transmission Range(CTR)

I. INTRODUCTION

A collection of wireless nodes that self-configure to form a network without the aid of any established infrastructure is called mobile Ad hoc network (MANET).[1] It is also known as a group of mobile nodes that perform inter-communication on a common wireless channel.

The nodes entering or leaving the network have routingcapabilities which allow them to create multi hop pathsconnecting node which are not within radio range. The characteristic feature of MANETs like no fixed network infrastructure, dynamic network configuration, mobility of nodes and frequent node failure, low battery power, etc make them distinct from other wireless networks. Hence routing in MANETs became one of the most challenging tasks [2]. In networking routing is known as the process of selectingpaths in a network to send network traffic. Routing in ad hoc networks and in normal wired networks differ a lot. A heavy computational burden on mobile computers makes theuse of conventional routing protocols inconvenient in adynamic network.

There are some challenges that make the design of mobile adhoc network routing protocols a tough task. Firstly, in mobile adhoc networks, node mobility causes frequent topology changes and network partitions. Secondly, because of the variable and unpredictable capacity of wireless links, packet losses may happen frequently. Moreover, the broadcast nature of wireless medium introduces the hidden terminal and exposed terminal problems. Additionally, mobile nodes have restricted power, computing and bandwidth resources and require effective routing schemes [2].

The cluster head within each cluster that acts as the local coordinator for its member nodes also guarantees for faster communication [3]. Therefore, the need to design a novel routing protocol which seamlessly adapt to changing network topology was inevitable [5].There are three categories into which the routing protocol can be divided:

a. Proactive (table driven routing protocols)
b. Reactive (on-demand routing protocols)
c. Hybrid.

A. *Clustering In Manet*:

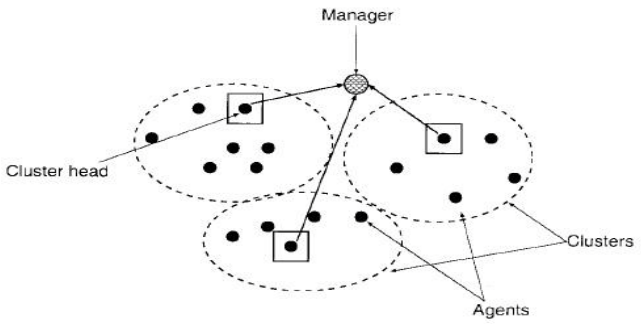

Figure 1

In a typical clustering scheme, the mobile nodes in a MANET are divided into clusters, as shown in Figure 1. Under the cluster structure, each node can be in one of the four states (or functions): the cluster head, managers and agents. A cluster head normally serves as a local coordinator for its cluster. It arranges intra-cluster transmissions and forwards data. A gateway is responsible for inter-cluster communications and forwards data between adjacent clusters. An agent is an ordinary node that communicates only with the other hosts in the same cluster. In a cluster of diameter more than two hops, a relay forwards data between an agent and the cluster head.

As compared with the flat structure, clustering improves both the scalability and energy efficiency of a network due to the following benefits. First, the geographically separated regions in different clusters facilitate spatial reuse of resource, such as bandwidth and codes, and increase system capacity. Second, the hierarchy localizes the node dynamics and gives a more stable view of the network topology. When a mobile host changes its attaching cluster, only nodes residing in the corresponding clusters need to update the routing information. Furthermore, cluster heads and

gateways can normally form a virtual backbone that gives smaller network connectivity with better coordination.

As there is no fixed infrastructure in MANET, this might not be as easy as it sounds. The protocols must be correctly designed and implemented in order to form logical clusters. In each cluster there is a cluster head which is equivalent to a base station in a fixed infrastructure cellular system. Also the cluster head is responsible or routing the packets in the mobile ad hoc network. Thus since the cluster head is an important part of communication in MANET, it became necessary to review the strengths and weakness of the existing protocols and design an energy efficient protocol for clustering.

B. Phases Of Clustering:

The process of clustering can be visualised as a combination of two phases,

a. Cluster formation
b. Cluster maintenance.

