Cross-Layer Design For Energy Efficient Multi-Cast Mobile Ad Hoc(MANET) Networks

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Abstract‑ **The reliability of delivering packets through multi-hop intermediate nodes is a significant issue in the Mobile Ad Hoc Networks (MANETs). The protocols used in mobile ad-hoc networks are based on the layered architecture. The layered approach is highly rigid and strict since each layer of the architecture is only concerned about the layers immediately above it or below it. Recent wireless protocols rely on significant interactions among various layers of the network stack. A cross-layer design (CLD) introduces stack wide layer interdependencies to optimize network performance. The CLD use the state information flowing throughout the network stack to adapt their behavior accordingly. In this paper, CLD based architecture is proposed, where the objective is to provide a solution for power conservation, congestion control, and link failure management. As main contribution, analyze the integration of Bandwidth utilization and clustering schemes to support multi-hop communication in large-scale ad hoc networks. The link quality is determined by the received signal strength at the physical layer. The channel interference, contention and Request to send /Clear to send packets of the MAC layer are used to determine the transmitting power and ensure the Quality of Service at the application layer Network Simulator 2(NS2) is used to simulate the performance Quality of Services. The simulation result shows the Energy conservation and average end to end delay.**

Index Terms: MANET, Wireless video streaming, cross-layer design, QoS, MAC layer, Network layer.

I. INTRODUCTION

The gigantic technological rejuvenation of wireless communication 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. [13]The CAR technique is a practical example of cross layer approach based protocol designs on the XCP architecture. It is proposed for providing end-to-end connections incorporates two cross-layer approaches: 1) between MAC and CAR layers, 2) between CAR and TCP layers.

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. 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. [3]With the growing availability of IP based heterogeneous wireless access technologies, increasing number of mobile devices will be

equipped with multiple wireless network interfaces, such as IEEE 802.11, 802.16, 802.15, B3G, etc.

As adhoc on demand distance vector routing (MAODV) protocol in MANET is an efficient and on demand protocol, that supports immediate service for communication. Authors proposed a well designed and developed improved MAODV concept. In MAODV 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 MANNET

II.CROSS LAYER CONCEPT

It may be required to accept new approaches in which the protocols can be designed by violating the reference layered architecture allowing direct communication between protocols in non adjacent layers. Such violation of a layered architecture is termed as cross-layer design (CLD) sometimes called Delay-erred model .

Cross-layer feedback means interaction of a layer with any other[16] layer in the protocol stack. A layer may interact with layers above or below it. Weak Cross-layering: enables interaction among establishment at separate layers of the protocol stack; it thus represents a generalization of the closeness interaction concept of the layering paradigm to include "non-adjacent interactions". Strong cross-layering: qualify joint de-sign of the algorithms implemented within any entity at any level of the protocol stack where cross-layering optimization can lead to loss of independent

features related to different layers. Potentially, powerful cross-layer design may provide higher performance at the expense of narrowing the possible deployment outline and increasing cost and complication.

The cross layer design (CLD) approach is a new dynamic area of analysis into MANET networks. This approach provides new possibilities to increase the performance and adapt-ability of MANET . Evolutionary approach to cross layer design is based on extending the layered structure to maintain compatibility with existing systems and networks. Examples are Layer Triggers, Event Helix Protocol, Mobile Man Project, [2]physical layer cooperative communications, there are three transmission manners in MANETs: direct transmissions multi hop transmissions and cooperative transmissions Joint Secure Channel coding and designing a mobile broad-band wireless entry network. Revolutionary approach is not based on extending the layered structure. Hence, it is free from any existing execution. Examples are wireless sensor networks (WSNs) and Shannon Mappings. Evolutionary approach to Cross Layer Design is based on expand the layered structure to maintain the similarity with existing systems and networks.

Cross Layer Design(CLD) intricate, mainly the combination of Network-Transport, Physical-MAC-Network combinations. Hence, their functionalities are also limited. There is no complete CLD solution covering issues like - fault tolerance, congestion control, energy minimization, flow control and power conservation. The main drawback of poorly framed cross-layer design are unstable system (tightly coupled protocols), uncontrolled stack design and mistaking implementation which degrades their performance. If proper care is not taken for CLD, it can create loops through unintentional interactions between different layers of the system. As destiny design improvements are impossible, it will be difficult to find out exactly how a new modification will affect the overall system operation.

