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Energy Efficient MANET Protocol Using Cross Layer Design for Military Applications

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ABSTRACT

In military applications mobile adhoc network plays very important role because it is specifically designed network for on demand requirement and in situations where set up of physical network is not possible. This special type of network which takes control in infrastructure less communication handles serious challenges tactfully such as highly robust and dynamic military work stations, devices and smaller sub-networks in the battle field. Therefore there is a high demand of designing efficient routing protocols ensuring security and reliability for successful transmission of highly sensitive and confidential military information in defence networks. With this objective, a power efficient network layer routing protocol in the network for military application is designed and simulated using a new cross layer approach of design to increase reliability and network lifetime up to a greater extent.

Keywords: MANET, AODV, QoS, PDR, power, MAC layer, network layer, mobile adhoc networks

1. INTRODUCTION

The gigantic technological rejuvenation of wireless communiqué has been emerged in the system of mobile adhoc networks (MANETs) in current decade. MANETs are excellent networking structure that are based without any fixed infrastructure. Because of the highly dynamic, extremely mobile and self-configurable nature of its autonomous nodes, performance of this network is outstanding in terms of transmission, throughput and reliability.

Nodes in the mobile adhoc networks are equipped with limited battery power which gradually diminishes as they do more and more processing task such as remaining active in the node, sending and receiving hello messages, control information, data packets, forwarding packets and messages, processing routing logic, etc. So, in order to optimise the performance of the network, many routing protocols are proposed by many eminent researchers based on different network parameters such as power consumption, delay management techniques, etc. There are many existing routing protocols in MANET which are basically of two types. One category is table driven and another is on demand.

Mobile adhoc networks have very important application and operations in battle fields and in disaster situations such as deployment of networks, high security measures in the network, any end to end transmission, mobile connectivity without failure, anti jamming mechanism, etc. All network activity must be done spontaneously without any link failure even in micro second level. The soldiers during on line battle should be able to remain continuously connected with each other in order to get any latest information, or command from their chief or to discuss before any action. Sometimes penetration of the satellite signals is not possible to caves or dense forest or under sea places where it is again challenging to sustain connectivity.

As adhoc on demand distance vector routing (AODV) protocol in MANET is an efficient and on demand protocol, that supports immediate service for communication. Authors proposed a well designed and developed improved AODV concept. In AODV functionality, whenever a sending station wants to transmit some data to a destination station, first of all a RREQ message is broadcast by the source. This RREQ travels from hop to hop across the consecutive nodes in a path, and this path is determined as per logic implemented in the particular protocol. Like this, a path is created and another reverse path just in the opposite routing direction is also stored in the routing table. This procedure helps in creation of a forward route for the data packets. In this conventional mode of operation the end to end delay is highly affected and few routes which are centrally located in the network, gets over burdened, though some other nodes remain idle for long time without any task of packet forwarding or processing. Therefore this conventional method of routing that finds the shortest path instead of using a load balanced path is not appropriate for such a magnificent network like MANET. This type of unfair load balancing among MANET nodes and the power deficiency problem motivated us to consider a cross layer approach of power efficiency with development of a load balanced protocol for MANET.

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2. RELATED WORKS

Over last decade's most of the researchers have come out with different intelligent proposals some of which are based on energy efficiency, delay management and few of them are based on cross layer architecture. Agbaria[1], *et al*. devised extrapolation based technique that considered dynamic scheduling, resource management, velocity, multipath search to provide real-time and QOS need of a MANET. Sivakumar and Duraiswamy[2] presented efficient algorithm to support Quality of Service (QoS), by the use of load-distributing and congestion avoidance routing method. Their proposed algorithm computes the cost metric based on link loads. The links having lighter loads were preferred for sending traffic to avoid congestion. Srivastava and Daniel[3] advised an energy-efficient routing to improve the link utilisation by equalising the energy consumption between already exploited and underutilised entities. Their protocol deals with few key factors like residual energy, bandwidth, load and hop count for route discovery. Ahmed[4], *et al.* have given ant colony based load balanced approach in MANET. They analysed routing by linking it with resource scheduling problem. Their algorithm adaptively adjusts segment size based on node mobility and minimises the transmission time.

