

Enhancement in Cross-Layer Routing In Mobile Adhoc Networks

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Abstract--As Mobile Ad hoc Networks (MANETs) gains popularity, the need for suitable ad hoc MAC and routing protocols will continue to grow. Cross-layer design is an emerging proposal to support flexible layer approaches in MANETs. Various algorithms were proposed to improve the packet delivery ratio and fairness among flows for multi-hop ad hoc networks through cross-layer interaction between MAC and the routing layer. The routing information about bandwidth, channel capacity, received power and distance to reach its destination could be exploited by the MAC layer in order to give priority to the packets that are closer and appropriate to their destination. In this work I am going to exploit bandwidth information by the MAC layer in order to find out the best route for multimedia data. Normally shortest route is computed in network layer routing, whereas my problem here is to find out adequate "bandwidth" route required by multimedia traffic instead of finding a shortest route. Then, with the help of performance metrics like packet delivery ratio, average end-to-end delay and normalized routing load, it will be shown that cross-layering between MAC and routing layer performs much better than using routing layer and MAC layer separately. I am going to use NS2 for the implementation of the said problem.

Key words: AODV, MANET, ad hoc network, routing, CLD

I. INTRODUCTION

A. Overview of Mobile Ad Hoc Networks

A Mobile Ad Hoc Network (MANET) is a set of mobile nodes that perform basic networking functions like packet forwarding, routing, and service discovery without the need of an established infrastructure. All the nodes of an ad hoc network depend on each another in forwarding a packet from source to its destination, due to the limited transmission range of each mobile node's wireless transmissions. There is no centralized administration in ad hoc network. It guarantees that the network will not stop functioning just because one of the mobile nodes moves out of the range of the others. As nodes wish, they should be able to enter and leave the network. Multiple intermediate hops are generally needed to reach other nodes, due to the limited range of the nodes. Each and every node in an ad hoc network must be keen to forward packets for other nodes. This way, every node performs role of both, a host and a router. The topology of ad hoc networks is dynamic and changes with time as nodes move join or leave the ad hoc network. This unsteadiness of topology needs a routing protocol to run on each node to create and maintain routes among the nodes.

B. Mobile Ad Hoc Networks' Characteristics and Challenges

MANETs have several major characteristics and challenges. They are as follows:

- 1) Dynamic topologies: Nodes are allowed to move randomly. Thus, the network topology may change randomly and rapidly at unpredictable times.
- 2) Bandwidth-constrained, variable capacity links: Wireless links have significantly lower capacity than their hardwired counterparts. In addition, the observed throughput of wireless communications, because of the effects of multiple access, fading, noise, and interference conditions, is often much less than a radio's maximum transmission rate.
- 3) Energy-constrained operation: Most of all the nodes in a MANET may rely on batteries or other exhaustible means for their energy. For these nodes, the most important system design optimization criteria may be energy conservation.
- 4) Security: Mobile wireless networks are generally more prone to physical security threats than fixed-cable networks. The increased possibility of eavesdropping, spoofing, and denial-of-service attacks should be carefully considered.

These characteristics and challenges create a set of essential assumptions and performance concerns for protocol design which extend beyond those guiding the design of routing within the higher-speed, semi-static topology of the fixed Internet.

C. Cross-Layer Design (CLD) In Wireless Networks

Cross-layer design is said to be the violation of the layered architecture in order to get some improvements in the network parameters. In literature the cross-layer design is defined as follows:

Definition: Protocol design by the violation of layered communication architecture is cross-layer design with respect to the original architecture.

- 1) Violation of a layered architecture involves giving up the luxury of designing protocols at the different layers independently. Protocols so designed impose some conditions on the processing at the other layer(s).
- 2) Cross-layer design is defined as a protocol design methodology. However, a protocol designed with this methodology is also termed as cross-layer design.
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For example, let us consider a model in the fig.1 which consists of three layers viz. layer-1, layer- 2 and layer-3 and follows the traditional layered architecture. Layer-1 is the lowest layer which provides its services to the layer-2 and layer-2 provide service to its layer just above it i.e. layer-3 via well-defined interfaces which exists between layers. If we define an interface which can communicate directly between the layer-1 and layer-2 bypassing the layer-2 then it is the violation of the layered protocol and hence it is a cross-layer design. While doing this the designer must

take care of the headers which are combined at the layer-2 (as layer-2 is responsible of various operations and convert the layer-1 frame as required by the layer-3 by adding its own header).

