

Clustering Ad hoc Network Scheme and Classifications Based on Context-aware

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Abstract— In ad hoc network, the scarce energy management of the mobile devices has become a critical issue in order to extend the network lifetime. Current research activity for the Minimum Energy Multicast (MEM) problem has been focused on devising efficient centralized greedy algorithms for static ad hoc networks. In this paper, we consider mobile ad hoc networks(MANETs) that could provide the reliable monitoring and control of a variety of environments for remote place. Mobility of MANET would require the topology change frequently compared with a static network. To improve the routing protocol in MANET, energy efficient routing protocol would be required as well as considering the mobility would be needed. In this paper, we propose a new method, the CACH(Context-aware Clustering Hierarchy) algorithm, a hybrid and clustering-based protocol that could analyze the link cost from a source node to a destination node. The proposed analysis could help in defining the optimum depth of hierarchy architecture CACH utilize. The proposed CACH could use localized condition to enable adaptation and robustness for dynamic network topology protocol and this provide that our hierarchy to be resilient. As a result, our simulation results would show that CACH could find energy efficient depth of hierarchy of a cluster.

Index Terms—Clustering, MANET, Context-Aware.

I. INTRODUCTION

Mobile ad hoc networks(MANETs) are comprised of mobile nodes that perform multiple hop datagram

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forwarding over wireless links. MANETs intended to monitor and record conditions at diverse locations. Commonly monitored parameters are temperature, humidity, pressure, wind direction and speed, illumination intensity, vibration intensity, sound intensity, power-line voltage, chemical[1]. The mobility of network nodes results in a rapidly changing network topology. The dynamic nature of the network environment makes the task of routing in MANETs far more difficult than in static networks. Further, The limited resources in MANETs have made designing of an efficient and reliable routing strategy a very challenging problem.

To overcome these problems a number of routing protocols have been proposed for MANETs. These protocols can be classified into three different groups: global/proactive, on demand/reactive and hybrid. In proactive routing protocols, the routes to all the destination (or parts of the network) are determined at the start up, and maintained by using a periodic route update process. In reactive protocols, routes are determined when they are required by the source using a route discovery process. Hybrid routing protocols combine the basic properties of the first two classes of protocols into one. That is, they are both reactive and proactive in nature. Each group has a number of different routing strategies, which employ a flat or a hierarchical routing structure.

II. RELATED WORK

Recently, there has been much work on “energy conserving” routing protocols for MANETs. Hybrid routing protocols are a new generation of protocol, which are both proactive and reactive in nature. These protocols are designed to increase scalability by allowing nodes with close proximity to work together to form some sort of a backbone to reduce the route discovery overheads. This is mostly achieved by proactively maintaining routes to near by nodes and determining routes to far away nodes using a route discovery strategy.

In ZRP [14], the nodes have a routing zone,

which defines a range (in hops) that each node is required to maintain network connectivity proactively. Therefore, for nodes within the routing zone, routes are immediately available. For nodes that lie outside the routing zone, routes are determined on-demand (i.e. reactively), and it can use any on-demand routing protocol to determine a route to the required destination. The advantage of this protocol is that it has significantly reduced the amount of communication overhead when compared to pure proactive protocols. It also has reduced the delays associated with pure reactive protocols such as DSR, by allowing routes to be discovered faster. This is because, to determine a route to a node outside the routing zone, the routing only has to travel to a node which lies on the boundaries (edge of the routing zone) of the required destination. Since the boundary node would proactively maintain routes to the destination (i.e. the boundary nodes can complete the route from the source to the destination by sending a reply back to the source with the required routing address). The disadvantage of ZRP is that for large values of routing zone the protocol can behave like a pure proactive protocol, while for small values it behaves like a reactive protocol.

Unlike ZRP, ZHLS [18] routing protocol employs hierarchical structure. In ZHLS, the network is divided into non-overlapping zones, and each node has a node ID and a zone ID, which is calculated using a GPS. The hierarchical topology is made up of two levels: node level topology and his paper addresses the problem of clustering in mobile ad-hoc network that nodes are densely distributed within a transmission range. zone level topology, as described previously. In ZHLS location management has been simplified. This is because no cluster-head or location manager is used to coordinate the data transmission. This means there is no processing overhead associated with cluster-head or Location Manager selection when compared to HSR, MMWN and CGSR protocols. This also means that a single point of failure and traffic bottlenecks can be avoided. Another advantage of ZHLS is that it has reduced the communication overheads when compared to pure reactive protocols such as DSR and AODV. In ZHLS, when a route to a remote destination is required (i.e. the destination is in another zone), the source node broadcast a zone level location request to all other zones, which generates significantly lower overhead when compared to the flooding approach in reactive protocols. Another advantage of ZHLS is that the routing path is adaptable to the changing topology since only the node ID and the zone ID of the destination is required for routing. This means that

no further location search is required as long as the destination does not migrate to another zone. However, in reactive protocols any intermediate link breakage would invalidate the route and may initiate another route discovery procedure. The Disadvantage of ZHLS is that all nodes must have a preprogrammed static zone map in order to function. This may not be feasible in applications where the geographical boundary of the network is dynamic. Nevertheless, it is highly adaptable to dynamic topologies and it generates far less overhead than pure reactive protocols, which means that it may scale well to large networks.