MadhanMohan & Selvakumar[5] has proposed PC-AODV which is another cross-layer design approach that uses power control strategies to send data and control packets of both network layer and data link layer. In this approach, various routing entries are made according to the left level of power in the nodes. As per necessary power level a path is selected during the route finding process. This protocol incorporated power level logic in route discovery and route maintenance phases. According to the routing table values, various power levels (PL) are applied with different packets. So there is compatibility of power levels in both the layers. This algorithm exhibits better performance in lowering the energy consumption and a higher packet delivery ratio. Another layered approach for Improving power efficiency in MANET[6] has been used which is different from customary style of design and it gears the cross-layer communication between three important layers physical, MAC and network layer. A new scheme called cross layer power control (CLCP) is used to augment the transmission power by using an enhanced strategy to find an appropriate route between two nodes. NS2 was used to simulate this approach, which shows better result. A detailed survey on real time MANET protocols have been carried out by Rath & Pattanayak[7]. Similarly mobile agent intruder detection system with delay and power issues are analysed by Pattanayak & Rath[8].

3. POWER AND DELAY OPTIMISED PROTOCOL

The main core module in our proposed power delay optimised AODV protocol is a routing engine that is the controller of all functions in the mobile work station. Sequentially it performs three important tasks during static or mobile position of a node and after a packet arrives to a node such as the channel sensing, the mini database handling module and the intelligent decision taking sub module. In the first sub module of channel sensing, status messages are transmitted periodically with regular interval of time by the node in order to broadcast presence of that node in the channel. In the next sub module a small database is maintained to store and retrieve routing information's regarding a particular path, which can be referred next time data transmission takes place between same sender and receiver. A threshold value is calculated in order to select the next hop station as per the algorithm given in Fig. 1, which will be used in the routing decision module to finally select a suitable station.

```
Step 1    for every intermediate node w_node from
          Source to Destination
Step 2    For every neighborhood node t_node of w_node
Step 3    Find all the neighbor nodes of t_node from
          Routing_Table of t_node
Step 4    Calculate the Cost_Func of every node using
          Calc_Threshold( )
Step 5    Sort the neingbor nodes of t_node in ascending
          order their cost function.
Step 6    Store the sorted values in Temp_Buffer
Step 7    For every node j_node in Temp_Buffer Check
Step 8    If ( j_node ( ! Congested_node )
Step 9    Then go to Step 11
Step 10   Else select the Next_Node
Step 11   If Cost_Func > Req_Cost_Func
Step 12   Select Node as Next_Node
Step 13   Else go to Step 2

Sub_routine Calc_Threshold( )
          Begin
          Return ( Power_level * Pcket_Size * No_Packets)
End
```

Figure 1. Algoritm for node selection.

3.1 Optimised Service Layer in PDO AODV

During packet delivery our optimised protocol provides the following types of service at network layer.

(i) *Data delivery with guarantee* **:** It ensures correct delivery of data to the correct destination in correct form, without any alteration. It achieves this feature by implementing error checking and intelligent route finding mechanism.

(ii) *Bounded delay:* The proposed Protocol can check the data delivery in time by not exceeding the allowed delay. This is achieved by checking the processing time at every relay node during packet forwarding and selecting only those nodes which can process and forward the packet in a load balanced route with sufficient less delay than the total allowed delay. The average allowed delay is calculated for every node and a threshold function is computed for the current node processing time.

(iii) *Minimum bandwidth guaranteed:* Whatever data is sent , the protocol will deliver the data with required minimum bandwidth to achieve the required throughput. This condition is normally required in Quality of service satisfaction of an application data.

(iv) *Maximum jitter guaranteed:* Jitter refers to gap of time interval between adjacent packets during data delivery. This is a required parameter for audio and video applications where it is necessary to have some gap between packets during their transmission.

4. CROSS LAYER ALLIANCE

Author proposed a cross layer mechanism between the data link layer and the network layer by introducing a friendly packet between the two layers. To reduce the overhead of route finding in terms of delay and power consumption we suggest that this friendly packet provides necessary information from the data link layer to its upper network layer. Developed an improved channel access technique at the MAC layer which is similar to HCCA controlled channel access (HCF) to make it compatible to work with PDO-AODV. These two new techniques at two different layers when function together achieves better performance in terms of throughput, packet delivery ratio and network life time.

4.1 Medium Access Controller Functionality

Medium access control (MAC) layer of data link layer co-ordinates and manages the wireless medium and the radio channels required by the stations by properly utilising the protocols and interfaces over the channel. It is an intermediate layer between the network layer and physical layer that offers the interior framing activity by conversion with network stations and backbone network.