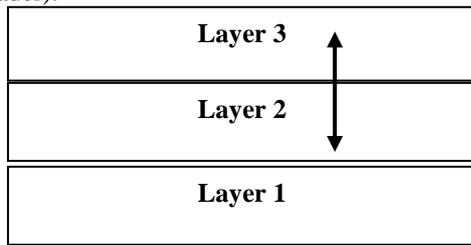


Fig. 1: Cross-layer design between layer1-3

A big picture of the cross-layer design in the wireless network can be seen in the Fig .2 which shows all the five layers in the wireless protocol stack.

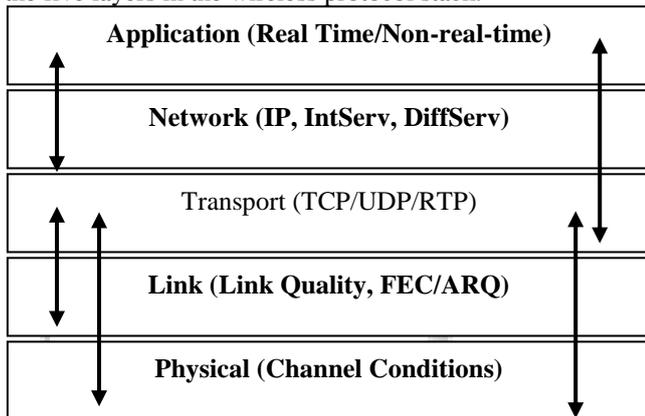


Fig .2: Cross-Layer for wireless protocol stack

D. Challenges Involved In Cross-Layer Design (CLD)

Here We Will Be Discussing The Challenges Offered By The Architecture To The Researchers. For Pointing Out The Challenges In This Section, We Came Across Various Design Proposals Given In The Literature And Found Some Initial Ideas On How Cross-Layer Interaction Can Be Implemented. The Following Are the Challenges

- 1) How To Identify The Most Important Cross-Layer Design Technique Which Best Fit For Our Model?
- 2) How to Achieve Better Network Performance?
- 3) Have We Made The Cross-Layer Proposal After A Detailed Study Keeping In Mind All The Effects Of The Layer-Interaction On The Parameters Of Different Layers And On The Overall Network?
- 4) Which Layers Of The Protocol Stack Should Be Involved In The Cross-Layer Proposal?
- 5) Whether We Should Go For The Deployment Of New Interfaces Bypassing The Adjacent Layers Or For Merging Of Layers?
- 6) How These Non-Adjacent Layers Will Communicate With Each Other?
- 7) What Information Should Be Exchanged Across Protocol Layers and How Frequently This Information Exchange Should Take Place?
- 8) What Are The Adequate / Efficient Procedures To Exchange This Information?
- 9) How to Counter the Loss of the Respective Header Which Will Be Lost When Direct Communication Takes Place between the Non-Adjacent Layers?
- 10) What Is The Trade-Off Between The Improved Network Performance And The Loss Of Modularity?

II. RELETED WORK

Cross-Layer Metrics for Reliable Routing in Wireless Mesh Networks proposed a novel routing metric, Expected Forwarded Counter (EFW), and two further variants, to cope with the problem of selfish behavior (i.e., packet dropping) of mesh routers in a WMN. EFW combines, in a cross-layer fashion, routing-layer observations of forwarding behavior with MAC-layer measurements of wireless link quality to select the most reliable and high-performance path. Authors evaluated the proposed metrics both through simulations and real-life deployments on two different wireless testbeds, performing a comparative analysis with On-Demand Secure Byzantine Resilient Routing (ODSBR) Protocol and Expected Transmission Counter (ETX). The results shown that poposed cross-layer metrics accurately capture the path reliability and considerably increase the WMN performance, even when a high percentage of network nodes misbehave. [1]

