A SURVEY OF CROSS LAYER OPTIMIZATION IN MANETS
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Abstract--- Computer communication has been going through major changes throughout the last decades. The strict boundary of the five layers in the TCP/IP network model provides the information encapsulation. However, the encapsulation results in some side effects, including compromise of Qos, latency, extra overload, etc. Therefore, to mitigate the side effect of the encapsulation between the abstract layers in the TCP/IP model, a number of cross layer designs have been proposed. Cross-layer design refers to protocol design done by actively exploiting the dependence between the protocol layers to obtain better network performance in terms of throughput, average end to end delay etc. In this paper, we are providing a survey of different cross-layer proposals for wireless networks taking in the account the on-going research in this area.

Keywords: Cross Layer Design, QoS, TCP/IP, Wireless Networks

I. INTRODUCTION
One of the most visible trends in today’s commercial communication market is the adoption of wireless technology. Wireless networks are expected to carry traffic that will be a mix of real time traffic such as voice, multimedia conferences, games and data traffic such as web browsing, messaging and file transfer. All of these applications require widely varying and very diverse Quality of Service (QoS) guarantees. In an effort to improve the performance of wireless networks, there has been increased interest in protocols that rely on interactions between different layers. Cross-Layer Design has become the new trend in wireless communication systems as it seeks to enhance the capacity of wireless networks significantly through the joint optimization of multiple layers in the network. Cross-layer design allows us to make better use of network resources by optimizing across the boundaries of traditional network layers. It is based on information exchange and joint optimization over two or more layers.

Cross layer design refers to protocol design done by actively exploiting the dependence between the protocol layers to obtain better performance gain. Cross-layer designs imply that each layer is able to share parameters, status, and other information with other four layers, without breaking the five layer structure of computer networks. Security, quality of service (QoS), and mobility are three issues that cross-layer designs consider, and they can be viewed as three goals of cross-layer designs.

To achieve these goals, a cross-layer design may allow one layer to exchange and share data with other layers, may allow one node to exchange and share data with other nodes as well.

II. MOTIVATION OF CROSS LAYER DESIGN
Cross-layer design emphasizes on the network performance optimization by enabling different layers of the communication stack to share state information or to coordinate their actions in order to jointly optimize network performance. It is a human mentality and psychology that if a new design paradigm is proposed, we compare it with the existing one. Hence the concept of cross layer design must be compared with the traditional layered architecture so that people can be motivated towards the use of the Cross Layer Design.

In the following discussion we will examine the motivating factors for ad-hoc networks.

A. Cross-Layer Aspects: Nodes in wireless ad hoc networks have to manage several performance aspects like system management, power management, and security management that cut across traditional layers. The strict boundary separation of layers in the layered architecture and standard interlayer interfaces in traditional approaches do not permit adequate communication among layers to make joint decisions to optimize these cross-layer aspects.

B. Mobility: Mobility introduces an additional challenge for ad hoc network design. Routing protocols would have to cope with this mobility of the mobile terminals by constantly adapting routing state to the changing user positions. Mobility causes changes for the physical layer (for e.g. interference levels), the data link layer (for e.g. link schedules), the routing layer (for e.g. new neighbouring nodes), and the transport layer (for e.g. connection timeouts). As such, a cross-layer based design enhances the capability of the node to manage its resources in the mobile environments.

C. Wireless Link Property: Wireless links are more susceptible as compared to the wired links to interference variations and channel errors. Wireless links are also more vulnerable to security attacks because of easy access to the wireless channel as the wireless channel is open. If the wireless link status information is provided at the higher layers the nodes can adapt their configuration in a better way at the physical layer.

D. New Communication Modalities: Ad hoc network design can exploit the broadcast nature of the channel to enhance performance. nodes can sneak on the neighbouring transmissions in order to estimate and evaluate the quality of links with neighbours. The cooperation of various layers such as routing, data link, and physical layer can ensure the forwarding of data for all the connections within time.

E. Security: Due to the fact that a wireless channel is open and could be access easily by an attacker security has become more and more important to secure our communication. Security is an important concern in wireless
networks due to their increased vulnerability and exposure to varying types of attacks. Proper interaction and coordination among different protocol layers helps in developing a robust intrusion detection system suitable for wireless networks. Such interactions are the key elements to building cross layer architectures.

III. CROSS LAYER BASICS

A. Definition: We can define cross-layer design as follows: “A design where the boundary among the protocol layers is violated by sharing internal information, helping layers to become aware of the changes in the others and hence provide higher quality of service to user”

B. Cross Layer Signalling Method: Cross-layer designs involve cross-layer signalling which is not defined in the protocol architecture. These signalling methods should consume as scarce resources as possible, reducing the overhead. Now discuss about the following four methods of signalling:

C. Packet Headers: Information can be encoded in layer headers which can later be used by some other layer to glean the desired information. This can be compared to have pipe like flow of signals among the layers.

D. ICMP Messages: In IP based networks, Internet Control Message Protocol (ICMP) messages can be used for signalling. However, as ICMP messages are always encapsulated by IP packets, the messages have to traverse through the network layer, even if the interacting layer pairs are data link and physical or transport and application.

E. Network Service: An additional storage in the network can be used to store the layer parameters. This storage can be managed by some distributed servers which gather channel and link states and serve the layers as needed.

F. Local Profiles: This approach is similar to the previous one, but instead of using some other locations, layer parameters are stored and shared locally, inside the host.

IV. CROSS LAYER PROPOSALS

While reviewing various works by the researchers, we came across a large number of cross-layer designs proposals. A classification of such proposals is based on the layers that are coupled by the different proposals.

A. Designing A New Interfaces: 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:

1) 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, as shown in Fig. 2.

2) 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, as figured in the Fig. 3.

3) Back And Forth Information Flow: 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 such as in Fig. 4.

B. Merging Of Adjacent Layer: 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 as illustrated in Fig. 5.

C. 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, as illustrated in Fig.6. The advantage of such a design is very easy to understand. The overall-performance of a layer is seen at the level of the application is a function of all the parameters at all the layers which are below it. It is feasible that a collective action can help to achieve better performance than that of the performance of network in which the parameter are set at the individual layer (incase of the protocol designed in the traditional layered format where protocols are designed at individual layers independently).
V. CONCLUSION

The aim of this paper is to provide a survey of Cross Layer Design for wireless networks. It presents the motivation behind Cross-Layer design, categorizes it. Cross-layer design was a demand of the time, to which researchers have replied with great enthusiasm. Cross-layer design introduces the advantages of explicit layer dependencies in the protocol stack to cope with the poor performance of wireless links and the mobile nodes, high error rates and power saving requirements. It has been applied to various domains, achieving a significant performance gain and better quality of service. The recent trend shows an inclination towards cross-layer design.

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REFERENCES


