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Power Efficiency in Mobile Ad-hoc Network: PEMA

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Abstract: *Achieving a better system existence is tranquil and a close problem within portable ad hoc network. In subsequent years of investigation and innovation, a tough performance to make certain power competence is nevertheless to explore more than ever to prevail over an undesirable outcome of active network and a variety of extremely stabilize links intended for the time of direction-finding. Consequently, an extraordinarily uncomplicated and proficient middleware called as PEMA i.e. Middleware for Power Efficiency in Mobile ad hoc network that offer an efficient resolution towards this difficulty. PEMA offers cost efficiency by changing the middleware to enhance its scale of variety of stable route based on formulating the new multiple decision-making parameters e.g. Time for Route Termination, Time for Stable Routing, Frequency of Route Error, Reduction in Signal Attenuation, and Remnant Network Lifetime. The design of PEMA is carried out using quadratic approach thereby retaining parallel processing of an algorithm to enhance the communication performance of the mobile nodes. The outcome of the study was found to excel better results in comparison to frequently used routing protocol e.g. Adhoc On-demand Distance Vector (AODV) and Optimized Link State Routing (OLSR) with respect to power consumption and algorithm processing time. The algorithm is found to be compliant of time and space complexity thereby results in cost effective solution.*

Keywords *Power efficiency · Middleware · Mobile adhoc network ·Network lifetime, Route selection, Stabilized links.*

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I. Introduction

A mobile ad hoc network is scrupulous as one of the commercial communication performance for vital situation. Conversely, due to the active topology in mobile adhoc network, it is connected with several challenges. Mobile nodes always dispel power whether it is in active state, passive state or in sleep state. As of uncertainty in power conservation system among the nodes, there is constantly a warning of broken links, which is greatly disadvantageous to the communication standard. Less than two decades, there has been sufficient advancement of troubles towards power efficiency in mobile ad hoc network. But, there is no facts of 100 % solution towards power efficiency due to over-burdened everyday jobs towards resource-limitation nodes [5]. Hence, introducing middleware system can significantly reduce the load of routing and multiple operations that are carried out by mobile nodes in ad hoc network and thereby introduce enough power efficiency. However, retaining power efficiency in mobile ad hoc network is not simpler and has multiple challenging factors as an impediment. Till date, there is no substantial study towards encouraging usage of middleware over ad hoc network to enhance network lifetime. This paper discusses an efficient middleware design that targets to accomplish power efficiency in the presence of dynamic topology of mobile ad hoc network. significant literature towards middleware design in present system followed by brief discussion of problem statement in Sect. 3. Section 4 discusses the proposed model followed by research methodology in Sect. 5. Algorithm implementation is discussed in Sect. 6 followed by a discussion of the accomplished result in Sect. 7. Concluding remarks are discussed in Sect. 8.

II. Related Work

This section discusses the significant work being carried out towards manipulative middleware application in mobile ad hoc network most in recent time. Most in recent time, Pasricha et al. [6] have developed a middleware for the purpose of optimizing power for the mobile devices. The study has considered the case of Android-based smart phones, where the authors have developed a middleware that can bring out the dispensation and power consumption to be controlled in the highest degree. The outcome of the study was found to conserve around 29 % of power.

However, the study considers ad hoc network for the stage networking and investigation. Another author named as Silva [7] has also dedicated their research towards evolving up with a middleware design exclusively for the mobile system. The focus of the study was into attaining scalability by developing aUDP protocol executed over the mobile nodes for addressing the unstable or broken links. The outcome of the study has also assured enhanced packet delivery ratio for the presented middleware that supports various forms of data delivery too. However, just like the previous study, this study also doesn't emphasize on ad hoc network.

An interesting concept of middleware was formulated by Haschem et al. [8] who presented a system for processing information gathered from mobile internet-of-things. The authors have implemented service-oriented architecture to enhance the usability and scalability of the middleware framework using non-deterministic approach. The outcome of the study was assessed using response time of the system. Mehrotra et al. [9] have developed a middleware system focusing on social networking system. The system also uses contextual data from the social network applications from the information that is sensed from the mobile. It also makes use of a centralized server. The evaluation of the study was hypothetically carried out over multiple databases on server mainly focusing on context awareness. Akingbesote et al. [10] have developed a framework for middleware focusing on the healthcare sector. The authors have incorporated middleware layer in between the multimedia interface and grid infrastructure layer. The outcome of the study was evaluated with respect to waiting time on increasing server utilization. Gherari et al. [11] have introduced another middleware system that using profiling approach over cloud interface. The middleware is designed over a sophisticated architecture using contextual information of both cloud and mobile interface. However, the study doesn't emphasize much on data analysis.

