Survey of Energy Efficient Routing Protocols for MANET

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ABSTRACT

MANETs are deployed in situations where there is no existing infrastructure, such as emergency search and rescue, military, etc. It is pertinent to mention here that emergency search and rescue operations rely heavily on the availability of the network and the availability of network is directly proportional to energy/batter-life of nodes. This limited battery capacity or restricted battery life in MANETs makes it necessary to consider the energy-awareness feature in their design. Since routing protocols have main role in MANETs, therefore, the energy-awareness about them can increase network life time by making efficient use of available limited energy. Given the choice between two routes to a destination, a requesting node is required to select one with better power status. Battery power of a node is a precious resource that must be used efficiently in order to avoid early termination of network. Higher energy efficiency implies that a greater number of packets can be transmitted by the node with a given amount of energy reserve. Adhoc wireless networks have very limited energy resources. The increasing gap between the power consumption requirements and power availability adds to the importance of energy management. In view of the above, survey of energy efficient routing protocols have been carried out in order to propose a better energy efficient routing protocol for MANET.

KEYWORDS: Adhoc, Efficient, Energy, MANET, Routing, Stable, Wireless

1. INTRODUCTION

An adhoc network [1, 2] consists of hosts communicating among themselves

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with portable radios. This network can be deployed without any wired base station or infrastructure support where routes are mainly multi-hop because of the limited radio propagation range. Topology of the network changes frequently and unpredictably since its host moves randomly. Therefore, routing is an integral part of adhoc communication, and has received interests from many researchers. In traditional "on-demand" routing schemes like Adhoc On Demand Distance Vector Routing (AODV) scheme, when route disconnects, nodes of the broken route simply drop data packets because no alternate path to the destination is available until a new route is established. When the network traffic requires real time delivery (voice, for instance), dropping data packets at the intermediate nodes can be costly. the energy efficient adhoc routing protocol enables dynamic, self starting, multi hoprouting between participating mobile nodes wishing to establish and maintain an adhoc network. It allows mobile nodes to maintain routes to destinations with more stable route selection. One distinguishing feature of energy efficient adhoc routing protocol is its use of battery power for each route entry. Given the choice between two routes to a destination, a requesting node is required to select one with better power status and more active.

2. BATTERY POWER MANAGEMENT IN MANET

The nodes in an adhoc network are constrained by battery power for their operation. To route a packet from a source to a destination involves a sufficient number of intermediate nodes. Battery power of a node is a precious resource that must be used efficiently in order to avoid early termination of a node or a network. Efficient battery management, transmission power management and system power management [3, 4, 5] are the major means of increasing the life of a node. These management schemes deal in the management of energy resources by controlling the early depletion of the battery, adjust the transmission power to decide the proper power level of a node and incorporate low power consumption strategies into the protocols. Typical metrics used to evaluate adhoc routing protocols are shortest hop, shortest delay and locality stability. However, these metrics may have a negative effect in MANETs because they result in the over use of energy resources of a small set of nodes, decreasing nodes and network lifetime. The energy efficiency of a node is defined by the number of packets delivered by a node in a certain amount of energy. A few reasons for energy management in MANETs are:

- Adhoc networks have been developed to provide communication for an

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environment where fixed infrastructure cannot be deployed. Nodes in adhoc networks have very limited energy resources as they are battery powered.

- In so many situations like hostile territory, it is very difficult or almost impossible to replace the battery or recharge it.

- There is no central coordinator in case of adhoc networks as a base station in cellular networks. Therefore adhoc networks work on the concept of multi-hop routing in which intermediate nodes play the role of the relay nodes. If the relay traffic is very high, it leads to rapid depletion of a node and if the traffic is negligible upon a node that leads to the partitioning of a network. If the battery size is very small, it decreases the lifetime of a node and if battery size of a node is large, it increases the weight of the mobile node. So to keep the standard small size of a battery, energy management techniques are required to utilize it efficiently. Optimal value selection for transmitting a packet is difficult but as this transmission power increases, it increases the consumption of the battery but the connectivity increases. This increases the number of paths to the destination. Therefore selection ofthe transmission power should be done in order to reduce the consumption of the battery power so as to maximize the simultaneous packet transmission and preserve connectivity. Energy control algorithms are very useful for the systems in which the available bandwidth is shared among all the users. Reduction in transmission power increases frequency reuse, which leads to better channel reuse. Although developing battery efficient systems that have low cost and complexity, remains a crucial issue. Efficient battery aware protocol is the need of today's adhoc networks. Designing smart battery packs that can select appropriate battery discharge policies under different load conditions is a challenging problem. Other issues that exist at the physical layer includes efficient battery scheduling techniques selection of an optimal transmission power for the nodes and finding the appropriate time duration for switching off the nodes . Investigations at data link layer are; addressing the issues of relay traffic, such as finding an optimal strategy that decides the amount of allowable relay traffic for a node. Developing battery aware MAC algorithms for the nodes that increase the lifetime of the nodes is an important issue. Finally, at the network layer designing of an efficient routing algorithm that increases the network lifetime by selecting an optimal relay node.

