Critical analysis of Cross-layer approach

2 authors, including:

Vivekananda Gn
Madanapalle Institute of Technology & Science

20 PUBLICATIONS **98** CITATIONS

Some of the authors of this publication are also working on these related projects:

Bigdata Predictive Analytics View project

Doctorate-PhD View project

CRITICAL ANALYSIS OF CROSS-LAYER APPROACH

G.N.Vivekananda
Research Scholar, Dept. of CSE
JNTUA College of Engineering
Pulivendula, A.P., India
vivekanandagn@gmail.com

P.Chenna Reddy
Professor, Dept. of CSE
JNTUA College of Engineering
Pulivendula, A.P., India
pcreddy1@rediffmail.com

Abstract— **Internet has become everyday utility. Internet is ubiquitous. All the devices including household devices are connected to the Internet. Layer approach is used for the design of Internet. Layered approach is robust but is designed for wired networks. Cross-layer approach is examined extensively in mobile networks because of the layered approach inability to provide the required performance. There are many tradeoffs associated with the use of Cross-layer approach. It breaches the basic principles of layered approach and may compromise the robust nature of the Internet. But with wide use of multimedia applications and mobile devices, we cannot continue to use layered approach as it is. In this paper justification the role of Cross-layer approach is presented, and critical analysis of it is done to identify its limitations.**

Keywords— *Cross-Layer; Internet; Layered approach; Wireless networks;*

I. INTRODUCTION

The Internet and its technologies are growing at a rapid rate [1]. A Survey of Cisco presented interesting results, as shown in Fig.1 [2]. As we are trying to access the Internet from everywhere, using every possible device, its traffic is going to increase and is expected to triple in the next five years.
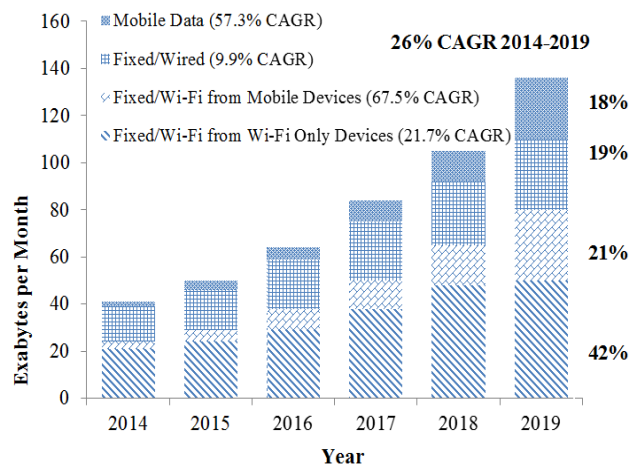

Fig.1: Cisco forecast of Global Internet Wired and Mobile Traffic

Increase of Internet users, increase in Internet enabled devices, increase in bandwidths, and also increase in video related traffic are some reasons for increase in the Internet traffic. Traffic from mobile network devices goes beyond traffic from wired devices by 2019. By 2019, it is expected that IP traffic due to wired devices accounts for 33 percent of the global traffic, whereas mobile devices and its procedures accounts for 66 percent of the whole. Wired devices and its policies resulted in maximum usage of 54 percent of the global IP traffic in 2014.

In recent times, for provisioning the wireless and mobile access, mobile networks are preferred due to their flexibility to provide communication [3]. Mobile networks can penetrate to the areas which cannot be reached by the wired networks. This requires an improvement in the performance that mobile networks offers in terms of throughput, congestion control, delay variations, stability and security. As the high level features of present wireless knowledge can be used to provide the better performances in various applications like online streaming and gaming, this paper besides critically analyses and evaluates the functionality issues of current and upcoming considerations of Cross-layer approach in wireless standards. It also studies their suitability for the transmission in wireless networks [4].

The principal motive behind proposing Cross-layer approach is to deal with the different issues that cannot be answered by the layered approach. In this paper, we approached various classifications of analysis and made a critique about Cross-layer approach in mobile networks. As per the various sources surveys and reports, by 2050 all the file sharing and high loads of Internet traffic will be only through different heterogeneous applications. There is need to bring coordination among different conventional layers to achieve the required performance improvement to support the applications of next generation.

