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A Survey on Energy Consumption in Routing Protocols for MANET Using Cross Layer

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Abstract

This paper presents the exhaustive search on reduced energy consumption routing protocols for MANET using cross layer. There are so many techniques available for energy consumption in routing protocols. MANET is a collection of wireless mobile nodes that forms a temporarily dynamic network without any centralized administrator. Each node in MANET moves arbitrarily that result as random change in network topology. Cross-Layer Design has recently become the new hype in MANET systems. This paper is to examine the current research activities in energy consumption of Cross-Layer Design. Keywords: MANET, Routing Protocol, Infrastructure Network, Cross Layer.

Keywords

Manet, Routing Protocol, DARPA, Cross Layer.

1. Introduction

The variety of mobile computational devices and communication devices (i.e. cell phone, laptops, user friendly digital devices or computer) is driving the revolutionary change in our information and science society. An autonomous system of mobile routers or nodes which is connected by wireless link is known as MANET (Mobile adhoc Network). The nodes or routers are free to move dynamically and can organize themselves arbitrarily [2]. The internet may connect such adhoc network.

(Fig(i): Infrastructure Wireless Network)[3]
(Fig (ii): Infrastructure less Wireless Network)[3]

History of MANET:
Historically, to improve the difficult circumstances the tactical network related application uses the mobile adhoc networks. In the military services the network is not pre infrastructure, but the network changes dynamically in the battlefield. Pure wireless communication also has limitation in that radio signals are subject to interference and radio frequency higher than 100MHz rarely propagate beyond line of sight [12]. A suitable and proper is created by Mobile Adhoc Network to address these issues by providing a multi-hop wireless network without pre-installed infrastructure and connectivity beyond line of sight (LOS). Years ago adhoc networking can be traced back to the DARPA Packet Network project in 1973, that the efficiency of packet switching technology was primarily inspires (i.e. bandwidth sharing and store-and –forward routing and its application in mobile wireless environment).Furthermore, using multi-hop store-and-forward techniques removes the radio coverage limitation.

In 1983, DARPA had developed survivable radio networks to address main issues in PRNet, in the area of network scalability, security, energy management, capability of processing. The main object of developing the network algorithms was to support the network application such as to increase the scalability of tens of thousands of nodes and undamaged security attacks, as well as small, low-cost, low-power radios that could support sophisticated packet radio protocols. In 1987, the low-cost packet radio design was resulted in which features a digitally controlled DS spread-spectrum radio with an integrated 8086 Intel processor based packet switch. Towards 1990s, the initial packet radio network ideas were made applicable and feasible by the growth of internet infrastructure and the microcomputer revolution.

In 1994, DOD initiated DARPA Global Mobile information systems program was introduced which introduced the study of Ethernet- type multimedia was introduced as to support anytime and anywhere

among the wireless devices, for the application in which the global infrastructure leverages into the mobile wireless network environment. Several networking designs were explored such as: Flat peer to peer network architecture was deployed by the wireless internet gateways (WINGS). In 1997, the largest-scale implementation of mobile wireless multi-hop network was implemented for the defense department (i.e. army). The modified commercial internet protocols are used for networking purpose. It has the limitation over wire line protocols was not good at coping with topology changes, as well as low data rate, high bit error rate in wireless link. In 1999, ELB ACTD was demonstrated for the MANET deployment exploration to demonstrate the feasibility of Marine Corps was fighting concepts. It requires the communication over the horizontal from ships at sea to marines on land via aerial relay. In the middle of 1990s, the radio frequencies standards were demonstrated with the use of IEEE 802.11 and the commercialization of the radio technologies were started to appear in the market using wireless technologies. Most of the existing adhoc networks have been developed in the academic environment also.

2. Mobile Adhoc Networking Related issues

In general, a wireless links (without using the existing networks infrastructure or centralized administration or pre installed infrastructure) connects the autonomous mobile nodes dynamically; this is defined or formed as adhoc networks. The nodes are free to move randomly in the adhoc network. Thus mobile adhoc networks are infrastructure less and for the operation no fixed or pre installed network infrastructure is not required. So for the network operation base station information is not fixed. Multiple hops may be included or operated to decide the routes between the nodes in adhoc networks. In the execution of multi-hop wireless adhoc network, each node will be able to communicate directly with any other node that lies within its transmission range (i.e. using more than one hop). For the communication with the nodes which lies beyond this range, the nodes need to use the other intermediate nodes deliver the messages hop by hop technique.