Delay-Guaranteed Cross-Layer Scheduling in Multihop Wireless Networks proposed a cross-layer scheduling algorithm that achieves a throughput to the optimal throughput in multihop wireless networks with a tradeoff in average end-to-end delay guarantees. The algorithm guarantees finite buffer sizes and aims to solve a joint congestion control, routing, and scheduling problem in a multihop wireless network while satisfying per-flow average end-to-end delay constraints and minimum data rate requirements. This problem has been solved for both backlogged as well as arbitrary arrival rate systems. [2]

Cross-Layer Schemes for Reducing Delay in Multihop Wireless Networks addressed how to minimize end-to-end delay jointly through optimizing routing and link layer scheduling. Authors have presented two cross-layer schemes, a loosely coupled cross-layer scheme and a tightly coupled cross-layer scheme. In the loosely coupled cross-layer scheme, routing is computed first and then the information of routing is used for link layer scheduling; in the tightly coupled scheme, routing and link scheduling are solved in one optimization model. The two cross-layer schemes involve interference modeling in multihop wireless networks with omni-directional antenna. A sufficient condition on conflict-free transmission is established, which can be transformed to polynomial-sized linear constraints, and a linear program based on the sufficient condition is developed. [3]

Cross Layer AODV with Position based Forwarding Routing for Mobile Adhoc Network designed a MAC layer based approach to calculate the received power of the packets from other nodes. If the power of the packets is not sufficient (We determine a threshold value for received power based on observation) then MAC layer informs the network layer which interns removes those nodes from the routing table. Experiments are performed in OMNET++. Here, AODV-PF is presented which is a hybrid routing scheme that integrates the characteristics of on-demand and with cross layer based power management. AODV-PF shows great scalability for mobility. It is demonstrated through simulations that AODV-PF outperforms on-demand routing protocols (AODV) in various constraints such as control overhead, throughput, latency when simulated with pause time and different loads. AODV-PF sustains high packet delivery rates. In terms of

routing overhead, AODV-PF has scalable routing overhead for mobility, random packet loss, and traffic load, thus utilizing the channel efficiently. [4]

Performance Analysis of Cross-Layer MAC and Routing Protocols in MANETs. Cross-layer design is an emerging proposal to support flexible layer approaches in MANETs. LEMO (Less remaining hop More Opportunity) algorithm was proposed in this paper to improve the packet delivery ratio and fairness among flows for multi-hop ad hoc networks through cross-layer interaction between MAC and the routing layer. The routing information about the total hops and the remaining hops required by a packet to reach its destination is exploited by the MAC layer in order to give priority to the packets that are closer to their destination.

This paper compared the performance of LEMO algorithm by using DSR and AODV protocols at the routing layer and varying the mobility and the load conditions. [5]

III. PROPOSED WORK

A. Cross-Layer Proposal

While reviewing various works by the researchers, we came across a large number of cross-layer designs proposals. A classification of such proposals are based on the layers that are coupled by the different proposals can be found in literature. This section gives a classification of the existing cross-layer design proposals according to the type of architectural violations they represent in the design. We assume here that the reference architecture has the application layer, the transport layer, the network layer, the link layer which comprises the data-link control (DLC) and medium access control (MAC) sub-layers and the physical layer with all the layers performing their generally understood functionalities. The following are the architectural violations which are proposed by various literatures:

- 1) Designing new interfaces (e.g. any two layer can exchange the information)
- 2) Merging of adjacent layers (e.g. any two adjacent layers can be merged)
- 3) Vertical calibration across layers

Many of the cross-layer designs proposals require creation of new interfaces between the layers preferably non-adjacent layers. These can further be divided into three categories depending on the direction of information flow along the new interfaces:

- A) Upwards: From lower layer(s) to a higher-layer.
- b) Downwards: From higher layer(s) to a lower-layer.
- c) Back and forth: Iterative flow between the higher and lower layer.

1) *Designing New Interfaces*: In this new interface between non adjacent layers are developed. These are designed into three subcategories; we now discuss the three sub-categories in more detail.

