Energy Efficient Node Management Techniques using Cross Layer System for Mobile Adhoc Networks

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ABSTRACT: *MANET nodes are naturally well-known by their limited energy, processing, and memory resources as well as high degree of mobility. In such networks, the mobile nodes may dynamically enter the network as well as leave the network. Due to the restricted transmission range of wireless network devices, multiple hops are usually needed for a node to exchange information with any other node in the network. A joint routing and energy allocation plan is developed which stabilizes the system and provides surrounded average delay guarantees whenever the input rates are within this capacity segment. multi-path routing algorithm is proposed for industrial wireless mesh networks for improving reliability and determinacy of data transmission, as well as to effectively deal with link failures. The proposed algorithm adopts the enhanced Dijkstra's algorithm for searching the shortest route from the gateway to each end node for first route setup. A virtual pheromone distinct from the regular pheromone is introduced to realize pheromone diffusion and updating. This paper considers jointly optimal design of cross layer congestion control, routing overhead and Throughput for Mobile ad hoc networks.*

Keywords: Congestion Control, Multipath Routing, Mobile Adhoc Networks, Bandwidth Availability, Dijikstra Algorithm

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1. Introduction

The fundamental idea of cross layer method is maintaining the functionality of the unique layers, but communication, synchronization among diverse layers can be allowed, because of this simplicity among the layers can be maintained, and number of control signals can be concentrated [1].

The demanding of designing network protocols for MANET comes from link break which caused network performance degradation. The route rebuilding of link takes major challenge of routing protocols task can be lost making QoS (Quality of Service) of connections depending on the state of networks. A number of MANET routing protocol becomes efficient and correct. There are three types of routing in MANETs float routing versus non-flat or hierarchical routing which benefits of proactive (e.g. DSDV, OLSR), reactive (e.g. AODV, DSR), and hybrid (e.g. ZRP, TORA) mechanism for routing [2].

In most cases researches did not go over complex cross layer design completion but try to propose a cross layer design to be able to solve the problem at the present. In most of the proposals only two or perhaps three layers need to share information, and therefore had extensive the original strict layered structure to present a result to the problem with performance development. Cross layer design started a gain lot of concentration from the researches with its performance development and the need for cross layer interaction for different applications and the mobile ad hoc behavior. Though different cross layer design had provided a means for protocols to interact with the protocols of other layers, there may be some interaction that may be estimated by the designer which if occur would create some loops. These kinds of loops caused due to unintentional interactions could compromise the stability of the entire system [3]. Figure 1 shows the various applications using the manet and their topoloy structure are defined in this diagram.

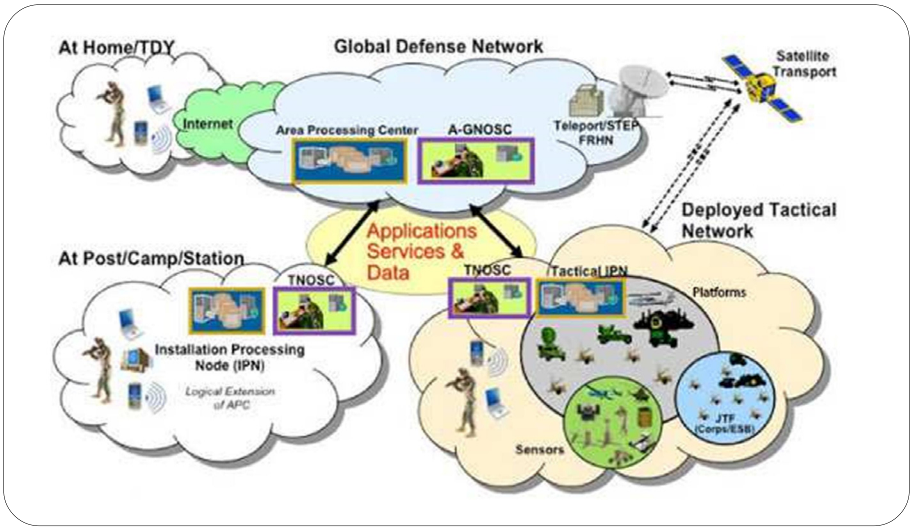

Figure 1. Mobile Adhoc Network

The layering design of the standard protocol stacks has achieved great success in wired networks. It separates abstraction from implementation and is thus consistent with sound software engineering principles information hiding and end-to-end principle. Though, protocol stack implementations based on layering do not function efficiently in mobile wireless environments. This results from the highly variable nature of wireless links and the resource limitation nature of mobile nodes [4]. As a solution, there has recently been a proliferation in the use of cross layer design techniques in wireless networks.