Layer triggers are commonly used in both wired and wireless network because of their low cost and ease of implementation and similarity with original inflexible layered structure. Predefined signals used to inform special events between protocols are named as layer triggers. For example - The Explicit Congestion Notification (ECN) bit. Event Helix Protocol Design – It is based on incorporating cross layer design principles used in CLD protocols. It uses equalized interface between

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different layers, and is able to decouple the separate protocol layers. In Event helix design, layers can be inserted or re-moved without changing the implementation details of individual layers. For example encryption need not be supported by application, substitute and IP security layer is inserted between the Network layer and Data Link Layer.

Mobile Man project design goal is to maintain the satisfaction of a modular architecture without modifying each layer's core function for a robust upgrade environment. In this paper, authors aim to avoid duplicating efforts for accumulate, internal state information, increased local interaction among protocols, minimized remote communications leading to saving network bandwidth. Joint Secure Channel coding (JSCC) - shares information between source coder, the channel coder and exploit soft information from the Physical Layer. [7]Most research use pre-fetching strategy to assist solving the interactivity problem for multimedia streaming. Researchers have proposed a hierarchical pre-fetching scheme for popular or sub-popular segments in , which is based on the assumption that the popular or sub-popular segments will be visited more often with random-seek. Christo Ananth et al. [9] discussed about Reconstruction of Objects with VSN. By this object reconstruction with feature distribution scheme, efficient processing has to be done on the images received from nodes to reconstruct the image and respond to user query. Object matching methods form the foundation of many state- of-the-art algorithms. Cross layer designs avoid duplicating efforts to gather internal state information leading to a more efficient design. Cross layer design are based on knowledge derived from wireless networking, signal processing and information theory fundamentals. [6]Peer-to-peer (P2P) technology has been proved to be an effective and resilient approach for media streaming in dynamic and heterogeneous network environments

Fig 1 There are three different cross layer designs: Direct Communication between two adjacent layers, Shared database and Heap architectures of completely novel approaches as shown in Fig . In Direct Communication, shared variables, inside packets or layer triggers may be used. In shared database approach, methods exist to retrieve/insert data from/into the common data-base. Heap architectures exploit new concept for protocol information sharing. The specific characteristics of MANET leads to problems that

the CLD is trying is solve, when the solutions can be divided into the following areas :
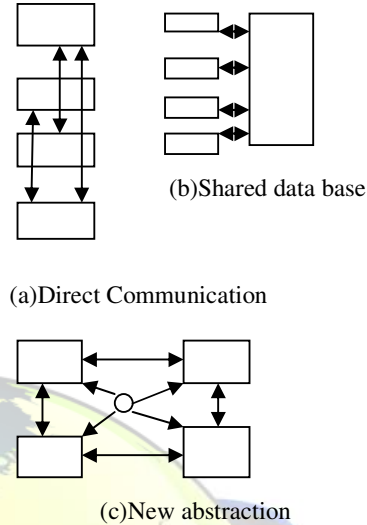

(b)Shared data base

(a)Direct Communication

(c)New abstraction

Fig 1.Cross layer designs Types

A .*Adaptation and self organization*

The system may be called adaptive if they can regulate to dynamically changing topology, shared medium contention, varying traffic patterns and distributions while keeping their organization as much as possible intact. Due to presence of decentralized self-determining entities operating in dynamic environment, MANET nodes spontaneously create a globally coherent pattern out of local interactions.

B. *Mobility*

In mobility models, nodes present behavior as per definition of underlying mobility model and this greatly impacts overall network configuration and capacity.

C. *Energy Control or power Control*

Power consumption is the most suitable metric to be adopted by a routing decision in MANET. Hence, the need appear to develop a cross layer design for Power conservation.

D. *Different QoS requirements*

Delay, jitter, system buffer, network/system bandwidth and error rate are disparate QoS constraints. Bandwidth, latency,

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jitter and loss are network layer QoS. Different traffic behaviors have their particular QoS requirements.

E. *Security*

Security aims to remove multiple layers of encryption and security attack. Security represents one of vital QoS dimension.

III. CROSS LAYER PROPOSED METHOD

The proposed a cross layer mechanism between the data link layer and the network layer by introducing a friendly packet between the two layers. To overcome 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. [1] Generally speaking, cross-layer design refers to protocol design done by actively exploiting the dependence between protocol layers to obtain performance gains

A. *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. [14]Traditionally, network protocols take a strictly layered structure and implement congestion control, routing and scheduling independently at different layers.