Problems of Wireless MANET:

- As the wireless medium is not absolute.
- Outside the boundaries of MANET the channel is unprotected.
- It is less reliable than wired networks because of the no pre installation infrastructure of network.
- The applied channel in MANET has time-variant and asymmetric propagation properties.
- Hidden terminal and exposed-terminal situation and its corresponding phenomenon may occur.
- The wireless medium has not the readily observable boundaries for the nodes which are outside from the limitation of station that are unable to receive network frames.
- As there is a lack of fixed infrastructure adds the characteristics and design constraints that are specific to MANET due to the above mentioned problems and complexities.

Characteristics and complexities of MANET

- **Autonomous and infrastructure less:**

MANET does not contain the established infrastructure or the centralize administrator. Each node of MANET act as independent router and communicates with the other one under peer-to-peer communication under the distributed environment.

- **Link Variation :**

Each node may be provided with one or more stations that may vary the transmission/receiving capabilities and can be operated with different frequency bands. This phenomenon may lead to the discontinuities or may result in possibly asymmetric links.

- **Node Processing Capability:**

In MANET, each node may be configured with different types of software and hardware. This results as variation in processing capability of the concern node (each node). To design the algorithms and network protocols for such network can be complex. So these types of network implementation require dynamic adaptation to change the conditions (for i.e. routing, congestion, energy, quality of service etc.).

- **Energy constrained operation:**

In the mobile adhoc network each node battery carries limited power supply and limited processing capabilities which in turns limited services and limited application.

- **Scalability of MANET:**

Management algorithms designs are used. Large networks with tens of thousands number of nodes ware involved by many mobile adhoc networks. Scalability for successful deployment of such large mobile adhoc network is critical and tough. The

further step for large mobile adhoc network which contains the large number of nodes with limited resources is not straightforward. Many challenges that are still not solved is to be described and solved in the below mention areas: Routing, power management, configuration management, security, high capacity of MANET.

- **Multi-hop routing:**

No fixed or default router is available. In this technique, each node act as individual router and forwards the packets to each other.
Use: Enable the information sharing between two mobile hosts.

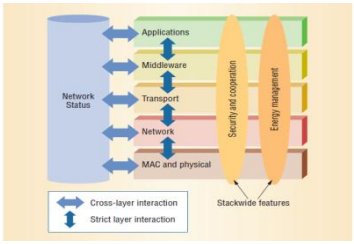
- **In MANET the network topologies changes dynamically:**

As each node can move arbitrarily in mobile adhoc network. The network topology can be changed So the resulting routes changes in MANET, frequent network partitions unpredictably. So the packets losses possibility can be occur.

Difference Between Layered and Cross Layer Approach

Parameter	Layered Approach	Cross-Layer approach
Modularity	Each layer can be modified if interface preserved.	Each Layer can't be modified even if the interface preserved
Design	Non- optimal design	Optimal design
Use	Wired network	Wireless network
Link variation	Deterministic on-off link	No deterministic on-off link
Error rate	Low	Medium
Interface	Each layer provides interface to neighbour layers and acts alone to perform its tasks	Layers are combined for the exchange of information so cross layer provides interface to neighbour layers but the combined layer act as alone to perform both the combined layer task.
Variable interaction	Predictable	Unpredictable

The cross layer design energy conservation may lead to affect all the layers of the system:



(Fig.1: Mobile Adhoc Network architecture. Some network functions, such as energy management and Security and cooperation are cross-layer by nature. Mobile Man seeks to extend cross-layering to all networks Functions through data sharing.)[1]

3. Energy conservation

The mobile devices have D.C. batteries for energy. So the battery power is finite and it is related with the important constraint in the designing algorithms for mobile devices. The researchers are under development that only small improvements in the batter battery capacity are expected in next future. Identifying the ways to use less power without any impact on the applied application efficiently manages for the power utilization. The energy conservation problem usually occurs due to the limitation of battery life time and the additional battery requirements for the supporting the network operations such as routing inside each and every node. This challenge leads to the new research area for the energy conservation problem (energy saving in MANET). The techniques to solve the battery conservation problems has been invented at several levels of mobile devices which includes the physical layer transmissions, the operating system, and the applications which points to the battery properties that impact on the design of battery powered devices. The power saving techniques with the operating system includes the cpu scheduling algorithm and the hard disk management. The remote execution leads to the profit if we apply it at the application level. The networking activities in the small mobile devices they have major effect on energy conservation. Experimental results show that power consumption related to the networking activities is approximately 10% of the overall power consumption of a laptop computer, but it rises up to 50% in handheld devices.[14]. In idle state, in energy aware network,