The network layer can aid in the conservation of energy by reducing the power consumed for two main operations, namely, communication and computation. The communication power consumption is mainly due to

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transmission and reception of bits. Whenever a node remains active, it consumes power. Even when the node is not actively participating in communication, but is in the listening mode waiting for the packets, the battery keeps discharging. The computation power consumption refers to the power spent in calculations that take place in the nodes for routing and other decisions. The following section discusses some of the power-efficient routing algorithms. In general, a routing protocol which does not require large tables to be downloaded or greater number of calculations is preferable, the amount of data compression before transmission decreases the power consumed for communication although the number of computation tasks increases. Since the energy required per bit for communication is hundred times compared to computation, data compressed is preferred. MANETs allow anywhere, any time network connectivity with complete lack of control, ownership and regulatory influence. Each node in a MANET participates in the routing function. To establish communication among different nodes, the "death" of few nodes is possible due to energy exhaustion.

In traditional routing algorithms, routes are constructed on the basis of shortest path but these protocols are not aware of the energy consumed for the path setup or maintenance. Shortest path algorithm may result in a quick depletion of the energy of nodes along the heavily used routes. Designing energy aware and stable routing protocols has attracted a lot of attention for prolonged network operational time. Design objective of energy aware protocols is to select energy efficientroutes and simultaneously minimizing the overhead incurred in the selection of the routes. Some routing algorithms given by can optimize the energy use with a global perspective. But these algorithms incur expensive overheads for gathering, exchanging and storing the state information. These algorithms can be improvised in order to make them scalable. For this purpose a localized topology controlling algorithm or a distributed energy aware dominating set generating algorithm can be applied on nodes and a traditional base algorithm like AODV or DSR may be run in the network. This kind of protocol design can reduce the communication overheads consumed for route discovery. Implementation of this kind of approach requires the knowledge of one or two hop neighbours at the nodes. This requirement can consume bandwidth and use energy for gathering such information at nodes constantly in dynamic networks. Some algorithms work without assuming any topological knowledge at nodes and they can avoid the proactive overheads required for topological information. These kind of on demand approaches are required for energy efficient paths.

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Due to the reactive nature of on demand protocols, these are more energy efficient in MANETs and therefore in this chapter, only on demand protocols have been analyzed on the anvil of their energy, so that selection of a better base protocol may lead to find energy efficient paths.

3. ENERGY EFFICIENT ROUTING PROTOCOLS/TECHNIQUES

A lot of work has been carried in the direction of energy aware routing. Modifications pertaining to energy efficient routing have been done either in AODV or DSR, which are taken as the base protocols.

Chansu Yu et. al. [6] classifies the energy efficient routing protocols for MANET which minimize either the active communication energy required to transmit or receive packets or the inactive energy consumed when a mobile node stays idle but listens to the wireless medium for any possible communication requests from other nodes. Transmission power control approach and load distribution approach belong to the former category and sleep/power-down mode approach belongs to the latter category. While it is not clear whether any particular algorithm or a class of algorithms is the best for all scenarios, each protocol has definite advantages/disadvantages and is well suited for certain situations. Chansu Yu et. al. surveyed and classified a number of energy-aware routing schemes. In many cases, it is difficult to compare them directly since each method has a different goal with different assumptions and employs different means to achieve the goal. For example, when the transmission power is controllable, the optimal adjustment of the power level is essential not only for energy conservation but also for the interference control. Flow Augmentation Routing (FAR), Online Max Min Routing (OMM), Power aware Localized Routing (PLR) and Minimum Energy Routing (MER) protocols fall into the category of transmission power optimization. When nodedensity or traffic density is far from uniform, a load distribution approach must be employed to alleviate the energy imbalance problem. The specific goal of the load distribution approach is to balance the energy usage of all mobile nodes by selecting a route with underutilized nodes rather than the shortest route. This may result in longer routes but packets are routed only through energy- rich inter mediate nodes. Protocols based on this approach do not necessarily provide the lowest energy route, but prevent certain nodes from being overloaded, and thus, ensure longer network lifetime. The protocols that fall into this category are Localized Energy-Aware Routing (LEAR) protocol and Conditional Max-Min Battery Capacity Routing (CMMBR) protocol. The sleep/power- down mode approach is essentially independent of the other two approaches

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because it focuses on inactivity energy. Unlike the previous approaches, the sleep/power down mode approach focuses on inactive time of communication. Since most radio hardware support a number of low power states, it is desirable to put the radio subsystem into the sleep state or simply turn it off to save energy. The protocols that fall into this category are the SPAN protocol, Geographic Adaptive Fidelity (GAF) protocol and PEN protocol.

