A CROSS LAYER DESIGN FOR ENERGY EFFICIENCY IN PEER TO PEER APPLICATION OVER MANET

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ABSTRACT: *Recent development in communication technologies has brought a big change in the life of human beings. In this rapid era of human history, disasters are also happening very rapidly in the form of floods, earthquakes etc. In these circumstances, communication is a major issue among peoples. Mobile ad hoc networks are formed in these areas using laptops, mobile and handheld devices. Peer to peer network application is used as a big source of file sharing. When we deploy P2P network application over mobile ad hoc network it may perform poorly and consumes a lot of energy because both are operating on different layers. Both networks send their own messages for search and connectivity of peers and these messages are a big source of energy consumption. We propose a cross-layer design of peer-to-peer network over mobile ad hoc network which reduces the complexity and removes the duplication of routing messages gives the efficient results. In this research work, we used a well know ad hoc routing protocol Ad hoc On Demand Distance Vector (AODV) under a peer-to-peer network protocol Gnutella. A cross layer optimization has been made for these protocols to increase the energy efficiency. The results have been validated by using NS2 (Network Simulator). Results collected from this research work shows that cross layer optimization gives improved performance in case of Hit Rates, Number of messages received and energy consumption than the layered design approach.*

Keywords: Peer-to-Peer Network, Energy Efficiency, Ad hoc Network, *Ad hoc On Demand Distance Vector (AODV)*

I. INTRODUCTION

As communication technologies are increasing day by day, wireless and mobile devices are becoming most common communication media for all types of user communication. There are a wide variety of networks from PANs (Personal Area Networks) to VANs (Vehicle Area Networks) Jerome [1], clouds networks, Internet of things (IOT) and D2D [2] etc that are used for communication in our daily life. The hotspots, mobile networks and sensor networks exist with greater bandwidth and excellent data rate. In these networks, Peer-to-Peer (P2P) network are more important due to its efficiency and reliability for communication and file sharing. Although, P2P network was actually designed for wired network but due to growing demands of mobile users and improvement in wireless and sensor network technologies, these are used in almost all type of networks.

P2P networks are self-configuring and self-organizing networks Rudiger [3], mostly there is no central management system in these networks and resources are distributed between different peers. There is no single point of failure and these are used for file sharing in LANs to WANs. Two main types of P2P network are structured and unstructured. In a structured overlay network, the overlay has specific rules for nodes joining, leaving and for the routing between them. The overlay also controls the content placement, meaning that the location of the content is always known by the overlay. Unlike the structured networks, in the unstructured network nodes can leave and join easily.

Mobile Ad hoc Network (MANET) [4] is a network of mobile nodes for a limited time with limited resources. Mobile ad hoc networks are also self-configuring network and with dynamic topology. Mostly, these networks are formed for military operations, disaster recovery and accidental handling. In this network, every node works as a source of information, a router and drain for information. Users are equipped with PDAs, handheld devices, laptops and cell phones are communicating with low range devices. They can share their contents, files and other resources with each other forming a temporary network. P2P applications can be used to share these files.

P2P network applications are most commonly used in the wired network as an overlay network. There are large numbers of protocols that are used in these applications. Due to its flexibility, these are also used on ad hoc networks as well. P2P applications are deployed over a MANET as an overlay network where these applications use their own protocols for searching for nodes and contents as shown in Figure 1.

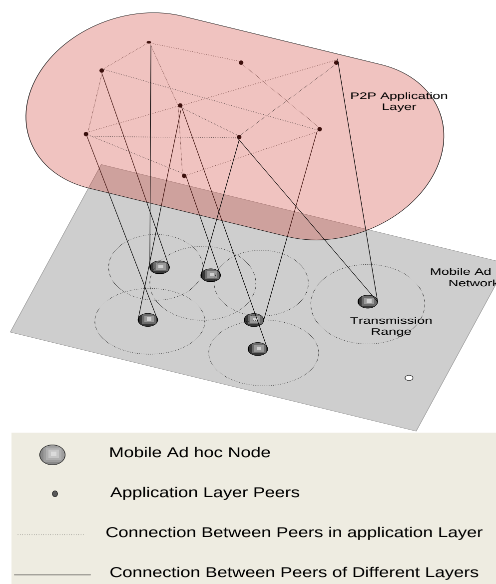

Fig 1: P2P Over MANET

One of the main problems of ad networks is energy limitation due to their less battery power. These nodes communicate with each other for limited time period and for specific tasks to perform. Files are shared using P2P network application that works as an overlay network over MANET. When P2P applications are deployed on MANET, these applications performs their own searching and querying mechanism for files. In the meantime, MANET also performs its own routing and searching mechanism. So in this way, redundant packets are generated for file searching by both networks that consume a lot of energy.