the wireless interface consumes the same quantum at transmission side and at the receiver side. in the sleep state, the interface cannot transmit or receive as its energy consumption is very high. The reduction of energy consumption at the stage of network interface, it is necessary to reduce define the network protocols that maximize the time the interface spends in the power saving mode by reducing the network interface idle times.[1]. In the infrastructure-based wireless network where the policies are predefined at all the layers of the protocols stack by moving the communications and efforts of computations on the fixed infrastructure and maintaining the network interface of mobile in the idle sleep state for many times, uses this approach commonly. There is no viable approach available for fixed elements of wireless adhoc network however they are not exist such as fixed elements. In addition new approaches for power saving can be introduced by the self organization of the protocols. For implementation of such protocols introduces a matrix for the measurements of energy saving and network lifetime. The energy management techniques are local to each node and they are aimed for the minimization of energy minimization in the infrastructure wireless network. The defined metric for self organization is not viable for the adhoc network. A greedy node which remains most of the time in sleep state without giving contribution in routing and forwarding will maximize its battery lifetime but it may effect on the lifetime of the network.

There are two classes to identify the power saving techniques for the MANET:

- Local Strategies
- Global strategies

Local Strategies:

Local strategies is applied in the node itself and it forces to put the network interface in power saving mode with minimum energy requirements during transmit ion and receiving operations. These techniques usually applied at the physical and MAC layer, with the object to maximizing the node battery lifetime without any impact of the high-level protocols. Some authors have proposed the techniques which focusing on energy saving, and avoid the useless transmission when the channel noise makes low the probability of the successful transmission. Authors have also proposed the strategies for the random access-based MAC protocols.

At the MAC layer energy saving strategies:

Objective: They are designed to avoid the transmission when the channel is congested.
Problem: There is a high collision probability occurs. So it requires the power consumption by reducing the energy required for the successful transmission of packet.
IEEE 802.11 MAC Protocol:[11]
Objective: optimal tuning of the network interface for saving energy consumption.
Strategy: optimal channel utilization.
Advantage: The transmit ion, receiver and idle states are almost same from a power consumption stand point.
CSMA- based Protocols:
Strategy: this protocol is achieved by using the information inherited from MAC protocol to observe and calculate the intervals during which the network interface does not need to be listening. For ex, the node

Global Strategies:

The main objective of this strategy is to maximize the network lifetime. These are based on this approach is designed for power saving and the idea on which the network traffic is forwarded need a small number of nodes which are responsible for the region dense. To achieve maximize the energy saving, the set of nodes are identified that must guarantee the network path connections between them and keep the rest of the nodes in sleep rate. The nodes selected for participating for packet forwarding in MANET may loss their energy sooner, so the network connectivity compromises. Therefore, periodically the set of selected active nodes are recalculated by selecting the alternative paths in such a way that maximize the network lifetime. To identify the network dominating set of nodes is the typical goal of global strategy. The dominating set of nodes defined as the subset of network nodes either each node in the set or it has a neighbour in that set. The connected dominating set constitutes the routing backbone in MANET. The calculation of the minimal dominating set is not feasible. To construct the dominating set computations either using nodes local decisions to sleep or to join the routing backbone. The nodes of MANET which are participating in the backbone known as coordinators. The nodes which are selected as coordinators are always kept in active state where as non-coordinators are kept in sleep state and wake up to exchange the traffic with the coordinators. So, the coordinator set is recomputed periodically in MANET. The effect of span technique depends on the energy consumption and consciousness in the idle

and sleep state: as in increase of idle-to-sleep energy-consumption ratio it increases the span benefits. Span integrated with 802.11 in power saving mode, thus the non-coordinator nodes can either transmit or receive packets that are buffered by the coordinators while they are sleeping. The physical position of the nodes are obtained by GPS is used in GAF algorithm to construct the routing backbone [1]. In the grid structure each node is associated with the square in grid with the use of its physical position. Inside the square structure only one node is in non-sleeping state [1]. An asynchronous distributed algorithms for construction of the routing backbone. Nodes are kept alternative between the sleep and active states, where in principle a node remains in sleep state for the time which is proportional to the numbers of neighbours, thus it can give the assurance in average the active nodes' constant number.

To control the transmission power of node is the other main goal for achieving the power saving in MANET. The reduced transmission energy allows the special reuse of the frequencies, which is responsible for better throughput of network and minimize the references.

In MANET, the variation of link and lack of link between two nodes is depends on the transmission power and transmission rate. As the transmission power increasing the number of feasible links is increased, this may results in increasing the energy consumption. For the network connectivity assurance and minimizing the transmission power, assign the power per node to control the network topology.

The energy consumption is highly correlated by the transmission power. It calculates both the energy drained from battery for each transmission, and the possible number of links. These two effects have the opposite impact on energy consumption. As increasing the transmission power results in increase in per packet transmission cost, but it decrease the number of hops to reach at the destination because the long paths are available. Finding the balance is not easy task. We have to consider the resource signal strength at distance r from the sender has non-linear decay. S(r) =S.r^ (-a) (a? [2, 4]), where S stands for amplitude of transmitted signal. This states that covering the sender-to-receiver distance a multi-hop path may require the less energy, from transmission. On a multi-hop path delay and processing energy is increased due to multiple hop and due to receive and locally process a packet respectively.