III. CACH ARCHITECTURE

This paper aims to address the energy efficient level of cluster in the cluster hierarchy-based MANETs. Numerous hybrid routing protocols have been proposed and developed for MANETs. Most of them are hierarchical clustering architecture but have no significant consideration about the level of cluster. In this paper, we analyze context-aware clustering hierarchy(CACH) in massively dense network

A. Network Model

FTEP consider a two level clustering scheme to illustrate the protocol that all sensor nodes are homogeneous, which can work in dual mode i.e. high power transmission mode and low power transmission mode. Proposed protocol uses resilient hierarchical depth depends on node's density of a cluster, therefore a two level clustering scheme in the FTEP is not available for CACH. Furthermore, each node not use 2 mode, but different power mode depends on transmission distance. Fig1. Shows the network model used. In this paper, we assume that energy efficient hierarchy level is two and consider 0-level clustering hierarchy.

B. Cluster Head Selection

CACH forms clusters by using a distributed algorithm, where nodes make autonomous decisions without any centralized control. A 0-Level Cluster Head(CH) selected arbitrarily. Let the R is the communication range, $R/2$ is the 0-Level CH's communication range. This could guarantee that other 2-Level CH could reach by 1 hop. A 0-Level CH broadcast JREQ(Join Request) to the neighbors with the communication range $R/2$. When a JREQ packet reaches the neighbor, each neighbor node elects itself to be a 1-Level cluster head arbitrarily and reply

JREP(Join Reply) packet. Further, 0-Level CH attempts to select 6 JREPs by the order of arrival to decide as a 1-Level CH. 1-Level CH has communication range of $R/6$ and rest vary same procedure is follows for initial cluster set at 1-Level CH.

For simplicity, we define only two level cluster hierarchy here but this process can be recursively applied to build a multi-level cluster hierarchy.

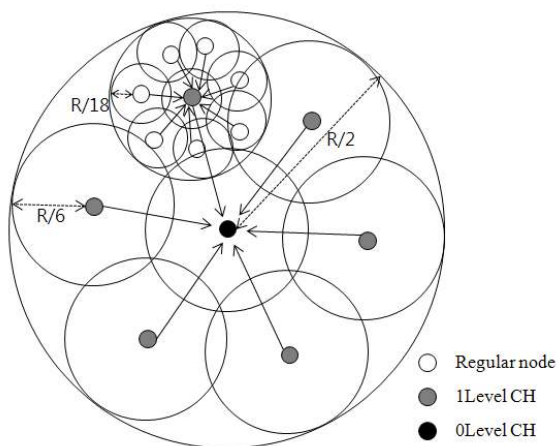


Fig. 1 Network Model.

C. Energy Model of Sensor

A typical sensor node consists mainly of a sensing circuit for signal conditioning and conversion, digital signal processor, and radio links [14]. The following summarizes the energy consumption model for each sensor component.

The key energy parameters for communication in this model are the energy/bit consumed by the transmitter (α_{trans}), energy dissipated in the transmit op-amp (α_{amp}), and energy/bit consumed by the receiver electronics (α_{recv}). Assuming a $1/d^4$ path loss attenuation function, the energy consumed is:

$$E_{tx} = (\alpha_{trans} + \alpha_{amp} \times (d)^4) \times r \tag{1}$$

$$E_{rx} = \alpha_{recv} \times r \tag{2}$$

Where, E_{tx} is the energy to send r bits and E_{rx} is the energy consumed to receive r bits. Table I summarizes the meaning of each term and its typical value.

Table 1 Symbol for assuming the energy consumption

Notation	Meaning
α_{trans}	Energy dissipated in transmitter electronics per bit (Taken to be 50 nJ/bit)
α_{recv}	Energy dissipated in receiver electronics per bit (Taken to be 50 nJ/bit).
α_{amp}	Energy dissipated in transmitter amplifier (Taken = 100 pJ/bit/m ²).
d	Distance that the message traverses.
r	Number of bits in the message
R_{jCH}	Communication range of j-Level CH'
L_C	Top level of a Cluster
B_{jCH}	Energy level of j-Level CH
P_{ij}	Probability that regular node(i) of j-Level cluster distributed in the R_{jCH}
R_{ijCH}	Distance-to-Default from node i to j-Level Cluster Head

$$R_{jCH} = R/3 \times (L_C - j), L_C > j \tag{3}$$

$$R_{ijCH} = R_{jCH} \times P_{ij} \tag{4}$$

The value for R_{jCH} guarantees that cluster heads elected as same level can communicate within 1 hop. The value for L_C is top level in the cluster. The value for E_{iCH} adjust the transmission power to control the transmission distance. The value for P_{ij} is the probability that regular node i distribute in the j -Level cluster. The Value for R_{ijCH} get calculated each cluster head election process.