Ad hoc On-demand Multipath Distance Vector which is an extension of Ad hoc On-demand Distance Vector and it's also establish the multiple loop-free and link-disjoint paths A starting place node floods a Route Request to the entire network in order to find routes to the destination and when the destination node receives the Route Request via different neighbors, it transmits multiple Route Reply packets to the source node. Lee proposed a multiple routing protocol considering the residual battery capacity of route candidate nodes based on AOMDV [5].

Multi-path routing schemes, which are developed based on the three categories of routing algorithms, can search multiple paths through a single-route discovery process. A source node chooses a path among multiple paths, after which it transfers data packets using the chosen path. If a link on the path is broken, the source node chooses another path and continues to transfer data instead of initiating an additional discovery process. New route discovery process is initiated after all paths have failed, thereby reducing the number of flooding initiations. Recently, several multi-path routing schemes have been proposed, which include multi-path dynamic source routing [5], split multi-path routing [6], and ad hoc on-demand multi-path distance vector (AOMDV) [7].

The abovementioned routing algorithms are known as the shortest path algorithms. Recently, many researchers have considered quality of service (QoS) in routing algorithms for WSNs, which magnifies the difficulties associated with some optimization goals. Gelenbe and Lent [8] proposed an energy-efficient routing algorithm for ad hoc networks based on the cognitive packet network (CPN) [9,10] protocol. The CPN algorithm is a fast, adaptive routing algorithm that uses smart packets for QoS-based path finding to minimize power consumption. QoS-aware multi-path routing algorithms have also been proposed in [11–13], in which QoS routing problems are formulated as different optimization problems (e.g., video quality and energy awareness). However, meeting QoS requirements in WSNs introduces certain overhead to routing protocols in terms of energy consumption, intensive computations, and significantly large storage. Thus, the energy conservation in industrial wireless mesh networks is achieved by the time division multiple access scheduling algorithm. The proposed routing algorithm aims to gain reliable and low-delay communications without high flooding.

The traffic at each mobile node is transmission among different path instead of single path. This has been accepted out at routing layer allows major energy protection. At MAC layer retry limit is powerfully adjusted over each wireless links to achieve energy protection there by increasing the network lifetime. There are papers which talks about high throughput and minimum delay in wireless networks [14,15].

The blend of MANET with multicasting introduces new challenges towards secure data transmission. The secret keys are also known as Traffic Encryption Key (TEK) used to encrypt and decrypt data by sender and receiver respectively. For achieving maximum security Key management techniques are used. This technique takes the liability of creation, distribution and updates the secret keys when the membership changes. If the entire network is considered as single network, when the node join or leave new secret key must be evaluated and distributed to entire network [18].

2. Problem Definition

In mobile ad-hoc network all the node are move from one place to another place very frequently. The major challenges in ad-hoc networks are power control, scheduling and routing. These are related to different layers in the wireless protocol stack. Several protocols have been designed independently without considering the interactions between these layers.

Most of the energy related study in MANET has been done at routing layer to reduce energy consumption in either transmission or suggesting a different routing approach. This paper proposed the new routing techniques for betterment of energy management techniques. So the link break between senders to receiver is very frequent. Source node is not able to predict either data can be send by the source is delivered to the destination or not because of uncertainty of link between sources to destination. The End to end delay between the source and destination also discussed to improve for route stability.

3. Cross Layer Interaction

Cross layering came into maintenance because of particularly variable nature of links used in the wireless communication systems and due to resource reduced nature of the wireless mobile devices there has been multiple research studies to develop the performance of the protocol stack by allowing cross layer interaction by wireless systems. Because of QoS, energy utilization, poor performance, wireless links, mobility, packet loss, end to delay problems observed in the wireless networks much attention is paid in the cross layer interactions. Normally, wireless sensor nodes avoid straight communication with distance end since maximum broadcast power is required to achieve reliable transmission. Instead in wireless sensor networks, sensor nodes communicate by forming a multi hop network to forward messages to the collector nodes, which is also called the sink node. In situation to energy efficient routing in multi hop becomes critical in achieving energy efficient network. In addition to using multi hop communication for reducing the power condition for communication, an efficient routing protocol is needed to decrease the end - to - end energy consumption when data send to sink node.

Major sources for power consumption are idle listening, re-transmission resulting from collision, control packet overhead, unnecessarily high transmitting power, and sub - optimal utilization of the available resources. If any of the quoted causes are reduced power could be saved to some extent. In circumstances where the transmission power can be diverse with the distance of the link, the link cost is higher for longer hops; the energy aware routing algorithms select a path with a huge number of small remoteness hop. It should find how it leads to an efficient choice between a path with huge number of short distance hops and another with a smaller number of large distance hops. Use of smallest amount energy paths for packet transmission may not always minimize the operational lifetime multi hop wireless network [16].