The market trade-off between the minimum transmission power and multiple numbers of hops again creates the complications for designing the routing algorithms. A major part of recent work is concentrated on the routing where the power level is further variable in routing protocol designs. There are two distinct perspectives to address these two problems: Energy is expensive, but not a limited resource i.e. the battery can be either recharged or replaced. The energy is deterministic and finite. The former case applies to mobile adhoc network. In the 1st case the energy consumption must be minimized as the total energy consumed per packet to forward it from source to destination. The minimization of the energy does not results as the minimization lifetime of the network. In the 2nd case the energy is hard constraint and maximizes the network lifetime is the target.

Minimum energy routing minimizes the energy consumption needed to forward the packet from source to destination. In proactive routing algorithm design try to find the route for all the nodes wile PARO behaves as a reactive algorithm by minimizing the energy consumption of ongoing flow. [13]

On-line live application maximum lifetime is a complex problem. In static network where everything is pre decided about the known and constant flows, the maximum lifetime routing is implemented or abstracted as linear programming problem. The solution of this model is used to analyze the effectiveness of the algorithms. [15]. For a single power an optimal algorithm is presented and for the general cases the algorithm choose the routes and adjust the corresponding power levels to achieve close to the optimal life.

4. MANET Routing Protocol Performance Issues

Quality parameter issues:

- Operation using Distribution: As there is no prerequisite for the construction of network, therefore the particular node operation the routing can't rely due to the existence of MANET.
- Loop-Free: To avoid the waste of frequency bandwidth the graph of routing should not contain cycle in MANET.
- Operation on demand: The burden reduction on each node can be reduced using this approach which is defined as the establishment of the path is established only

when the path is needed and a particular query path is there.

- Security: The implementation of key challenges provides the security in MANET as there is link variation, topology changes dynamically in MANET. So to provide security is a challenge.
- Proactive operation: It is somewhat similar as on demand operation. In this the path is predefined in table to speed up for the path establishment.
- Operation on sleep period: MANET is a smaller wireless device, using battery as a power supply. To save the power consumption the strategy can be such that for the non working node goes in sleep mode, so that can be operated in better way. So the routing protocol should be able to accommodate the sleeping period of node without facing the overly consequences. Unidirectional support:

Quantity parameter issues:

- End to end packet delivery throughput and delay: To improve the transmission quality designing such protocols is complex.
- Route Discovery time: The table driven is higher than on-demand for the route discovery. The path specified in cache is more reliable, requires less time to construct the path, fixed path etc. are commonly used.
- Efficiency: It is the simplest method for the control overhead of messages is a powerful characteristic in common for all routing protocols.
- Out of order delivery: It is measured in foam of percentage. In general the upper TCP co-operation is the IP routing work will not be affected.

Types of MANET Protocols:

- Protocol Classification: There are many techniques to classify the routing protocols, depending on various parameters i.e. the packet delivery ratio. There are three types of protocols in MANET: Proactive, Reactive and Hybrid.
- Proactive Protocols: It is also known as the table-driven or oriented routing table protocols. In this type of protocols the each route to node information is maintained in routing table. The packets are transmitted over the predefined route in the specified routing table. Proactive protocols have lower delay in packet forwarding and route discovery because all the paths are maintained in the routing table at all time. Examples: DADV, GSR etc.
- Reactive Protocols: The reactive protocols are also known as On-Demand or Demand driven. In this type of protocols the routes are not predefined for routing. The route discovery is performed when it is needed for the packet transmission. It is basically based on flooding algorithm which employs the technique of broadcasting of the packet to all its neighbor s and the intermediate nodes forward the packet to their neighbors. This process is repeatedly performed until the packet reaches at the destination. This technique has the smaller routing overheads but high rate of delay in packet delivery. Examples: AODV, DSR etc.
- Hybrid Protocols: It is the combination of the reactive and proactive routing protocols and it has the advantages of both reactive and proactive protocols, so the routes can be find path quickly in this routing type. Examples: ZRP.

5. Conclusion

This paper involves the exhaustive study of energy conservation in MANET using cross layer. It also presents the study and comparison of routing protocols of MANET i.e. Proactive, Reactive etc. Energy is utilized effectively in MANET using cross layer framework. It is described in such way that the sender can send the desired level of resource signal strength of link. The elimination before data reduces results such that the frequency of failures and route discovery overheads also.

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