Challenges in MAC layer design – radio frequency based link quality – Within the ISM band, there is noise, interference, unauthorised and unlicensed computing components, and fading of spectrum signals.

Hidden and exposed station problem – Collision frequently occurs in wireless channel due to simultaneous data transmission between stations without noticing the boundary of radio waves resulting in packet loss and retransmission. To solve these problems, RTS and CTS signals are used in MACA and MACAW protocol.

Enhanced distributed channel access (EDCA) and HCF controlled channel access (HCCA) are the basic mechanisms provided by HCF function. The first one is an additional form of the distributed coordination function (DCF) and the later is an additional form of point coordination function (PCF), which are defined in IEEE 802.11 standard. The HCCA utility functions in the communication based approach.

4.2 Carrier Sensing in MAC Layer

(i) *Physical carrier sensing*: Depending on the strength of the signal, from many other sources in the channel these functions check the strength of signal.

(ii) *Virtual carrier-sensing:* This mechanism is done using an intermediate time period in 802.11 frames by network allocation vector (NAV). NAV is a logical timer that holds a medium for reservation for a particular time period. For carrier sensing and channel access instead of conventional polling mechanism of HCCA, we have implemented the low latency queuing (LLQ) procedure for efficient as this algorithm is found to be improved than all other scheduling algorithm like FIFO, priority queuing, weighted fair queuing.

4.3 Low Latency Queuing Algorithm

Individual traffic classes are placed in a single queue as per LLQ algorithm for scheduling real time tasks. There is an option in LLQ algorithm to handle the strict-priority queuing scheme to allow delay sensitive traffic flow. For example voice packets will be processed first before any other packets are processed. Special attention is given to delay sensitive traffic flow. One or more number of classes can get the priority status. Main difference among the LLQ and the priority queuing is the fact that the Strict Priority queue facility of LLQ algorithm never allows any other queue to go to starvation. Bandwidth reservation mechanism is employed for strict priority based queuing in LLQ.

4.4 Cross Layer Communication

Figure 2 describes the functional block diagram of the cross-layer interaction. As explained above, a friend packet is sent by the data link layer to provide quick service and support to the network layer PDO AODV protocol during path finding process.

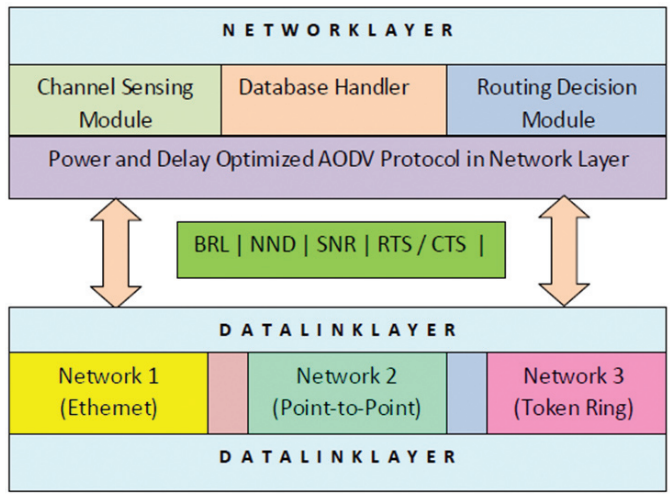

Figure 2. Functional Block diagram of cross layer interaction.

The packets contain the broken link (BRL) field that provides the possibility of broken link due to mobility of the forwarding node. The neighbor node detection (NND) field sends the nearest updated neighbor node information which can be quickly updated in the routing table. Signal to noise ratio (SNR) field provides strength of noise in wireless channel while the packet is transmitting. RTS/CTS packets convey the control information like request to send data to that particular node and clear to send data that offers total time for which the channel remains eventful.

5. SIMULATION AND RESULTS

Table 1 shows the parameters considered for simulation of our protocol. When compared with other two similar protocols PC-AODV[5] and CLCP[6] which are also based on cross layer design approach as discussed above, our protocol was found to perform better in terms of throughput, delay, power consumption and network lifetime than them.