The **cluster formation** phase deals with the logical partition of the mobile nodes into several groups and selection of a set of suitable nodes to act as heads in every group.

The objective of **cluster maintenance** is to preserve the existing clustering structure as much as possible. In one hop clustering, since every node is directly connected to a cluster head, the mobility of either the member node or the cluster head may drive them away from each other.

The requirement for the re-election of cluster heads arises when the current heads fail to cover all the nodes in the network. Sometimes a node may move away from the transmission range of all the current cluster heads and becomes an orphan node. This demands a re-election of cluster heads. Even at times any of the cluster heads may drain out of energy or may even fail to work due to any fault occurrence and needs a head re-election process. However, such an unavoidable re-election increases the computation cost and the message complexity.

II. ALGORITHMS USED FOR CLUSTERING IN MANET

A. Neighbour Detection Protocol:

It is the protocol in which each node probes its neighboring nodes in order to transmit the message. In this protocol, every node broadcasts its own information to the network, so that it is received by a node that lies within its transmission range. The receiver senses its neighbors and updates its neighbor table from time to time. Neighbour Detection protocol has been proposed to enable the nodes to find their one hop neighbours in the network. The protocol is modelled by using the well-known Coloured Petri Net (CPN) tools and validated through simulation.

a. Coloured Petri Net:

Coloured Petri Nets is a modelling tool that combines the strength of Petri-Nets with the strengths of formal modelling language. Petri Nets are also called as the Place-Transition Nets where a set of places and transitions provide the primitives for describing synchronization of concurrent processes. The formal modelling language (ML) provides the primitives for definition of data types and manipulation of their data values.[4]

Coloured Petri Nets have tools, known as the CPN tools that provide a graphical environment to model and simulate any proposed system to analyse it with respect to its required flow of operation. CPN is a formal method which is suitable for modelling analyzing complex systems where hierarchy can be created, timing information can be included and complex information can be handled by using simple tokens.

b. Petri-Nets:

Petri nets are promising graphical and mathematical modelling tools for describing and studying information processing system.

B. Topology Adaptive Clustering Algorithm:

In this protocol a node having the highest weight among its immediate neighbors voluntarily declares itself as a cluster head. After the current cluster head has consumed its battery power beyond a certain threshold, the other non-volunteer nodes are selected as cluster heads locally. The algorithm aims to utilize the battery power in a fairly distributed manner so that the total network life time is enhanced with reduced cluster maintenance overhead.

Design of topology control protocols deal with the algorithms, where the mobile radios are allowed to adjust their transmission ranges so as to retain the desired topological property of the network. That is the connectedness of the nodes are maintained with optimum energy consumption. Usually the transmission range of the nodes are much smaller than the span of such networks. For the purpose of packet forwarding, a multi hop network is created where every node performs the role of router for other nodes. But due to the node mobility, the wireless link between the nodes are frequently disrupted. The objective of topology control is to allow the wireless transceivers to increase or decrease their transmission ranges to an optimal value so that the network remains connected. Such minimum value of the transceiver's transmission range that enable to maintain network connectivity is called the ***critical transmission range*** (CTR).

A topology control protocolshould have the following features:

a. Fully distributed and asynchronous
b. Principle of locality
c. Setting up of bidirectional link as well as preserving the network connectivity
d. Trust on low-quality information
e. Lesser degree of connectivity

III. EVALUATION OF NDP AND TACA

In particular, the algorithms under consideration are single hop representatives of the energy constrained ad hoc network. The emphasis is given mostly on the cluster formation principles and the cluster maintenance parameters of the algorithms.[5] Simulation results are discussed to describe the effect of transmission range and the size of the network on the parameters like cluster density, frequency of re-election, frequency of cluster changes in the dynamic network.

The principle of partitioning the nodes varies in different algorithms by emphasizing various node parameters such as mobility, connectivity, identification, remaining battery power and sometimes the combination of multiple parameters. However, it could be seen that energy

constraint which is a major challenge in this kind of network has not been emphasized properly in any of the algorithm. This provides a motivation for designing an energy efficient clustering algorithm that could reduce the maintenance overhead as well as could increase the cluster stability.