Nikzad et al. [12] have presented a middleware that is responsible for maintaining power efficiency on the mobile application considering Android operating system. The experimentation was carried out using sensed data from the mobile communication system where the outcome of the study shows 64 % of power conservation. Similar sort of studies was also presented by Makki et al. [13] by presenting a middleware for android device focusing on the security aspect of mobile devices. Mohapatra et al. [14] have developed a middleware for enhancing the power conservation for the mobile devices. Similar direction of the study was also carried out by Bajwa [15] by presenting a middleware for maintaining interoperability and integration in e-commerce. Lin et al. [16] have presented a schema of middleware for a mobile application using Bayesian approach using experimental approach. Zhuang et al. [17] have presented a scheme for middleware services for sensing processed information captured from the mobile device. Hence, it can be seen that that there are enough works being carried out in the direction of middleware design. The next section highlights the problem statement of the proposed study.

III. Problem Statement

The existing studies towards middleware are developed mainly focusing on the mobile devices. However, challenges involved in ad hoc network are quite higher in the form of computational complexity. Even if such middleware is design, the next challenge will relate to the selection process of stabilized links. At present, the frequently existing routing protocols e.g. AODV [18] and OLSR [19] are used for routing. Hence, if a middleware will be designed it will have to solely depend on PEMA. The efficiency of such routing protocols, which are associated with both advantages and disadvantages too. A successful and cost-effective design of middleware will call for incorporating a good interface between the middleware components and routing protocols along with power efficiency. Unfortunately, enough studies have not been carried out in the direction of the mobile ad hoc network. This causes quite an uncertainty, in theory, formulation about how to define a middleware technique that can perform an efficient and faster selection of the routing in mobile ad hoc network. Besides, the present routing decision for selection of stabilized link is carried out by residual power, which is not enough. Hence, there is a need for manipulative a middleware system that can take more information about the stabilized and power-efficient links considering the problem of spontaneous dissipation of power among mobile nodes owing to issues of dynamic topology. The problem statement of the study can be stated as —It is a computationally challenging task to develop an efficient middleware for restoring significant network lifetime of mobile nodes in adhoc network. The next section presents a discussion about the proposed system that addresses the problems of developing a middleware system for enhancing power and network lifetime in mobile adhoc network.

IV. Proposed System

The principal purpose of the proposed system is to design a middleware system that can perform significant conservation of power among the nodes in mobile ad hoc network. The study introduces a technique called as PEMA (Middleware for Power Efficiency in Mobile ad hoc network). The present study is an extension of our prior design of middleware system called as MERAM (Message Exchange with Resilient and Adaptive Middleware system) [20]. MERAM was designed for mitigating the replication issues of a message in order to facilitate quick exchange of message for time-critical applications in mobile ad hoc network. The advantages of MERAM are (i) higher resilience to link failures on dynamic topology, (ii) applicable on delay tolerant protocol, (iii) outcomes witnessed with increased delivery probability and reduced message exchanging time. However, MERAM didn't focus on power efficiency, which may result in minimization of network lifetime. Therefore, in order to accomplish the objective of power-efficiency over MERAM, the present study performs following contribution:

• To design an ad hoc-based connectivity for wireless access technology that can track and to observe closely the emergency situation.

• To develop a middleware system that can minimize or control power drainage from the mobile nodes for data dissemination process in mobile ad hoc network.

V. Research Methodology

The proposed system PEMA considers analytical methodology and intends to design an extended version of the proposed middleware system for incorporating further resiliency against drainage of battery and thereby enhancing the lifetime of hybrid mobile ad hoc network. The proposed system will design a framework on mobile application that is purely on the basis of the MERAM system. The nodes in mobile adhoc network (e.g. Smartphone, laptops, tablets etc.) can always have multiple radio interfaces, although the conventional research-based study only consider single radio interface. Therefore, the proposed system considers multiple radio interfaces for connecting various mobile nodes and to increase data rates. In order to minimize any forms of radio frequency interference, the proposed PEMA considers smaller transmission range. The design of this part of the system will be based on message-oriented middleware system as well as to provide an asynchronous communication system between the communication mobile nodes. The prime focus of this part of the study is to develop an analytical modeling of power dissipation during the communication between the two mobile nodes. The intention is being to understand the cost involved in the transmission in ad hoc nature and give a proper solution to it and thereby present a robust middleware system. The proposed PEMA is a technique that will run over the mobile nodes to perform a certain operation which is mainly associated with communication control for ensuring power efficiency. PEMA will be responsible for reviewing the amount of various resources being used during routing and it will offer an empirical means of evaluating the following:

• **Time for Route Termination (TRT)**: This is the time witnessed after an established route expires.