The Figure 2 described all the levels of cross layer system and how it's linking or integrated with others layers during the data transmission between the nodes.

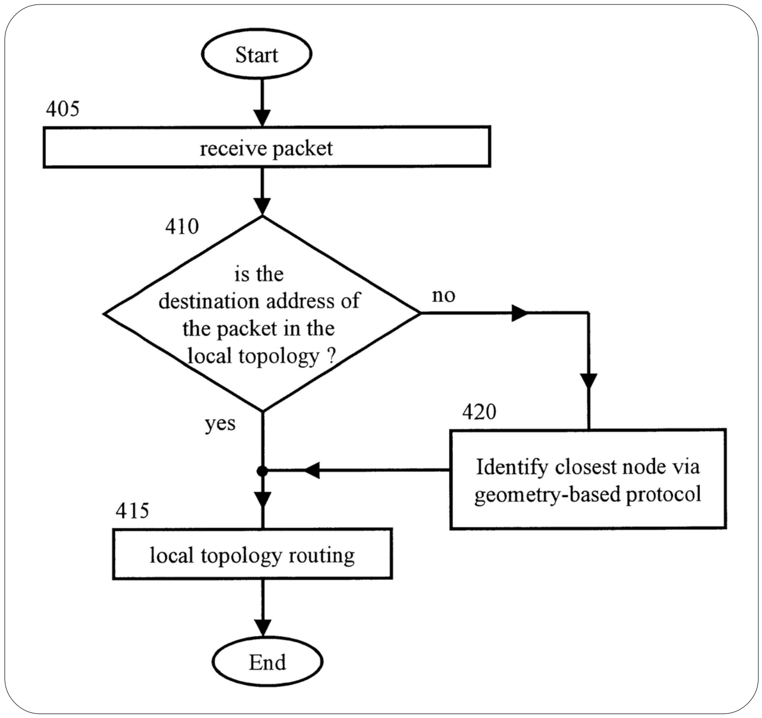

Figure 2. Examples of dynamic adding of protocol layers

Multipath Routing

Traffic/Load balancing method it may be valuable for increasing network lifetime. It is create to be a capable responsibility technique for MANET. The use of backup paths may lead to decrease packet loss, makes communication sessions maximum duration and provides strengthens to mobility. And all these factors result in minimum energy utilization so there is a possible benefit that network lifetime can be extended. The common nature of radio medium may influence the execution of multipath techniques because paths need to be node and link disjoint so making it not easy compared to single path routing but multiple routes can be formed to distribute the data to send and receive with in a time period.

The interruption of each node is intended based on packet arrival time and packet broadcast time. The normal delay at node includes the queuing conflict and transmission delays [16]. Then full path delay is calculated by sum of node interruption from source to destination.

$$\text{Total Packet } T_P = \Sigma R_k \, (k = 1 \ldots n) \tag{1}$$

Where R_k is the node delay. In route discovery process, the Route Request packet carries hop count, and the total path delay T_p of a path P. On receiving the Route Request packet the destination node send Route Reply packet back. If the duplicate Route Request packet has a minimum total path delay and hop count than the previous one, the destination sends a Route Reply packet again to the source node to change the route immediately. Load Aware On-demand routing protocol is an extension of the AODV.

1) LAOR allows the intermediate nodes to relay duplicate Route Request packets if the new path (*P*') to the source of RREQ is shorter than the previous path (*P*) in hop count, and *TP*' is smaller than *TP* (i.e., *TP*' < *TP*).

2) Each node updates the route entry only when the newly acquired path (*P*') is shorter than the previous path (*P*) in hop count, and *TP*' is smaller than *DP* (i.e., *TP*' < *TP*).

Route Discovery

Source node initiates a RREQ to the multicast address if the source has data to send to a multicast group and there exists no route. When the group leader or a member of the desired multicast group receives multiple RREQ packets, it selects the one with the highest sequence number and the lowest hop count and unicast a RREP to the requesting node.

The RREP packet contains the distance of the replying node from the group leader, power required to transmit from the replying node to its receiving node and the current sequence number of the multicast group. RREP packets update the power in the unicast routing table along that path. When the receiving node receives more than one RREP packet, it forwards all the RREP packets. Among the entire RREP packet, the packet which has the minimum energy required is selected. The path which requires minimum energy is selected at the source on the reception of RREP. This minimum energy path is used to transmit data so as to enhance the network life time and to reduce the energy consumption [20].