Cross-layer mechanisms are widely used for different purposes in P2P over MANET [14]. With cross layer technique, different layers of OSI model coordinate with each other irrespective of their position in the OSI model. Due to constraints on memory, energy and low transmission range of ad hoc nodes, cross layer approach seems to be more effective.

As we discuss that redundant messages are generated by both P2P and MANET, we reduced these redundant messages generation that saves a lot of energy. We proposed cross layer mechanism that reduces these redundant messages generation to save energy.

The rest of paper is organized as section II describes the related work and proposed mechanism is explained in section three. Simulation results are shown in section IV and section V conclude the paper.

II. Literature Review

A lot of work has been done in the field of mobile ad hoc network and peer-to-peer network. There are a number of protocols that have been proposed and used in these fields. But in these papers, most of the people concentrate on one mobility model which is random waypoint mobility model. Seddiki et al.[5] worked on minimizing the effect of the highly dynamic topology obtained through the combination of P2P networks and mobile ad hoc network. He proposed cross layering for configuration of these networks. He uses the random waypoint mobility model with peer-to-peer protocol Gnutella and ad hoc routing protocol OLSR [16] in a network simulator. It shows that in fast mobility the situation becomes worse for peers to keep connectivity and energy consumption becomes high. Choung Lu [6] discusses the energy efficient routing in coordination with sleep scheduling at the link layer. This paper describes how sleep scheduling can affect the overall network energy efficiency. They used 2-D grid topology and time division multiple access (TDMA) medium access control to demonstrate the effectiveness of integrated routing and sleep scheduling. Vasanthi et. al. [7] presented a performance comparison of mobility models for wireless sensor network. It provides a survey of different mobility models and describes the movement of the different mobile mode in the network. They also discussed the advantages and disadvantages of these mobility models and proposed future model also.

Shubham Sharma [8] presents an energy efficient path formulation for mobile ad hoc network. The author proposes a novel path selection approach called Source to Destination Energy Efficient Path (SDEEP) [17] selection that minimizes the number of hop in path selection. This technique presents a comparison of DSR [18], EPAR [19] and LAER [20] routing protocols for energy efficiency and the author concludes that new technique performs batters than all other techniques. But the author does not use a different type of mobility patterns to investigate the energy consumption.

Bin et al [9] described an integrated approach for peer-to-peer network file sharing using

FastTrack over an ad hoc routing protocol like AODV. In this approach, the main idea is to find the mobile node that has requested file and then the formation of the complete route to that node to get the file. It tried to limit the number of redundant messages as minimum as possible. In this simulation, a random waypoint mobility model was chosen. Only one scenario of mobility model was chosen for the performance of ad hoc routing protocol AODV. Rashid et al. [10] use the three mobility models random waypoint, probabilistic random walk, freeway mobility model in the evaluation of peer-to-peer network over mobile ad hoc network. He varied parameters for mobility models and a peer-to-peer network to evaluate the performance of protocols. It showed that the mobility models have a great impact on the performance of the routing protocols. It is necessary that proper mobility model should be used when nodes are moving.

Kim, Dohyung, et al. [11] presents an information-centric Networking (ICN) [15] for information distribution with low bandwidth consumption in the wired network. Author consider the unicast and broadcast technique to observe the energy consumption and proposed a novel mechanism that distributes the contents in unicast mode by avoiding the broadcasting features. This scheme performs batter in ICN application to reduce the energy consumption.