• **Time for Stable Routing (TSR)**: This factor calculates the time between two nodes with sufficient residual power. We say stable routing to be only formulated between two nodes of sufficient level of remnant power.

• **Frequency of Route Error (FRE)**: This variable calculates the total number of the occurrences of error witnessed in a particular route.

• **Reduction in Signal Attenuation (RSA)**: This parameter checks for the level of drop of signal attenuation as a quality signal to be evaluated.

• **Remnant Network Lifetime (RNL)**: It is the approximated residual power of all the nodes in the simulation network. The system architecture used in PEMA is highlighted in Fig. 1, which shows that PEMA performs aggregation of the information for TRT, TSR, FRE, RSA, and RNL on every routing cycle. All these metrics are used for finalization of one probable route to be established, hence, PEMA is an algorithm of the first kind in MANET where the establishment of stabilized link depends on multiple parameters. All these parameters can be taken from the design of a control message.

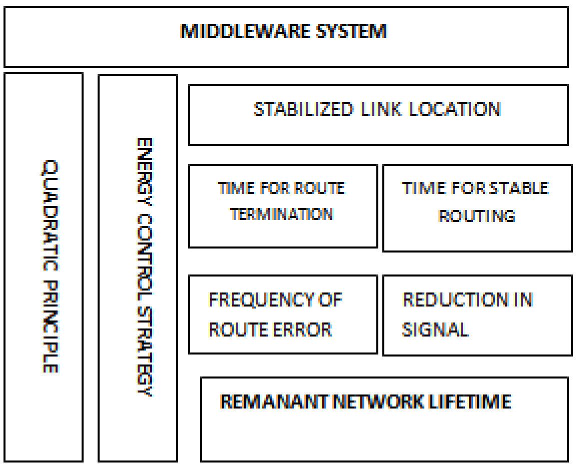

FIG.1: Architectural Scheme

shown in Fig. 1. Therefore, as a consequence PEMA minimizes the probability of broken links as now the routing technique have more decision parameters, which are not found in conventional power efficient routing protocols in MANET [21]. The mobile nodes are considered to follow the multi-path propagation of the message for faster message delivery in proposed schema. The next section discusses the algorithms that are designed for proposed middleware for power efficiency in mobile ad hoc network.

VI. Algorithm Implementation

This section discusses the implementation of the proposed PEMA. The proposed system considers n number of mobile nodes that are positioned in simulation area using random mobility model. The design of the algorithm mainly emphasized on accomplishing following components of middleware system in ad hoc network as Time for Route Termination (TRT), Time for Stable Routing (TSR), Frequency of Route Error (FRE), Reduction in Signal Attenuation (RSA), Remnant Network Lifetime (RNL). The brief discussion of the algorithms is as follows:

Algorithm for Time for Route Termination (TRT)
Input: n (number of nodes), r (transmission range), u1/u2 (node speed), φ1/φ2 (orientation of two nodes), α β γ, δ (orientation-based route termination parameters),
Output: Time for Route Termination.

Start
1. Init n, r
2. Init node speed u1 and u2.
3. Init direction φ1 and φ2.
4. Apply Random Waypoint
5. Applying quadratic principle
6. E1 =(α β+ β γ)
7. E2 $=|\sqrt{(\alpha^2+\gamma^2)}.\arg_{max} r^2-(\alpha-\gamma\beta)^2|$
8. E3 $=1/(\alpha^2+\gamma^2)$
9. $E=E_1.E_2.E_3$
10. TRT = $\arg_{min}|E|$