4. Proposed Energy Efficient Multipath Jeer

A Proposed Multipath Power efficient JEER by modifying the obtainable AODV and DSR protocol. The changes are made in the route detection phase of AODV and DSR algorithm. The Route Reply packet is drive to the particular source with the communication power in its header along with the route. Up on receiving the Route Reply packet, the source node measures the received power of the Route Reply packet and collects the transmit power of the Route Reply packet that is piggybacked in the same packet. Then the source node calculates the pathless of the Route Reply packet and calculates its required minimum transmission power using the receiver threshold. The receiver threshold along with the path loss gives the optimum power required for transmission at MAC layer. This algorithm is proposed to prevent link break and increase the throughput in the overloaded network scenario.

Proposed Algorithm to establish the reduce link break routing

```
Step 1: Begin
Step 2: If (R is a RREQ packet = MEL) then
        RREQ reaches neighbor nodes
        Neighbor node will be Send RREP
        Packet to the source node
        Go to 3
Step 3: Update the destination routing table
        MEL=1
        Return
        End if
        Go to step 8
Step 4: If (R is RREQ packet = MaxEL) then
        Other neighbor node will rebroadcast the
        RREQ (i.e) rediscover the failure
        RREP Packet
        MEL = 0;
        Go to step 3
Step 5: Source node it increase the TTL value by 1
        MaxEL=MEL+1
        Go to step 4
Step 6: if (Sequence number = MAX) &&
        (Broadcast Id = ID) then
        Broadcast the RREQ is rebroadcast
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packets by Source node.
        Update with the RREQ MEL,
        MaxEL
        End if
        Go to 5
Step 7: End
```

5. Methodology

Dijkstra's Algorithm

Dijkstra's algorithm [15], first conceived by Edsger Dijkstra, is a graph search algorithm that solves the single-source shortest path problem for a graph with non-negative edge path costs, thereby producing a shortest path tree. For a given source vertex in the graph, the algorithm finds the path with the lowest cost (e.g., the shortest path among all vertices) to each other vertices. This algorithm can also be used for finding the shortest path from a single vertex to a single destination vertex by stopping the algorithm once the shortest path to the destination vertex has been determined. Therefore, Dijkstra's algorithm is widely applied in routing algorithms, and is utilized as a subroutine in other graph algorithms to find the shortest routes from one node to all other nodes.

Route Selection for Data Transmission

When all the routes have regular pheromones, then the cycle of route exploration ends. However, for deterministic transmission, not all explored routes are used for data transmission. In this study, the network manager reserves top five routes for each node based on the pheromone values of routes. If node i does not have five routes, then all discovered routes are chosen for data transmission. Each of these top five routes is denoted by a graph ID, a regular pheromone value, and information regarding the next-hop node along this route. The information on these routes for data transmission is stored in graph tables of nodes along these routes. Prior to each data transmission, node i chooses the route whose graph ID is k from the graph table using the probability $P^k{}_i$, as shown in Equation (6). The pheromone value of this route is represented by $R^k{}_i$, while N_i^{Id} is the number of the graph IDs stored in the graph table of node i. The parameter $\beta 2$ controls the forwarding of data packet and is set at 5. Setting a high $\beta 2$ indicates that the data are spread thoroughly over the routes if several routes have similar qualities. However, if one path is clearly better than other paths, then the better path will always be preferred, whereas the data are spread out over multiple paths when $\beta 2$ is low.

$$P^k{}_i = \frac{(R^k{}_i)^{\beta 2}}{\sum_{k=1}^{N_i^{Id}} (R^k{}_i)^{\beta 2}}$$

Route Maintenance for Topological Changes

Topological changes may occur in industrial fields due to the faulty nodes or imminent external environmental factors. Any change of network topology, such as joining of new nodes, moving of nodes, and node failure, can trigger route maintenance. To adapt to these, the network manager can make corresponding processes based on different topological changes.

Joining of New Nodes

When a node wants to join a network, it must apply to join the network according to the information from the "Advertise" messages sent by other nodes in the network. After succeeding in joining the network, the new node establishes connections with other nodes if the distance between them is within communication range. This node can obtain the route information through pheromone diffusion, which is conducted by its neighbors. Afterwards, the node sends out proactive forward ants for route sampling. The network manager selects several routes to transmit data for this node according to pheromone values of sampled routes.