From the literature survey, it is clear that some researchers have used energy efficient mechanisms in mobile networks. The peer to peer networks are mainly used in wireline network where energy consumption is not a big issue but when they are applied on ad hoc networks then they consume more energy. They face the problem of link breakage, change in network topology, network partition and mobility of nodes. All of these events consume a lot of energy. When we deploy peer to peer network over mobile ad hoc network it faces above problems and nodes has less power so sometimes nodes may be not reacting.

Mobility models provide the necessary components for the simulations that are why a number of mobility models have been presented by the researchers. These mobility models try to present an environment that truly represents some of the components of the real world. It needs that a proper mobility pattern should be used to adopt different mobility scenarios so this will also reduce the energy consumption. If a proper mobility model is adopted during movement then unnecessary messages can be avoided and this energy can be saved.

III. Proposed architecture

When we deploy a peer-to-peer network application over a mobile ad hoc network routing protocol it faces the problem of routing overhead due to redundant message passing by both of this network. These redundant messages spent a lot of energy. So, to overcome these problems created by this complex and complicated network a cross layer optimization approach is adopted. The basic model of this technique is shown in the following figure.

Peer-to-peer network routing protocol has been deployed on the ad hoc routing protocol. In this cross layer model, the information exchange is done by creating new interfaces between application and network layer, so these layers can take benefit from each other. The information flow between these layers is in both directions and these layers share their data with each other to reduce the routing overhead. In a strictly layered approach, the components of the system are totally independent of each other and perform their functionalities independently and interact with each other using specific interfaces.

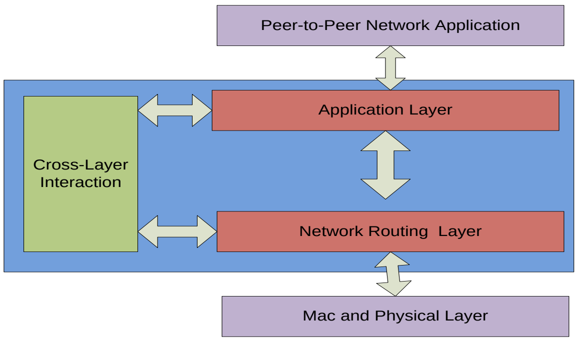

Fig 2: Proposed Cross-Layer Model

But peer-to-peer network over mobile ad hoc network using cross layer design has a different strategy from the layered approach. In cross layer design as shown in figure 3b, we improve the performance of Gnutella protocol by sending and receiving the routing information to the lower layer. As Gnutella is an unstructured overlay routing protocol for peer-to-peer networks, when we use Gnutella in ad hoc environment it faces the problem of peer discovery as the main issue. This discovery mechanism based on application layer flooding, increases the routing overhead therefore in high mobility areas Gnutella do not react properly. The peer discovery and link selection procedure of Gnutella are redesigned so that this can interact with a routing agent at the network layer. The following figure shows the complete design of cross layer framework.

We used two new classes for cross layer data exchange (as in above figure 3). In this model, we used to publish and subscribe scheme to exchange peer information between two different protocols.

Routing messages like Hello and peer discovery are sent to neighbor nodes. We used a call back function to get the cross layer data from the protocol. A call-back is a function that is stored in the library and can be fired at a later time. The cross layer interface does not generate its own information it just works as an intermediate between two protocols.

The cross layer interface is responsible for collecting the subscribe events from the Gnutella protocol and work with network layer protocol to get the information requested by the Gnutella layer. These events are responsible for notifying Gnutella peer about the recent peer information from the other peers. Peers at the application layer connect with other peers for finding files and it also keeps connectivity with other peers. If the corresponding peer is not available then it sends peer request messages to other peers. Application layer protocol is also responsible for sending application layer to subscribe messages to ensure its peer's connectivity alive. There are a different type of messages that are exchanged between two layers route request messages, route reply messages and hello messages.

As in the layered design approach of the peer-to-peer network over mobile ad hoc network, there is a problem of routing overhead due to lack of inter-layer communication. Both of these networks have a different perspective because they are operating on the different layers. So this redundant messages generation has been overcome by the use of cross layer design of the mobile peer-to-peer network. This framework has been used for the evaluation of different mobility model of ad hoc networks.