Figure 3. shows comparison of power consumption, Fig. 4 shows packet delivery ratio (PDR) comparison and Fig. 5 shows average delay comparison for video packets among these three significant cross layer based approaches. We can

Table 1. Simulation parameters

Parameter name	Parameter value
Channel type	Wireless channel
Radio propagation model	Two ray ground
Network interface type	Wireless Phy
Type of traffic	V B R
Simulation time	10 Minutes
MAC type	Mac/802_11
Max speed	100 Kbps
Network size	1600 x 1600
Mobile nodes	120
Simulator	Ns 2.35

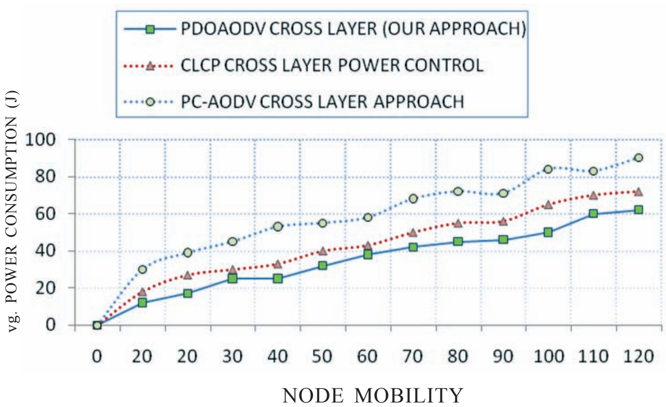

Figure 3. Comparison of power consumption.

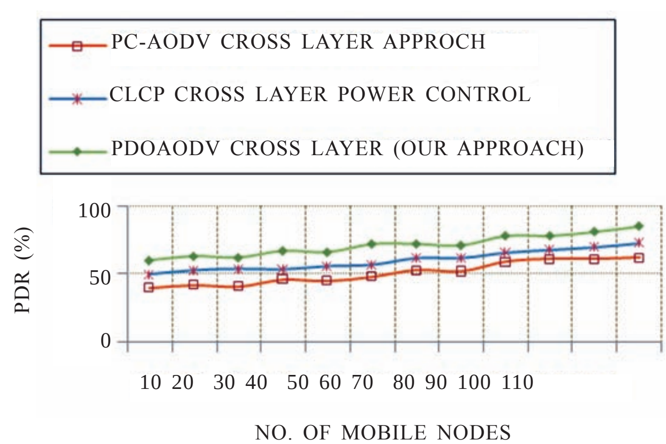

Figure 4. Comparison of PDR.

observe from the above graphs that under specific network parameters during the simulation our proposed PDO AODV approach with cross layer mechanism performs better in terms of power consumption, delay, PDR and network lifetime.

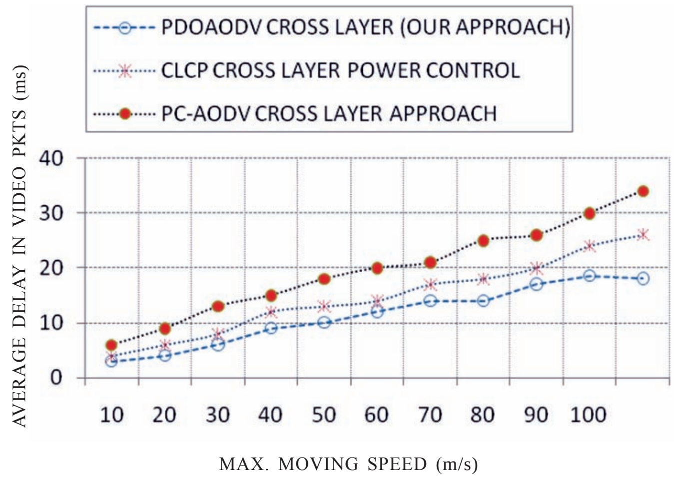

Figure 5. Average delay comparison for video packets.

6. CONCLUSION

In this study, authors inspected the issue of power efficiency, node selection and unfair load balancing for mobile ad-hoc networks using an interaction based cross layer mechanism. They focused on optimising link cost based on power and delay metric to mitigate this severe issue restoring precious network resources. In addition to this we have used a friendship based handshaking utility as a cross layer approach between data link layer and network layer to accelerate the routing layer process. We have used an optimised channel access method in MAC protocol of data link layer which sends a friend packet to the network layer that contains critical information such as broken link, updated neighbour list and signal quality which helps the router in network layer during route search by consuming less amount of residual energy. This protocol solves the resource constraint problem of adhoc network to a great extent and the simulation study shows that it shows better performance than other leading MANET protocols based on similar cross layer approach.

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In the current study, motivation for this research work and formulation of problem statement with solution methodologies are the basic contribution by him.

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In the current study, technical review of the system in this research work and simulation approaches are suggested by him.