Nodes Moving

When the existing node moves, "keep-alive" messages are sent to notify the neighbors of this moving node. In this case, the network manger decides whether or not to start route exploration based on the specific conditions. If the node moves a short distance, then there is no change of the hops between nodes. Therefore, starting a route exploration is not necessary; instead,

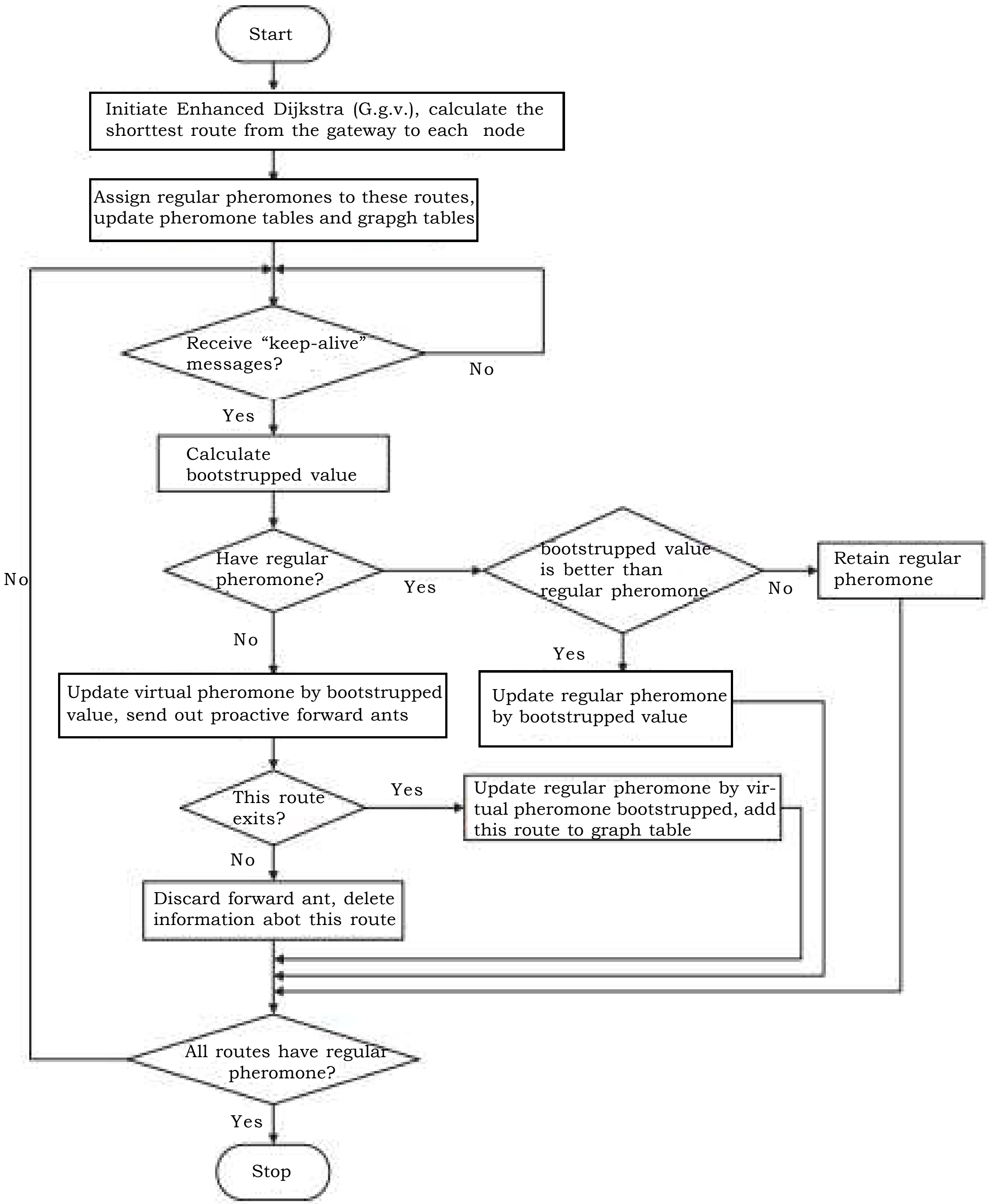

Figure 3. Proposed Algorithm Implementation

the network manager updates the pheromone values of the routes based on the moving node. This is because the distance between the node and its neighbors has changed. Otherwise, if the routes along this moving node are broken down, then the network manager considers the maintenance mechanisms below.

Node Failure

When a node receives the "unconnected message" from its neighbor node or when a neighbor node does not exchange the message exceeding the "Time keep-alive interval," then the node should send the command "Alarm graph route failed" to the network manager. Afterwards, the network manager informs the other nodes about the route of the failure node, so that other nodes can keep track of this topological change. The route maintenance for link failure is similar to the two maintenance mechanisms presented for nodes moving. In this study, if there is only one route available for data transmission of an end node, the network manager must restart route exploration for this node.