3.1. Cross-Layer Gnutella (Cl-Gnutella) Operation

When we use the cross layer interface in the protocol stack then we can take benefit from the network topology information to find the files and peers in the network. The approach, used in this work is inspired by cross layer design of XL-GNU (Marco et al., 2005) [12], but it is different because XL-GNU used proactive routing mechanism. In this research, a reactive routing protocol is used to collect the information about the nodes or peers in the network. We develop a cross layer design CL-Gnutella application using AODV as network layer protocol. A local publish and subscribe event mechanism is used to exchange the data between network layer and application layer. The peer receiving the information checks its local cache for the requested file if it finds then it precedes this content to the requesting node. If this information is not present in the local cache then application layer introduce search in network layer by sending routing layer messages.

There are two different types of operations that are performed in this network, the Gnutella operation at the application layer and AODV routing operation at the network layer. CL-Gnutella takes the information from the subscribe event of the application layer and this information is shared with routing agents so that requested peer information can be obtained. When CL-Gnutella collects the right information about the subscription then it sends this information to the application layer.

3.1.1 Application Layer Functionality

The application layer of the system is responsible for contacting with other peers for files and it also manages the connections among peers. If the peer does not find any information about the peer to contact then application layer instruct routing agents to launch the search operation to find the peers that have requested data.

Application layer also generates triggers for application layer subscribe messages so that updated peers information can be obtained. This peer information is much helpful for finding the contents when a peer wants to get a file or other peer information.

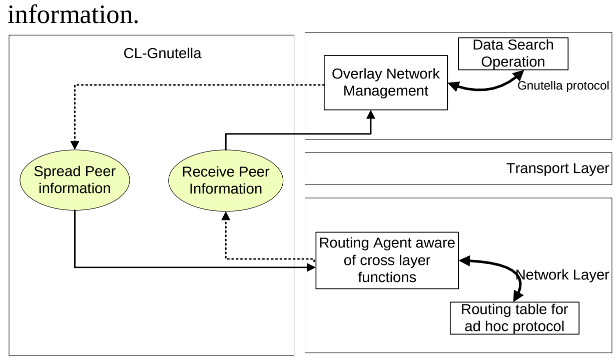

Fig. 3. Cross layer Operation

3.1.2 Network Layer And Cross Layer Functionality

The network layer or routing layer is used to get the peers information when CL-Gnutella instructs to get the peer or file information. When we want to download a file a node x, if node x does not have information about file then the application layer instructs the CL-Gnutella to search for the file using route discovery messages of AODV. This propagation for search is limited by using the time to live (TTL) method. If a node receives this message and it has this file then it will send a reply message to the client. A peer must have contacted with its peer cache before launching the search operation so that a valuable time can be saved. When a node has a particular file it sends this information to other peers in Hello message that are sent out periodically. Other nodes which receive this information update their peer cache information.

IV. Implementation and performance evaluation

We choose an open source discrete event Network Simulator NS2 and ProtoLib (Protolib) [13]. A peer-to-peer network application is built in NS2 using Gnutella as an overlay network and routing protocol chosen from ad hoc network is AODV. We take a network size of 300x300 m 2 and default numbers of nodes are fifty. Half of total nodes are on at every time and every node has five files to share in the network. The transmission range for each node is 50m and total simulation time is 300 seconds. We develop a P2P network application for mobile ad hoc network then a cross layer optimization is applied on this network to decrease the energy consumption. These results have been compared and it is shown that performance of the whole network is increased and energy consumed in with cross layer optimization is the less than the existing system.

We used the following performance metrics to evaluate the Peer-to-peer network over Ad hoc network.

- Network workload: It shows the workload of peer-to-peer network application in the network. It affects the energy consumption as an increase in workload may increase energy consumption.
- Peer node mobility: It can be described as the speed and pause time that is applied to the network. In this experiment, we have changed the speed by using values like 1, 2, 3 and up to 9 meters per second. The time taken by a packet to reach its destination including route acquisition time is calculated.
- Response time: The response time is the total time spent for a specific incident to occur when some input is applied. These events may query-hit or reception of an answer for the file. When network size increases then the response time for query-hit also increases.

