International Journal of Electronics Communication and Computer Engineering
Volume 5, Issue 1, ISSN (Online): 2249–071X, ISSN (Print): 2278–4209

Cross-Layer Protocol as a Better Option in Wireless Mesh Network with Respect to Layered-Protocol

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***Abstract* – The Optimal way to improve Wireless Mesh Networks (WMNs) performance is to use a better network protocol, but whether layered-protocol design or cross-layer design is a better option to optimize protocol performance in WMNs is still an on-going research topic. In this paper, we focus on cross-layer protocol as a better option with respect to layered-protocol. The layered protocol architecture (OSI) model divides networking tasks into layers and defines a pocket of services for each layer to be provided individually, The design of the protocol makes the services realized for different layers, No direct communication between nonadjacent layers is permitted as the architecture forbids such action, also communication is limited to procedure calls and responses between adjacent layers. Whereas the cross-layer design violates the reference architecture , By allowing direct communication between protocols at nonadjacent layers, and allows sharing variables between layers, which gives it a better performance that would satisfy the wireless mesh network demands.**

***Keywords* – Cross-Layer Design, Mesh Network, Layered-Protocol, Cross Layer Optimization, WMN.**

I. INTRODUCTION

In the world of telecommunications the interest in using wireless mesh network is growing day by day, Such growing is due to the need of fast and wide communication which wireless mesh network can provide, but with everyday`s growth the challenges in achieving the same service quality is less as the usage creates more issues in the field of high error rates, increased latency, mobility etc. The traditional protocol architectures follow a strict rolls which became a basic principles for the network protocols. The layered-protocol architecture follows the same strict rolls and principles, its design is an attractive design as it works to support standardization of network architecture using the layered model, but it does not provide an optimal performance for wireless mesh network. Considering Some features of wireless mesh network are different from wireless sensor and mobile ad hoc network features, as wireless mesh network is concerned more with scalable end to end throughput and quality of service[6] (QoS) , which makes the overall network performance is critical to optimize. A cross-layer protocol solves such problem by adapting the changes as it has the ability to be widely optimized, in another words a cross-layer design overcomes such limitation found in the layered protocol and could not be optimized. Cross-layer main idea is to maintain the functionalities associated to the original layer and to allow coordination, interaction and joint optimization protocols which is crossing every layer of the stack. Cross-layer design allows the different layer architecture to communicate with each other in order to provide services for all layers at all time .It is important to know that cross-layer optimization is still an-ongoing research Where researchers try to improve its performance for better quality of services but such improvement comes with some issues that complex it and make it more difficult to optimize. Cross-layer design can significantly improve the network performance [2]–[4], It can be performed in two ways, a-loosely coupled cross-layer design. b-tightly coupled cross layer design.

The loosely couple optimize without crossing layers, it focus on one protocol layer in order to improve that single layer.

The tightly couple works different as it optimizes all layers together as one optimization problem.

In the typical way used for wireless networks, The data transfer suffers from performance limitation which vary from 10^{-3} up to 10^{-1} for wireless links while for wired channels the transfer rate goes from 10^{-8} to 10^{-6} as researched proved [13] which defiantly shows the huge difference between them. By optimizing cross-layer we try to overcome such limitation and perform more data transfer rates. Finally, it is reasonable to believe that cross-layer optimization will continue to be one of the most important task in protocol design[1].

II. RELATED WORK

A cross-layer design approach is considered for joint routing and resource allocation for the physical (PHY) and the medium access control (MAC) layers in multi-hop wireless backhaul networks [16],We first consider the optimization of a single layer at a time, while keeping the other layers fixed. We make certain simplifying assumptions to decouple the layers and formulate optimization problems to compute a strategy that maximizes the network lifetime. We then extend this approach to cross-layer optimization of time division multiple access (TDMA) wireless sensor networks. In this case, we construct optimization problems to compute the optimal transmission schemes to an arbitrary degree of accuracy and efficiently [11].

Dzmitry Kliazovich and Fabrizio Granelli el al. think that Nowadays the networking environment significantly differs from the one the TCP/IP reference model was designed for Current trend in networking is towards heterogeneous networking [10] with the main driving factor represented by rapid development of large scale

wireless networks. In this heterogeneous environment, TCP/IP shows poor performance [7, 12], driving innovation towards the identification of more cooperative cross-layer design solutions. Yuan et al. [3] propose a cross-layer optimization framework that scales the demand of network flows at the network layer and the supply of link capacities at the physical layer in order to find high throughput paths. However, the decision about which layers should be involved in order to provide efficient mobility support represents a hot discussion topic [14, 15] A cross-layer design approach on the other hand, is one that utilizes function across different layers of the protocol stack. Recently several studies prove that cross-layer designs can yield significant performance gains[9]. What becomes clear is that the solutions implemented at different layers are more complementary to each other rather than alternative. While some layers appear to handle mobility better than others. There has also been work relating to the implementation of cross-layer interactions. It is high time that these various individual efforts be put into perspective and a more holistic view to be taken [5]. Typically, a mesh router is equipped with multiple wireless interfaces, each of which is corresponding to one wireless channel. These wireless channels have different characteristics, because wireless interfaces are running on different frequencies and built on either the same or different wireless access technologies [8]

III. Some Cross-Layer Design Proposal

Techniques used in cross-layer designing.