Algorithm Implementation

After the initialization of a network, the network manager adopts the enhanced Dijkstra's algorithm to calculate the shortest path to each end node. Once the first shortest route of each node is found, the pheromone tables of all nodes along this route and graph table of this node are populated. Route exploration consists of two sub-processes, namely, pheromone diffusion and pheromone updating. During the process of pheromone diffusion, a node can derive the bootstrapped value. If only a bootstrapped value is present instead of a regular pheromone value for a route, the bootstrapped value is converted to a virtual pheromone. Once a virtual pheromone is assigned to a route, proactive forward ants are sent out to sample this route. That a proactive ant arrives at a node that provides no routing information about the gateway suggests the route does not exist. Afterward, the forward ant is discarded. Conversely, the network manager records the route taken by the proactive forward ant once it arrives at the gateway. In this way, the regular pheromone is assigned on this route. If there is a regular pheromone value for a route, the bootstrapped value is treated as an update of the goodness estimate of this route and is used to replace the regular pheromone on this route when the bootstrapped value is better than the regular pheromone. In this way, pheromones on current routes are kept up-to-date. In this study, pheromone diffusion proceeds as soon as the shortest routes are discovered; it is then terminated when the regular pheromone information of all routes is populated through the process of pheromone updating.

4. Simulation

In this paper the simulation are carried out based on the following *NS*-2 simulation setup environment.

Simulation Parameters	**Value**
Simulation period	15M
Speed	1
Terrain range	500 x 500
No. of nodes	150
Node placement	Random
Radio type	Radio accumulated noise
Mobility model	Gauss Markov
Pause time	600sec
Maximum speed	35 m/sec
Packet size	512 Bytes
Routing protocol	DSR, AODV, JEER
Application traffic	CBR

Table 1. Simulation Properties

The used Parameters

These three parameters are:

1) Number of nodes per route.

2) Node mobility speed.

3) Node transmission range.

There are numbers of performance metric by which gives the performance of AODV .we here calculate packet delivery fraction, average end to end delay, normalized routing load and packet loss.

Gauss Markov Mobility Model:
The Gauss Markov Mobility model was originally used to suggest the group of nodes in a Personal Communication System (*PCS*). In this model, the level of random group of the nodes can be changed by using a tuning parameter. Each movable node is assigned a current speed and direction initially. At fixed time intervals, n, the speed and direction of each node is updated based on the $(n-1)^{st}$ instance using the equations –

$$S_n = \alpha_{Sn-1} + (1-\alpha)\,\bar{s} + \sqrt{(1-\alpha^2)}\, s_{x_{n-1}}$$

$$d_n = \alpha\, d_{n-1} + (1-\alpha)\,\bar{d} + \sqrt{(1-\alpha^2)}\, d_{x_{n-1}}$$

Where,

• s_n and d_n are the new speed and direction of the *MN* at time interval n;

• ∞, where $0 \leq \infty \leq 1$, is the tuning parameter used to vary the randomness;

• s and d are constants representing the mean value of speed and direction as

$n \rightarrow \infty$; and $s_{x_{n-1}}$ and $d_{x_{n-1}}$ are random variables from a Gaussian distribution

1. Packet Delivery Fraction
It is the ratio of the total numbers of packets received by destination to the total number of packet send by the source. The better result is obtained by Enhanced AODV.

$$PDF = (Received\ packets\ /\ sent\ packets) * 100$$

2. Data Packet Delivery Ratio
Total number of delivered data packets divided by total number of data packets transmitted by all nodes. This performance metric will give us an idea of how well the protocol is performing in terms of packet delivery at different speeds using different traffic models [17].

3. Normalized Protocol Overhead
Total number of routing packets divided by total number of delivered data packets. Here, we analyze the average number of routing packets required to deliver a single data packet. This metric gives an idea of the extra bandwidth consumed by overhead to deliver data traffic.

4. Throughput
Total number of delivered data packets divided by the total duration of simulation time. We analyze the throughput of the protocol in terms of number of messages delivered per one second.

5. Average End-to-End Delay
Includes all possible delays caused by buffering during route discovery, queuing at the interface queue, retransmission delays

at the MAC, propagation and transfer times [19].

7. Simulation Results

Figure 3 shows the Packet Delivery time with respect to number of nodes in cross layer based system provides high packet delivery ration compared with existing AODV protocol.