There are used two mobility model to simulate our results first is most popular Random Waypoint mobility model and the second is freeway mobility model. In Random Waypoint model nodes are moving a randomly with having any proper direction. In freeway mobility model to avoid a collision, the speed of a vehicle cannot exceed the speed of the vehicle ahead of it. Moreover, in some targeted MANET applications including disaster relief and battlefield, team collaboration among users exists and the users are likely to follow the team leader. Therefore, the mobility of mobile node could be influenced by other neighboring nodes. Figure 4 shows the hit rate of MANET routing protocol under a peer-to-peer network application. As we see from the figure that coss-layer approach improves the hit rate as compared to a layered approach. In Freeway mobility model has less hit rate as it is has been designed for vehicular network and node speed is almost high then the other mobility model.

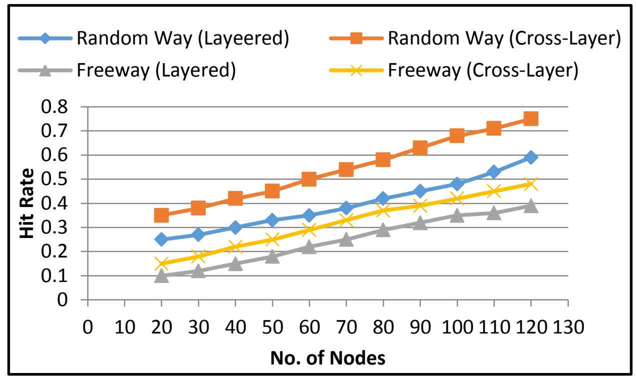

Fig 4: No. nodes and Hit Rate

In figure 5 we represent the number of nodes and number of messages a received using existing and proposed model. The figure shows that cross layer model improves the number messages received in either case random waypoint mobility model or freeway mobility model. We used 20 to 120 number of nodes to show the successful delivery ratio of messages.

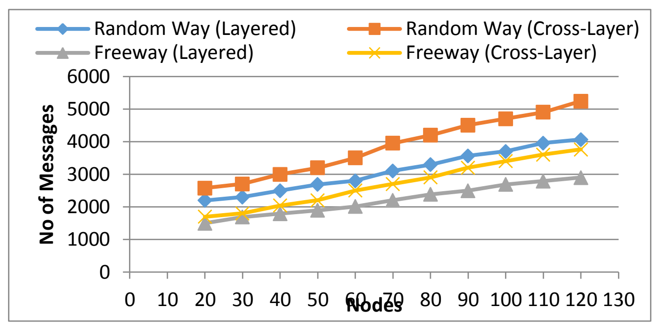

Fig 5: Number of nodes verse number of messages received

In figure 6, we calculate the amount of energy consumed when nodes are moving.

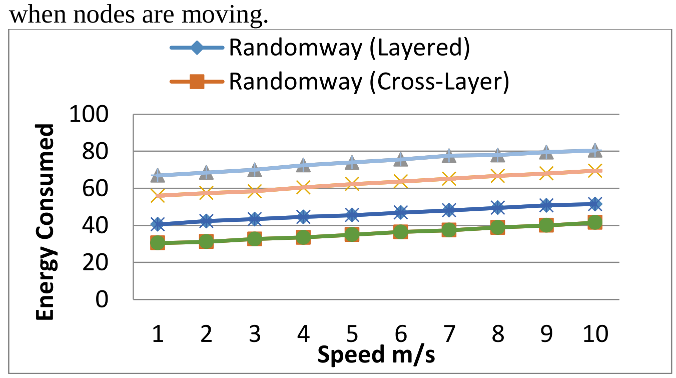

Fig 6: Node speed and energy consumed

In case cross layer optimization less energy is consumed. While in the case of layered design more energy consumed. It is concluded that cross layer design reduces the energy consumption.

V. CONCLUSION

In the layered design approach for the peer-to-peer network over mobile ad hoc network, there were the problems due to lack of inter-layer communication. Both of these networks have a different perspective because they are operating on the different layers, due to these reasons redundant messages are generated which consume the more energy. To solve these problems a cross layer design approach has been adopted. Coordination between these two layers (application and network layer) has been made by creating a cross layer interface. Results show that cross layer optimization improves the performance of the system. It improves the hit rate and a number of messages sent and reduces the energy consumption. We compared the results with layered approach that indicates that cross layer optimization reduces the energy consumption.

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