End

Normally, the termination of the route takes place owing to two reasons e.g. (i) dynamic topology, (ii) sudden node death. Hence, PEMA addresses both the problems by TRT algorithm. After suitable initialization of nodes (n), transmission range (r), speed and orientation of two communicating nodes (u1/u2 and φ1/φ1), we apply random waypoint as the mobility model and quadratic approach is considered for algorithm formulations. The prime reason behind the adoption of quadratic approach is

to incorporate optimization in the information for better middleware design. The system formulates three entities E1, E2, and E3 corresponding with the standard variables (a, b, c) in any quadratic approach. The parameter α computes the cosine difference of first node speed (u1·cos φ1) with second node speed (u2·cos φ2). Similarly, The parameter δ computes the sinusoidal difference offirst node speed (u1·sin φ1) with second node speed (u2·sin φ2).The parameter β and δ are the positional difference between two nodes and corresponds to x1−x2 and y1−y2 respectively. Finally, the time is computed that assist proposed middleware to decide about the selection process of a route during the route discovery process in mobile ad hoc network.

Algorithm for Time for Stable Routing (TSR)
Input: CE (Cut-off power of a node), ns/nd (nodes), Esd (remnant power of source-destination)
Output: Time for Stable Routing
Start
1. init CE
2. If Esd > CE
3. ns→nd
4. or else,
5. reject (nd)
6. search next(nd);
7. Evaluated time (ns→nd)

End

The TSR algorithm is responsible for exploring the total time found with the higher probability of stabilized link. An algorithm is designed with a cut-off power level of a node, which is a permissible battery level till which the node functions properly. It can be different for different applications. If the sender node finds the remnant power of its neighbor node to be less than cut-off power, it is believed that such link formation will not be reliable to carry forward the data and hence rejected. Hence, link formation is only supported by proposed middleware of the remnant power is more than cut-off.

Algorithm for Frequency of Route Error (FRE)
Input: rec_msg (RREQ), Cerr (Cut-Off Error)
Output:
Start
1. Capture rec_msg (nd) & Calculate BER
2. if (BER>Cerr)
3. remove those nodes
4. or else
5. Consider those nodes for communication

End

The above algorithm is responsible for the selection of route based on the error rate. In order to do so, our middleware system captures the control message from the communicating nodes and keeps on computing bit error rates. A cut-off error rate can be defined based on different applications which will be compared with accomplished BER. In the case of permissible limit, proposed middleware will give positive feedback for selection of such communicating nodes to establish a link.The next part of the implementation will focus on capturing the signal attenuation (in dB) (RSA) while the PEMA can keep on collecting the remnant power information of the entire node in the simulation for analysis purpose (RNL). The prime performance will be observed from the extent of power consumption in mobile ad hoc network.

VII. Results and Discussion

The outcome of the proposed system is evaluated with respect to power consumption per node in Joule and algorithm processing time in second. The proposed PEMA is compared with the frequently used AODV and OLSR routing algorithm by using uniform simulation parameters. The simulation study considers 500–1000 mobile nodes with a variation of 100–550 m of transmission range. With omni-antenna considered on each node, the initialized power is 0.5 J considering MAC protocol for IEEE 802.11 standard.

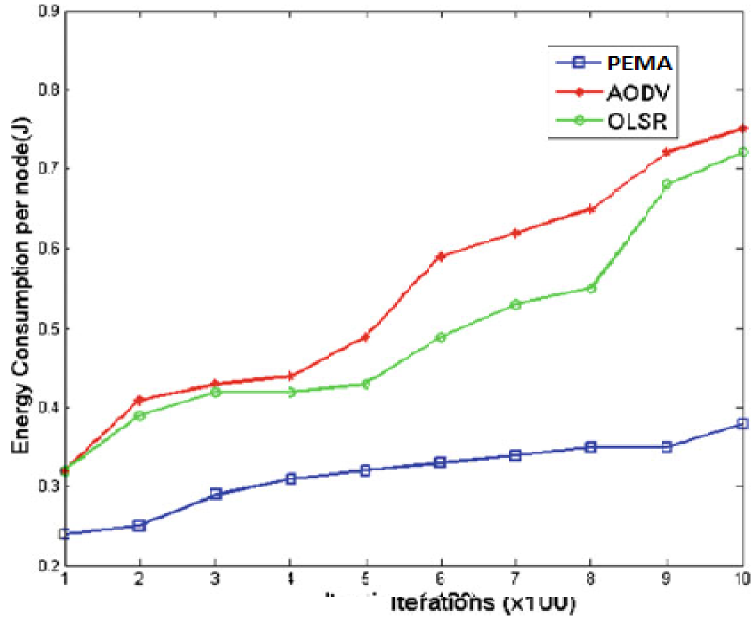

Fig.2 Comparative analysis of PEMA,AODV,OLSR(Power)