This paper presents the reader with the perception of the Cross-layer approach, drawing the motives and requirements, and offers the main outline enabling collaboration between layers. The study and analysis that is carried out in this paper would represent the roadmap for choosing an appropriate technique to be used in wireless networks for transfer of various multimedia related applications. The study would also classify the issues regarding layered approach and Cross-layer approach. We believe that these challenges could also be used for laying out the foundations for the design of new network models for different mobile network standards at different levels for the efficient transmission of resources.

The organization of the remaining paper is as follows. Section 2 exhibits the literature review that comprises of the

previous studies. Layered approach and their applications are discussed in Section 3. The justification for Cross-layer approach is given in Section 4. The paper is concluded by Section 5.

II. LITERATURE REVIEW

In [5], Various Cross-layer design techniques such as new interface creation, adjacent layer merging, design coupling excluding new interfaces, and vertical calibration among layers are emphasized. Using these proposals various interactions are specified such as database shared across the layers, layered direct communication and totally new abstractions. Various challenges such as coexistence of layers, when to invoke a Cross-layer approach, standardization of interfaces, and physical layers role in wireless systems and significant Cross-layer pairings are presented.

In [6], various goals such as security, Quality of Service (QoS) and mobility are involved into concern to increase their performance employing Cross-layer interactions. For this it specifies two methods in which scheme of sharing inside a node might be non-manager and manager methods and sharing scheme between the nodes that consists of distributed and centralized methods in a network. Non-manager method depicts one layer communicating with other whereas manager method introduces vertical plane as public library of Cross-layer information. Centralized method uses central node or tier structure to control Cross-layer information sharing whereas distributed method organizes information sharing deprived of a necessary node. It identifies various issues such as coexistence and signaling, extra overhead when exchanging information, universal Cross-layer design, and destruction of encapsulation in layers.

In [7], various challenges to implement proper architecture and their considerations are summarized. Properties of wireless networks that affect the layering mechanism are identified. Different Cross-layer principles and consequences of the inadvertent interactions of layers in wireless networks are defined. Finally, it shows various cautionary perspectives of the effects of uncontrolled design.

In [8], primary network service types and differences between wired and wireless networks are presented. Cross-layer approach is designed for the techniques like explicit congestion notification in TCP over wireless links. Various issues like gaining multi-user diversity, multi-user QoS gain, and Cross-layer design interoperability are discussed. It gives design of multi-carrier system using Cross-layer approach as its future research.

Literature survey reveals that there exists some gaps i.e., there are no surveys which are done in the recent years. This is significant, considering the changes that happened in recent years in Internet environment. This motivated us to do the survey of Cross-layer approaches.

III. LAYERED APPROACH

The two reference models ISO/OSI and TCP/IP are designed using the layered approach. The robust design of TCP/IP protocol framework stack survived for years and is the base for effective processing of the Internet. The layered method itself fortified well-organized operations. The primary ideas appealing layering are the following: [9]

- Each layer performs related functions whereas uncorrelated functionalities are performed by different layers. The only possible interaction between layers is peer to peer.

- The coupling between the functions is discouraged, and each layer is highly cohesive.

- The modifications to a layer can be done easily without disturbing the functionalities of other layers. No flow of data through the layers is permitted.

- Apart from performing the assigned functionality, the only other function performed by each layer is to deal with the services of upper layers.

- Global sharing of information is highly warned and minimum movement of facts between lower layer and immediate upper layer is permitted.

- Each layer possesses its individual protocol data unit and a layer never modifies the protocol data units of other layers, except adding or removing its own header by peer layers.

Table 1 gives the various uses and drawbacks of using the Layered approach.

TABLE 1: ADVANTAGES and DRAWBACKS of LAYERED APPROACH

	Advantages	Drawbacks
Layered Approach	It Provides modularity and clear interfaces.	Data overhead and processing, due to the duplication of functionality.
	Implementation simplicity, maintainability, flexibility, and scalability are maintained.	The more layers you have, the more risks you have for things to breakdown or data to get lost.
	Layered approach supports portability.	Various issues regarding Higher layer Vs. Lower layers.
	It Provides robustness and preserves stability.	Results in complex exploitation of user-intensive applications.
	It is a Time tested approach.	This leads to Sluggish operation modes on various applications.