IV. CACH ANALYSIS AND SIMULATION

As the level of cluster is increase, each transmission power consumption is lower, but the number of times is higher when use proposed network model. To structure energy efficient cluster depending on the number of nodes, we have simulated E_{total} where the network area is kept fixed and the level of cluster go to infinity and k -correction constant is 1.

$$E_{tx} = [\sum_{i=0}^{N-1} \sum_{j=1}^{L_C} (\alpha_{trans} + \alpha_{amp} \times (R_{ijCH})^4) \times r] \times k \tag{5}$$

$$E_{rx} = \sum_{i=0}^{N-1} \sum_{j=1}^{L_C} (\alpha_{recv} \times r) \quad (6)$$

$$E_{total} = E_{tx} + E_{rx} \quad (7)$$

In this approach, assuming N is the number of nodes in a cluster, we can get minimum E_{total} and the level of cluster as well.

Fig. 2 is the Energy dissipation upon level of cluster where the number of nodes is 50, 100 and 200 simulated with MATLAB. As a result, regardless of level of cluster or nodes, 1-Level cluster shows most efficient.

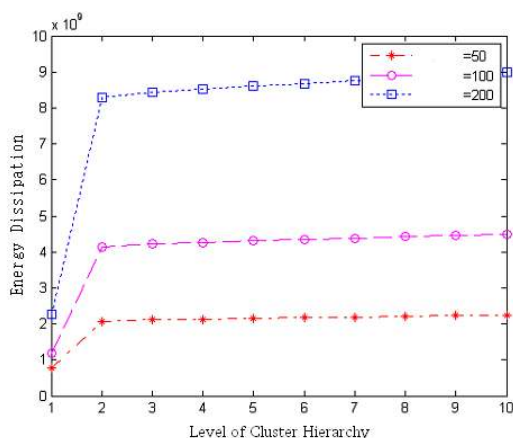


Fig. 2 Energy Dissipation upon level of cluster where the number of nodes is 50, 100 and 200.

V. Conclusion

In this paper, assuming the link cost in the hierarchical cluster, we find energy efficient level of cluster. The basic idea of this protocol is the election of a top-level cluster head and lower-level cluster head recursively. Results from our experiments show that CACH provides the energy efficient level of cluster.

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REFERENCES

- [1] Zhihao Guo, Behnam Malakooti, "Energy Aware Proactive MANET Routing with Prediction on Energy Consumption" IEEE CS. , Aug. 2007, pp. 287–293 [WASA. Conf. , 2007].
- [2] Sirisha Medidi, Jiong Wang, "A Fault Resilient Routing Protocol for Mobile Ad-hoc Networks", IEEE Transl. J. Magn.Jpn., vol. 2, Aug. 1987, pp. 740–741 [Dig. 3th. Conf. Magnetics Japan, 1982, p. 301].
- [3] Z.J. Hass, R. Pearlman, "Zone routing protocol for ad-hoc networks", Internet Draft, draft-ietf-manet-zrp-02.txt, work in progress, 1999.
- [4] M. Joa-Ng, I.-T. Lu, "A peer-to-peer zone-based two-level link state routing for mobile ad hoc networks", IEEE Journal on Selected Areas in Communications 17(8) 1415-.1425, (1999)
- [5] D. Johnson, D. Maltz, J. Jetcheva, "The dynamic source routing protocol for mobile ad hoc networks", Internet Draft, draft-ietf-manet-dsr-07.txt, work in progress, 2002.
- [6] S. Das, C. Perkins, E. Royer, "Ad hoc on demand distance vector (AODV) routing", Internet Draft, draft-ietf-manetaodv-11.txt, work in progress, 2002.
- [7] S.-C. Woo, S. Singh, "Scalable routing protocol for ad hoc networks", Wireless Networks 7(5) 513 -.529, (2001)
- [8] S. Radhakrishnan, N.S.V Rao, G. Racherla, C.N. Sekharan, S.G. Batsell, "DST - . . A routing protocol for ad hoc networks using distributed spanning trees", in: IEEE Wireless Communications and Networking Conference, New Orleans, 1999.
- [9] N. Nikaein, H. Laboid, C. Bonnet, "Distributed dynamic routing algorithm (ddr) for mobile ad hoc networks", in: Proceedings of the MobiHOC 2000: First Annual Workshop on Mobile Ad Hoc Networking and Computing, 2000.
- [10] W. Heinzelman; A. Chandrakasan ; H. Balakrishnan "Energy-Efficient Communication Protocol for Wireless Microsensor Networks" in Proc. of the 33rd Annual Hawaii International Conference on System Sciences, January 4-7, Page(s) : 3005-3014, 2000.
- [11] Nidhi Bansa*, T. P. Sharma, Manoj Misra and R. C. Joshi , "FTEP: A Fault Tolerant Election Protocol for Multi-level Clustering in Homogeneous Wireless Sensor Networks", ICON 2008
- [12] M. Bhardwaj, T. Garnett, A. P. Chandrakasan, "Upper Bounds on the Lifetime of Sensor Networks", In Proceedings of ICC 2001, vol. 3 pp. 785-790, June 2001.

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