1- upward information flow.
2- downward information flow.
3- back and forth information flow.
4- merging of adjacent layers.

1. Upward information follow:

The creation of a new interface from the lower layer to the higher layer at runtime is a result when higher-layer requires information from the lower-layer(s), as shown in Fig. Creating interfaces from the lower layers to the transport layer to enable explicit notifications alleviates such situations. Upward information flow serves the purpose of notifying the higher layers about the underlying network conditions

2. Downward information flow:

Some cross-layer design proposals rely on setting parameters on the lower layer of the stack at runtime using a direct interface from some higher layer, as illustrated in Fig. A good way to look at the upward and downward information flow is to treat them as notifications and hints, respectively. Downward information flow is meant to provide hints to the lower layers about how the application data should be processed

3. Back and forth information flow:

Two layers, performing different tasks, can collaborate with each other at runtime. The architecture here is violated by the two complimentary new interfaces. The repeated loop between the two layers with information flowing back and forth is clearly shown in the figure. Basically, with improvements in the signal processing at the PHY, it becomes capable of recovering packets from collisions.

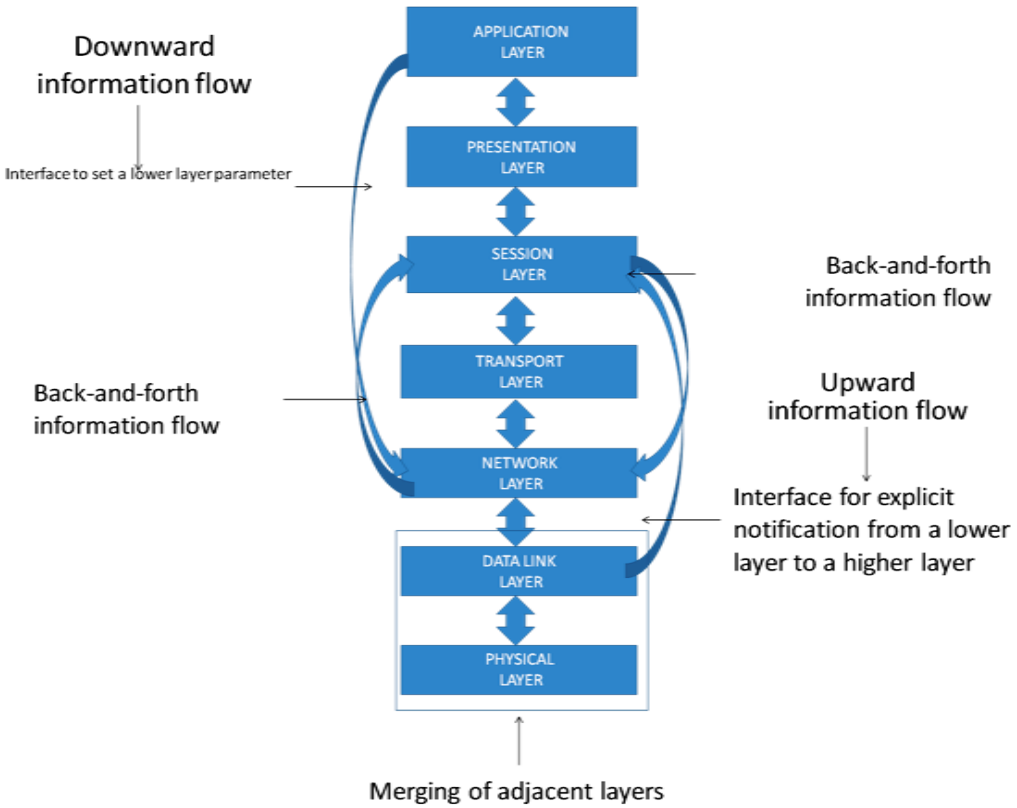

Fig.1. Cross-layer techniques for optimization

4. Merging of adjacent layers:

It is a design of two or more adjacent layers that work as new super layer with a union of service provided by the constituent layer. This does not require any new interfaces to be created in the stack. Architecturally speaking, the super layer can be interfaced with the rest of the stack using the interfaces that already exist in the original architect.

IV. CONCLUSION

In this paper, we describe that, by using cross-layer design techniques, we can easily see some performance improvement in throughput, delay, packet loss, etc when the percentage of improvement is high. If the percentage is low researches proved that at 5% improvement it is not wise to use cross-layer because performance improvement can easily vanish due to the uncertainties in a wireless network like interference, shadowing and noise. As a result a clear understanding shall be considered that many cross-layer schemes achieve great performance through simulations but even thus we still face some complexities in modifying protocols in different layers. But we should also know such issues usually do not exist in a layered design scheme as it follows a strict rules, whereas Cross-layer design breaks the standard way in operating on the architecture of the protocol stack.

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