IV. TOWARDS CROSS-LAYER APPROACH

Protocol architectures following strict layering principles, though achieved enormous success, limited their functionality and performance in wireless systems. To master the

restrictions of layered methodology, Cross-layer scheme has been suggested. The basic idea is not to change the layer functionalities, but to add coordination between layers to optimize the performance. As a rule, Cross-layer design alludes to convention plan done by effectively misusing the reliance between convention layers to get execution improvement. This is not like layering, where the conventions at the diverse layers are planned independently [10]. Various applications where Cross layering techniques are applied are as follows:

- Applied to attain adaptability to dynamically varying network traffic.

- To achieve resource allocation and better throughput.

- It is used to attain modest buffer requirements.

- High and effective capacity utilization can be attained by using Cross-layer design.

Table 2 gives various advantages and bottlenecks of using the Cross-Layer approach.

TABLE 2: ADVANTAGES and DRAWBACKS of CROSS-LAYERED APPROACH

	Advantages	Drawbacks
Cross-Layer Approach	This contributes to improve the QoS in mobile networks.	It suffers with lack of proper architecture.
	It is used in cutting off the congestion in various Internet applications.	Unchecked Cross-Layer patterns may create chaos.
	It is used in various Routing Schemes and for reservation mechanisms	Unintended Cross-layer Interaction, may lead to unforeseen dependencies among the layers.
	It is used in efficient transfer of multimedia resources in wireless networks	Cross-layer designs cannot be easily integrated
	This strategy supports information exchange and optimization across layers.	Chances of various improper stability issues if not handled correctly.

The reasons behind considering Cross-layer approach are as follows:

Conventionally every layer has access to the immediate layer above and below via standard interfaces. The application can access the transport layer; similarly the transport layer can access the application and the network layer, and so on. With Cross-layering control mechanisms the access is provided in a more flexible way, either between immediate layers or between layers that are otherwise isolated [11]. This access may include control or information exchange outside of the

layered programming interfaces. Cross-layer approach interactions explore the effects that occur because of various collaborations among layers and possessions. For example both the transport layer and the link layer might or might not perform retransmissions, which could affect the behavior and performance of the other layer. One of the foremost purposes of this paper is to examine the possibilities of using Cross-layer approach between the layers.

A. A Word of Caution

- Firstly, in designing a Cross-layer each has its specific Cross-layer communication manner, and thus the coexistence and signaling are the two challenges that Cross-layer designs must deal through [12].

- Secondly, it is inevitable to result in an extra overhead when exchanging the Cross-layer information in Cross-layer designs.

- Thirdly, it is difficult to have universal Cross-layer design which is suitable for all the applications, since different applications have diverse requirements.

- Finally Cross-layer design violates the independence of the layers and may make the design of solution to computer networks a complex problem and also hard to maintain.

B. Critical Analysis

This paper gives out some precepts that examine Cross-layer technique which are as follows:

- The upper protocol layer should avoid executing functions that the lower layer has done in order to deduct cost and energy. As we know layered protocol stack is redundant and the same function is realized by multiple protocol layers. In Cross-layer design it should avoid such redundant function and make good usage of existing resources by directly adopting the needed results from other layer.

- In general, each layer has different bound with alternate layers and transmits data in a typical way. Each layer composes one or multi-function modules, which are programmable and easy to be added and deleted as needed. These modules are connected with Cross-layer management module through input and output interfaces of control signals, provided event reference information. Cross-layer management module is an identical path for information interaction which helps to manage interlayer information and avoids complex connection among layers.

- Cross-layer designs do not intend to destroy best principles behind the layered design, but provide the inter-layer communication among two or further adjacent or distant layers. In addition, Cross-layer technique allows the internal working and parameters that are kept by each layer but now revealed to other layers. Cross-layer approach may allow sharing of information between all the five layers. Furthermore, Cross-layer method can permit the

layers for determining behavior that depends on the received or retrieved data from other layers. Therefore, Cross-layer designs entail that each layer is capable for sharing the status, parameters and other data with remaining four layers, without breaking the syntax of five layered model. Moreover, information can be shared in Cross-layer technique through the layer boundaries to enable reliability and network performance compensation e.g., better throughput, decreasing latency, bit error rate reduction through input controlling from layer to other.