Figure 2 shows the comparative analysis for proposed middleware-based communication system on mobile ad hoc network with AODV and OLSR. The sequence number of AODV is higher but definitely not the latest, for which purpose each intermediate node has to allocate an extra power in case of broken links. Owing to a periodic delivery of control message, OLSR keeps more updated route entries compared to AODV, but it requires an extra processing power to do so. However, proposed PEMA undertakes this decision of routing based on Time for Route Termination (TRT), Time for Stable Routing (TSR), and Frequency of Route Error (FRE). Hence, the amount of information required to avoid re-routing as well as reliable communication is quite high enough compared to AODV and OLSR and hence can take decision faster thereby requiring less processing power. In increasing iterations, the middleware becomes less dependent on routing information and hence processing power increases in a very slower pace thereby restoring sufficient amount of power (Fig. 3).

Algorithm processing time is one of the significant parameter for scaling the efficiency of the proposed middleware system. The outcome shows that processing time of PEMA is considerably less than existing routing mechanism e.g. AODV and OLSR. Although delay for establishing the connection is less in AODV but it requires a massive channel capacity to process the message for 500-1000 mobile nodes. This increases the time of construction of routes. On the other hand, OLSR is not at all dependent on such control message to ascertain the link stability. Unfortunately, OLSR consumes more processing time to find out the unstable routes as well as any broken links. We address this problem in PEMA by using cut-off level of remnant power which avoids the routing decision to be made on less stabilized nodes. Similarly, the system performs continuous monitoring of Time for Route Termination (TRT) and Time for Stable Routing (TSR) that significantly accumulates up with relevant routing data thereby requiring fewer algorithms processing time. Moreover, the cut-off values are completely dependent on the application which means PEMA can be customized for any futuristic applications of MANET. From storage complexity viewpoint, the algorithm doesn't require more than 20–30 Kb of space for 5000 iterations. This fact will mean that proposed PEMA can be used for any low-powered embedded mobile device in ad hoc network. Therefore, the proposed middleware is found with higher power conservation, lower algorithm processing time and it is highly compliant of time and storage complexity from the performance of the PEMA viewpoint.

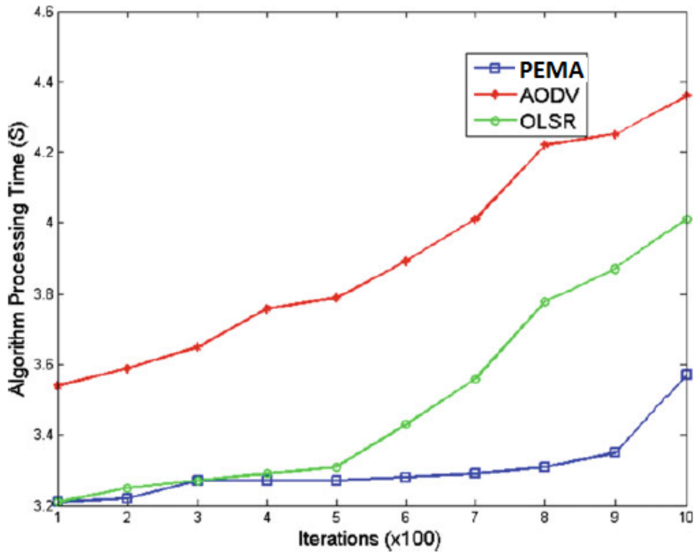

Fig. 3 Comparative Analysis of PEMA, AODV and OLSR (Algorithm Processing Time)

VIII. Conclusion

There are various adverse effect of dynamic topology where the outstanding one is on power efficiency and routing. For more than a decade there has been an enough evolution of various power efficient technique as well as the routing protocol for delivering better communication standards. However, till date, there is no such existence of power efficient routing that can overcome the adverse effect of dynamic topology in mobile ad hoc network. This paper appraises that there is an adoption of middleware and has been quite a common in mobile devices; however, there was a less attempt towards investigation of middleware towards power efficiency. This paper has introduced a technique called as PEMA that formulates multiple parameters e.g. Time for Route Termination (TRT), Time for Stable Routing (TSR), Frequency of Route Error (FRE), Reduction in Signal Attenuation (RSA), and Remnant Network Lifetime (RNL) for selection of stable routes. The outcome of the simulation study was compared with frequently used AODV and OLSR routing protocols to see superior performance in power conservation and lowered processing time.

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