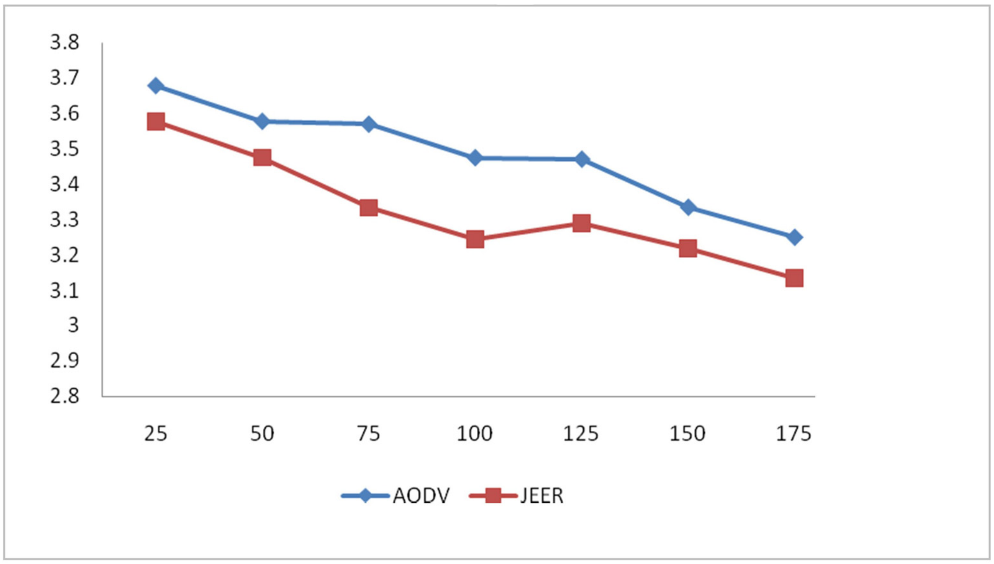

Figure 3. Packet delivery fraction of AODV and JEER

Figure 4 shows the Routing Overhead with respect to number of nodes in cross layer based Joint energy efficient multipath routing system reduced routing overhead compared with existing AODV routing protocol.

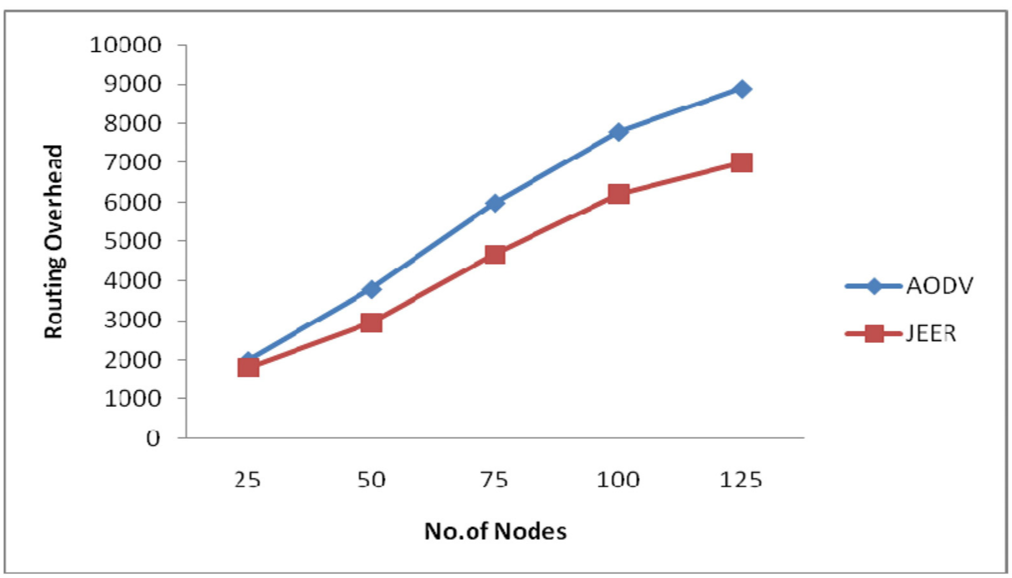

Figure 4. Routing Overhead AODV and JEER

Figure 5 shows the Throughput with respect to Traffic Load in cross layer based Joint energy efficient multipath system increased the throughput and reduced the traffic link break compared with existing AODV routing protocol.