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.

B. *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). 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.

C. *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.

D. *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.

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N E T W O R K L A Y E R

Channel Sensing	Database Handler	Routing Decision

Power and Delay Optimized AODV Protocol

BRL	NND	SNR	RTS / CTS

D A T A L I N K L A Y E R

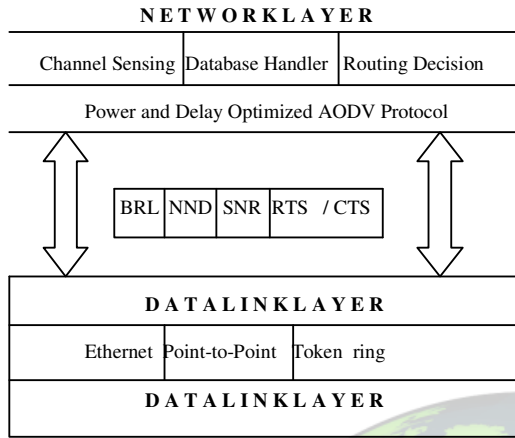| Ethernet	Point-to-Point	Token ring

D A T A L I N K L A Y E R

Fig 2 .Cross layer communication

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. [4]Superchunk-based efficient search Network (SURFNet). Since data at each peer is quite limited, it is possible to group peers storing the same data together in an appropriate granularity.

IV.SIMULATION RESULTS

Network Simulator, NS2 is used for the demonstration . The simulation area is a square and the nodes are placed uniformly. Each node chooses a random point and moves towards that point with non-specific speed chosen between minimum and maximum values. The nodes use distributed coordination function of IEEE 802.11 standard with RTS/CTS extension. Simulations are executed for 1200s for three rounds at varying values. The parameters along with the corresponding values that are considered to carry on the simulation are enlisted in given graph structures.
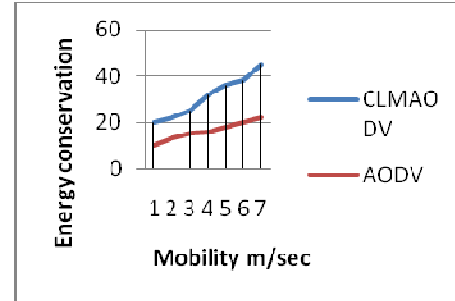

Fig 3 Energy Conservation

The above graph shows the Mobility Vs Energy conservation method of CLMAODV and MAODV. Further the graph shows CLMAODV is 60% better than the MAODV
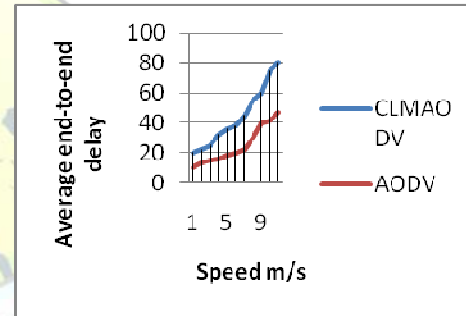

Fig 4 Average end to end delay

The above graph shows the Speed Vs Average end-to-end delay method of CLMAODV and MAODV. Further the graph shows CLMAODV is 75% better than the MAODV

V.CONCLUSION

The high mobility and heterogeneous nature of the ad-hoc network results in crash. The proposed cross-layer design is aimed to provide a solution for unidirectional link non-success management, reliable route discovery, and power conservation. The link quality can be forecast by the received signal strength from the physical layer. The links having low signal strength can be throw out from the route selection. From the MAC layer, the minimum power required can be estimated by performing RTS/CTS packet exchange. Based on this, the application layer can readjust the transmission rate, to avoid crash.

One of the successful methods to reduce collision is to accompany the cross-layer design to achieve greater network capacity and spatial reuse. The proposed cross-layer design makes the

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MAODV routing protocol to hold on with heterogeneously powered ad-hoc networks by identifying and rejecting the asymmetric links at the RREQ broadcast stage itself. The most important reality is the network designers who must list down the conditions under which cross layer design would improve the performance. To make accurate assessment of the state of the network efficient mechanisms need to be built into the protocol stack.

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