IV. PROPOSED CLUSTERING ALGORITHM

A. Transmission Range Adjustment Protocol(Trap):

It allows the isolated nodes to adjust their ranges to remain connected with existing cluster heads. The results show that, TRAP reduces the delay in communication by reducing the number of cluster heads in the network.

The Transmission Range Adjustment Protocol (TRAP) has been proposed which provides the mechanism to increase or decrease the transmission range of the mobile nodes enabling them to remain connected with others as and when required. The proposed distributed clustering algorithm TACA selects non-volunteer cluster heads that leads to the creation of isolated cluster heads and/or orphan nodes during the hand off process. The excessive number of cluster heads increases the number of nodes in the virtual back bone of the communication network. Thus the objective of the proposed algorithm is to reduce the number of nodes in the virtual back bone. This is made possible by allowing the isolated cluster heads formed during the execution of TACA to adjust their transmission ranges. It helps them to get affiliated to other nearby cluster heads instead of becoming isolated heads without having any cluster members.[6] The TRAP enables such nodes to adjust their transmission ranges so that they become the cluster members of other heads reducing the number of nodes in the virtual back bone.

The proposed topology adaptive clustering algorithm TACA is designed with the following features:

a. The nodes in the ad hoc network are capable to increase or decrease their transmission range. The maximum permissible transmission range a node can posses is denoted as *RangeMAX*.
b. Out of several parameters of the nodes in the MANET, the node mobility is considered to be a major challenge. The higher the rate of node movement, the greater is the frequency of topology changes. The battery power of the light weight nodes are another major constraint. The development of techniques for energy resourcesare much slower than the network devices counterpart. Both of these parameters decide the stability of the cluster as well as the network.[12] Hence, in the proposed algorithm these two factors are chosen as the weight deciding factors for the nodes.
c. A cluster head selection procedure takes place when the network is first activated. The set of selected cluster heads are called the volunteer cluster heads.
d. A volunteer cluster head serves its one-hop members till it exhausts its battery power beyond a threshold value.
e. As a node drains its battery power completely, it becomes dead and is removed from the network. As a result, the topology of the network is disturbed. Hence, in order to use the node battery power efficiently, the nodes get almost fair chances of serving as cluster heads, so that load on individual nodes could be avoided.

B. Calculation Of The Node Weight:

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. [8]

C. Selection Of Volunteer Cluster Heads:

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 : [11]

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

D. Proposed Energy Consumption Model For Ad-Hoc Networks:

Ad-hoc mode of operation does not use any base station. So a node communicates directly with one-hop reachable nodes and indirectly with unreachable nodes using dynamically computed routes. This demands the nodes to remain awake all the time to receive traffic from their neighbors and does not allow them to enter into sleep state. [7]However, a node can enter into idle mode when it neither transmits nor receives any traffic. But it constantly listens to the wireless media and consumes energy which is almost same as the energy consumption in receiving traffic. Thus, energy consumption of the mobile devices depends on the operating mode of its wireless network interfaces

Table:1 Comparison of NDP TACA and proposed TRAP protocol

Protocols	Initiation of protocol	Working of protocol	Observation/result
NEIGHBOUR DETECTION PROTOCOL(NDP)	Each node probes the other node present in the neighbour.	A node lying within the transmission range of the sender node receives the message.	Energy constraint is a major problem in this type of protocol
TOPOLOGY ADAPTIVE CLUSTERING ALGORITHM(TACA)	A cluster head is selected with the node having the maximum weight.	When the cluster head utilizes the energy beyond a certain threshold value then a new cluster head is selected.	The increase in the number of cluster heads increase the length of the communication backbone in terms of number of hops. This may increase the end-to-end delay in communication for the packets.
Proposed Efficient Protocol			
TRANSMISSION RANGE ADJUSTMENT PROTOCOL(TRAP)	The objective of the proposed algorithm is to reduce the number of nodes in the virtual back bone. This is made possible by allowing the isolated cluster heads formed during the execution of TACA to adjust their transmission ranges. It helps them to get affiliated to other nearby cluster heads instead of becoming isolated heads without having any cluster members.	The TRAP enables isolated nodes to adjust their transmission ranges so that they become the cluster members of other heads reducing the number of nodes in the virtual back bone.	TRAP reduces the delay in communication by reducing the number of cluster heads in the network