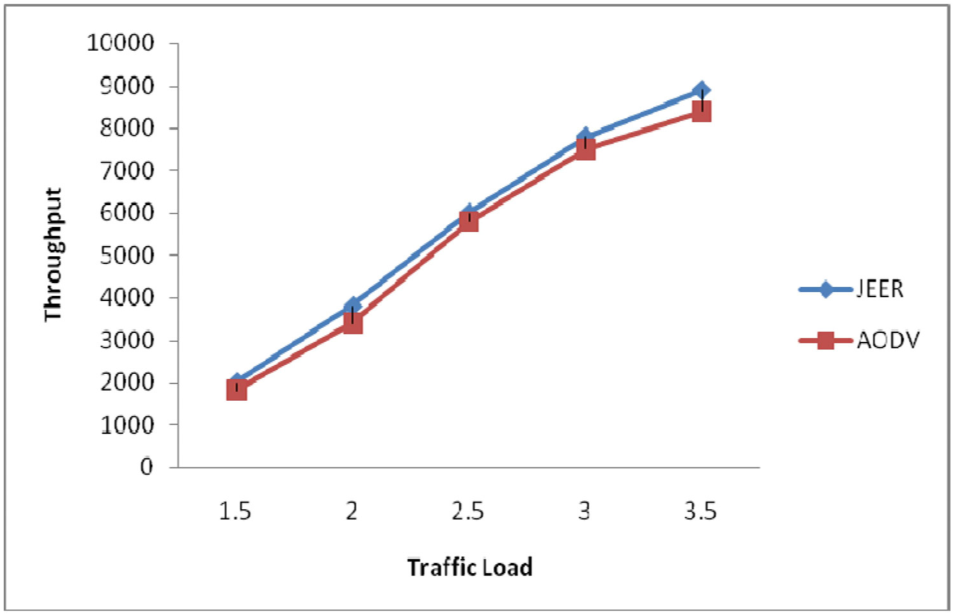

Figure 5. Throughput vs Traffic Load

Figure 6 shows the Delay with respect to number of nodes in cross layer based Joint energy efficient multipath system reduced end-to-end delay time compared with existing AODV routing protocol.

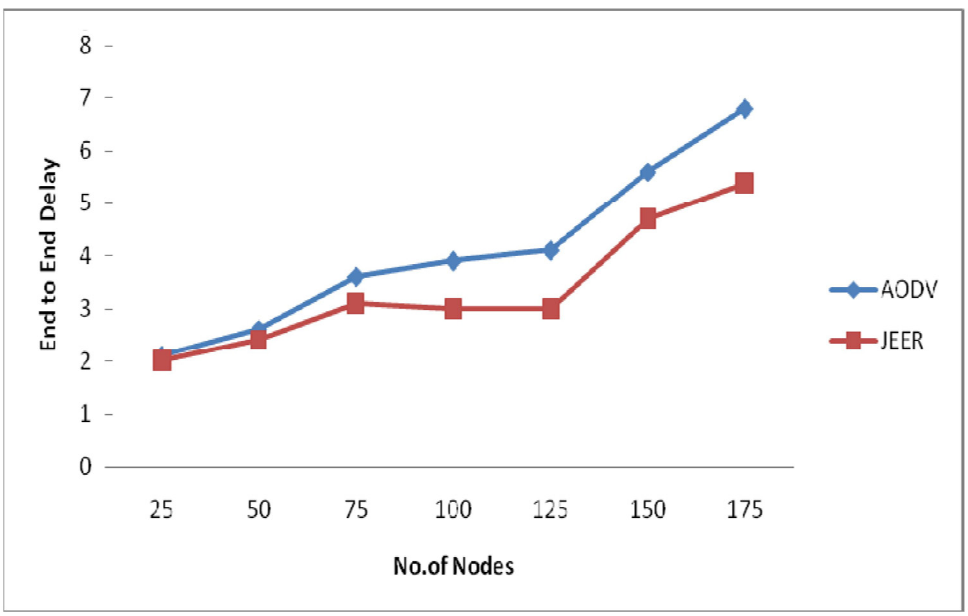

Figure 6.

8. Conclusion

In this paper, Simulation results show that cross-layer based routing system design yield considerably improved performance by exploiting the tight coupling between the layers in wireless systems. A disseminated algorithm for joint power control and routing along with cross layer communications in wireless ad-hoc networks had been developed and tested. The performance study shows that there is better progress in this algorithm compared to existing algorithm. The successful sending of Route

Request messages are significant in on demand routing protocols for MANET. The breakdown of Route Request causes serious problem in routing protocol. If Route request packet is failed, route re-discovery procedure attempts will be exhausted and adds additional control overhead. Once again the source node reinitiates the Route Request message, increasing the flooding process. To look up the performance, it is very important to balance the load. Load balancing is used to increase throughput of the network. Also it is possible to maximize nodes lifetime, packet delivery ratio, end-to-end packet delay can be minimized, and network energy consumption can be probably balanced. The proposed system achieves the significant results compared to existing AODV and DSR protocols; it decreases the routing overhead, link break and end to end delay.

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