Trust Aware Secure Energy Efficient Hybrid Protocol for MANET has been proposed by Eenavath Veeraiah et al. [7] Provision of energy-efficient and secure routing is a challenge to be incorporated in MANET having changing topology and restricted resources. Veeraiah et al. addressed the energy efficiency and security, a trust-based secure energy efficient navigation in MANETs, by employing the hybrid algorithm, cat slap single-player algorithm (C-SSA which selects the best jumps in advancing the routing. The fuzzy clustering is put on and the cluster heads (CHs) are picked predicated maximum worth of indirect, direct, and recent trust. Even the CHs participated from the multi hop routing and the assortment of the best route relies upon the projected hybrid protocol and it selects the best routes determined by the delay, throughput along with connectivity. The proposed protocol obtained a minimal energy of 0.11m joules, a negligible delay of 0.005 msec, a maximum throughput of 0.74 bps, a maximum packet delivery ratio of 0.99 %, and a maximum detection rate of 90%.

An Energy and Delay Constrained Routing in MANETs have been proposed by Miquel et. al. [8] in which energy saving and timely delivery of data packets is incorporated into the route discovery phase to select paths with lower cost. This algorithm utilizes two metrics, residual energy and queue length at each node. Buffer information is considered as a traffic load characteristic and its use is to limit the battery power consumption and end to end delay. A simulation-based performance comparison between a routing adhoc protocol and its modified energy and delay-constrained version demonstrates that the latter one improves system performance for certain network scenarios.Chen Ji et al. [9] have proposed an Energy Efficient AODV for Low Mobility Adhoc Networks, in which the node energy consumption of the overall network is reduced by dynamically controlling the transmission power by utilizing a novel route cost metric. Three extensions to the traditional AODV protocol, named Local Energy Aware Routing (LEAR-AODV), Power Aware Routing (PAR- AODV) and Lifetime Prediction Routing (LPR-AODV) have been proposed by for balanced energy consumption in MANETs. These algorithms use energy consumption

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as a routing metric and try to reduce the nodes energy consumption by routing packets using energy optimal routes.

Narayanaswami et al. [10] have designed an approach named COMPOW, which works to find the minimal common value of node transmission range to maintain the network connectivity. COMPOW attempts to satisfy three major objectives i.e. increasing the battery lifetime of all the nodes, increasing the traffic carrying capacity of the network and reducing the contention among the nodes. The main reason behind the need for an optimal transmit power level for the nodes in MANETs is that battery power is saved by reducing the transmission range of the node. It has been proved that the COMPOW protocol works only in a network with a homogeneous distribution of nodes. CLUSTERPOW is an extension of COMPOW for non-homogeneous dispersion of the nodes. It is a power control clustering protocol in which each node runs a distributed algorithm to choose the minimum power p to reach the destination through multiple hops. Unlike COMPOW, where all the nodes of the network agree on a common power level, in CLUSTERPOW the value of p can be different for different nodes and is proved to be in non-increasing sequence toward the destination. An extended approach to COMPOW is used to reduce the energy consumed in packet forwarding for heterogeneous networks. These approaches introduce the excessive overheads and they have the scalability issue.

Some pure on demand energy aware approaches have also been designed. Xue et al. [11] have introduced a location aided routing with energy awareness. In this approach each node with a packet to forward performs per hop power aware forwarding with the help of location information of the destination, neighbouring nodes and the node itself. With this approach good energy efficiency can be achieved but at the cost of more resource consumption for updating and collecting the information in the dynamic environment of MANETs.

CONCLUSION AND FUTURE SCOPE

In this paper, efforts have been made to carry out detailed literature survey of existing energy efficient routing protocols/techniques/schemes. It is difficult to compare them directly since each method has a different goal with different assumptions and employs different means to achieve the goal. For example, when the transmission power is controllable, the optimal adjustment of the powerlevel is essential not only for energy conservation but also for the interference control. When node density or traffic density is far from uniform, a load distribution approach must be employed to alleviate

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the energy imbalance problem. The sleep/ power-down mode approach is essentially independent of the other two approaches because it focuses on inactivity energy. While it is not clear whether any particular energy efficient routing protocol or a class of protocols is the best for all scenarios, each protocol has definite advantages/disadvantages and is well suited for certain situations. Therefore, more research is needed to combine and integrate some of the existing energy efficient routing protocols to keep MANET's functioning for a longer duration. The purpose of this paper is to facilitate the research efforts in combining the existing solutions to offer a more energy efficient routing mechanism. In future, a better energy efficient routing protocol shall be devised by choosing AODV as the base protocols. The performance of proposed energy efficient routing protocol shall be analyzed using various performance evaluation metrics viz. packet delivery ratio, average end-to-end delay, throughput, packet loss and normalized routing load etc. The simulation will be carried out using network simulator.

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