V. CONCLUSION AND FUTURE SCOPE

In cellular networks, base stations are connected with wired backbone, which support the mobility of client nodes for hand-off protocols, paging and user tracking in the network. In such networks, the mobile nodes directly communicate with the fixed base station, reducing the wireless part of communication to the single hop problem. This concept of cellular networks can be mapped into the infrastructure-less peer-to-peer network, so that selected number of nodes perform the job of base stations and form the virtual backbone of communication. This process of selecting few nodes as the virtual base stations, where their one hop neighbours directly communicate with them, can be visualised as the formation of logical clusters in the network. Thus, every cluster consists of a cluster head representing the virtual base station and its one hop members within it.

There are several auxiliary research directions, which can be further investigated. The proposed protocols that mostly deal with the cluster formation, cluster maintenance and energy consumption, can be extended to some other areas of clustering like load balancing among the cluster head, fault tolerant clustering or privacy and security in clustered MANET.

VI. REFERENCES

[1]. A dissertation on Analysis and Design of Protocols for Clustering in Mobile Ad Hoc Networks by Suchismita Chinara in 2011 at National Institute of Technology Rourkela http://ethesis.nitrkl.ac.in/2983/1/Thesis_50606001.pdf

[2]. Survey of Cluster Based Routing Protocols in Mobile Ad hoc Networks by Abdur Razzaq 4(3):75–82, 2006.

[3]. Analysis and Design of Protocols for Clustering in Mobile Ad Hoc Networks by Suchismita Chinara submitted to Computer Science and Engineering of National Institute of Technology Rourkela, July 27, 2011

[4]. D.J.Baker, J.E.Wieselthier and A. Ephremides, "A design concept for reliable mobile radio networks with frequency hoping signaling", proceedings of IEEE, vol. 75, no.1, Jan. 1987.

[5]. Kurt Jensen. Coloured Petri Nets. Springer Verlag,: 483–502, 2002.

[6]. Performance Analysis of Clustering Protocols in Mobile Ad hoc Networks Sharmila John Francis and Elijah Blessing Rajsingh School of Computer Science and Technology, Karunya University, Coimbatore, Tamil Nadu, India

[7]. An Asymmetric Quorum-based Power Saving Protocol for Clustered Ad Hoc Networks Shan-Hung Wu, Chung-Min ,Chen-Syan Chen, Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan, ROC Telcordia Applied Research Center, Taipei, Taiwan, ROC Industrial Technology Research Institute, Hsin Chu, Taiwan, ROC {brandonwu@research.telcordia.com, chungmin@research.telcordia.com, mschen@cc.ee.ntu.edu.tw}

[8]. C. Chao, J. Sheu, and I. Chou. An adaptive quorum based energy conserving protocol for IEEE 802.11 ad hoc networks. IEEE Transactions on Mobile Computing.

[9]. T. Murata. Petri nets: Properties, analysis and applications. In Proceedings of IEEE, 39:176–181, 2001

[10]. Andy An-Kai Jeng and Rong-Hong Jan. Adaptive topology control for mobile ad hoc networks. IEEE Transactions on Parallel and Distributed Systems

[11]. C Constantopoulos, D Gavalas, and G Pantziou. Clustering in mobile ad hoc networks through neighborhood stability.

[12]. Y J You and J H P Chong. A survey of clustering schemes for mobile ad hoc networks IEEE Commun. Surv Tutor

[13]. D. Turgut S. Das, M. Chatterjee. Wca: A weighted clustering algorithm for mobile ad hoc networks. Journal of Cluster computing (special issue on mobile ad hoc networks)