- a) Upward information flow: A higher layer protocol that requires some information from the lower layer(s) at runtime results in the creation of a new interface from the lower layer(s) to the higher layer.
- b) Downward information flow: Some proposals of the cross-layer design depends upon the parameter setting on the lower layer of the protocol stack at

run-time using a direct interface from some higher layer

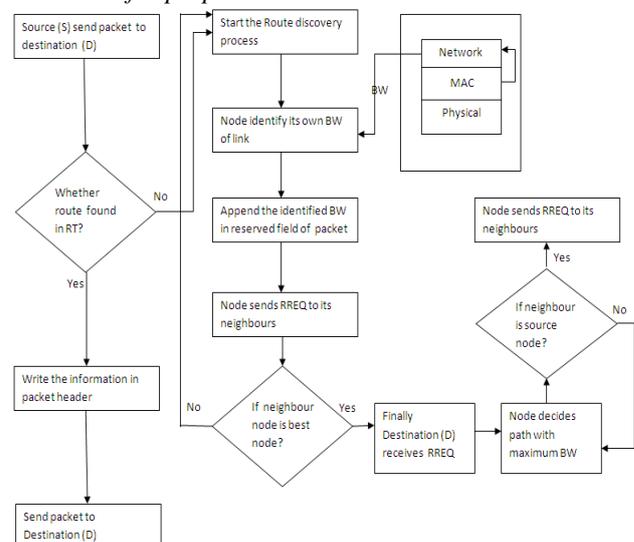
- c) Back and forth information flows: Any two layers which perform different tasks can communicate with each other at run-time. Very often it manifests in an open loop between the layers which is iterative in nature and provides the information flow back-and-forth between layers.
- 2) *Merging of adjacent layers*: Two or more adjacent layers of the protocol stack can be designed or merge together such that the service provided by the new layer which is the “super-layer” is the combination of their respective services which are supposed to provide by the individual layers.
 - 3) *Vertical calibration across layers*: This type of the cross-layer design proposals refers to adjusting parameters that extend across the layers of the protocol stack.

B. Steps for Proposed Mechanism

Note that here; we want to find the optimal path for multimedia data in terms of bandwidth, not in terms of shortest-path using hop-count.

- 1) Source node send RREQ message by flooding to its neighbors and finally RREQ reaches to Destination from various paths.
- 2) Instead of comparing hop-count value for various paths, Destination node will flood the RREP message to all the paths from where it has received RREQ messages.
- 3) Now all intermediate nodes who receive RREP will first calculate the bandwidth value for its neighbors, if neighbor has sufficient bandwidth it will forward the RREP message, otherwise it will not consider that path. So only those paths would have been chosen for which bandwidth is sufficient.
- 4) In order to correcting execute above step, each intermediate node will have to acquire the bandwidth information from MAC/Datalink Layer. So information from MAC/Datalink layer would be transferred to Network/Routing Layer.
- 5) Gradually the RREP will reach to Source Node and finally source node start transmission of multimedia data.

Flow-chart for proposed mechanism:



IV. CONCLUSION

At the present time, the cross-layer design (CLD) approach is an important concept in mobile ad-hoc networks (MANETs) which is adopted to solve several open issues and challenges. It aims to overcome MANET performance problems by allowing protocols belonging to different layers to cooperate and share network status information while still maintaining separated layers. Indeed, the mechanisms on how to access the radio channel are extremely important in order to guarantee “bandwidth and/or delay” and improve application performance.

Most of the work on cross-layer design (CLD) was done on Wireless Mesh Networks so there is a good scope of doing the same kind of work for MANETs. We can define a good routing metrics if we combine both the layer (e.g. network and datalink) instead of just using network layer for routing. In this work, presented a cross layer routing protocol which is based on the cooperation between the routing/network layer and MAC/Datalink layer. This proposal aims to find the best path according to application requirements in terms of delay, bandwidth, route stability, etc. The routing information about bandwidth, channel capacity, received power and distance to reach its destination could be exploited by the MAC layer.

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