- The layered architecture and controlled interaction enable designers of protocols at a particular layer to work without worrying around the rest of the stack. Once the layers are broken through Cross-layer interactions, this luxury is no more available to the designer. The interface can disturb not merely the layers concerned, on the other hand also with other network positions. Proposers of Cross-layer technique must thus consider the whole design that includes the interactions with all other layers, and also different possible solutions might be barred because they may act with the appropriate proposal that is being made. Thus these proposals of Cross-layer strategy must be holistic than fragmenting.

- By using Cross-Layering we can achieve Service Consistency, Connection Reliability, and Consistent Multimedia Streaming. If application knows the lower layer protocol trade-offs and these protocols responsive of the application trade-offs, these trade-off curves can be merged to function at the most favorable point for reasonable end-to-end performance.

- A network wide Cross-layer model can lead to "spaghetti" implementations that may shackle further innovations and becomes difficult to maintain.

- Challenges such as improving layer interaction, devising a framework and developing algorithms are concerns in the Cross-layer technique as improving layer interaction improves improved communication and interaction among layers to improve efficiency, while still protecting the benefits of layered design. Devising a Cross-layer architectural framework ensures modularity, longevity and extensibility of the architecture.

Few consequences and challenges to analyze are as follows:

- Have we made the Cross-layer proposal after a definite study remembering all the controls and issues of the layer associations on the parameters of diverse layers and on the general network?

- Which layers of the conventional stack are better to include in the Cross-layer proposal?

- Whether we ought to try for the organization of new interfaces bypassing the contiguous layers or for blending of layers

- How these non-adjoining layers will correspond with one another?

- What data ought to be traded crosswise over convention layers and how as often as possible this data trade ought to happen?

- What are the satisfactory and efficient strategies to trade this?

- Step by step directions to counter the loss of the particular header which will be lost when immediate correspondence happens between the non-contiguous layers

- For what network and ecological condition would a specific Cross-layer proposal be conjured?

- Would we be able to ready to make a standard interface which is in control of the facts imparting between the Cross-Layers?

- What are the instructions to make a Cross-Layer proposal secure? Can a Cross-layer network intended for advancing network security be coupled with different Cross-layer based network Optimizations?

- How to achieve better network performance, efficiency and optimization?

- Which layers should react to channel disparities? What layers should be organized & designed jointly?

- How Complexity and scalability can be achieved and what are conflicting paradigms between layered and Cross-layered approaches?

- Is cross-layer design the main methodology for fast growing demands?

- Do we need unified or diverse methodologies for different networks?

- Would the favorable circumstances of Cross-layer model lead to novel network design?

- What to send (format of message), when to send and how to act (rules/protocols)?

V. CONCLUSION

Wireless networks are made more efficient using Cross-layer approach as layered model suffered from various inconsistencies in wireless networks. Research is vital on where benefits can be gained from cross-layer strategy and optimization. This paper pays more attention to cross-layer technique in the wireless networks that sums up basic approaches and principles of cross-layer approach and puts forward vibrant strategy of cross-layer approach.

Cross-layer technique can make good utilization of interlayer information functionality and existing resources to react to environment changes quickly, reduce cost and energy,

and optimize the whole network performance for robust and scalable communication. But it is obvious to have some disadvantages. These will give some reference to practical design. The importance of cross-layer technique is clear in time to time wireless networks. In conclusion, based on proposed analysis of on-going efforts, cross-layer design looks like to be an appropriate approach for future contributions that is able to address emerging issues related to higher performance of multimedia transmissions.

REFERENCES

[1] Jayavardhana Gubbi *et al.*, "Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions," *ACM Future Generation Computer Systems,* vol. 29, No.7, pp. 1645-1660, Sept. 2013.

[2] *Cisco white paper on Visual Networking index of global data traffic forecasting from 2014-2019* [Online].

[3] K Pentikousis, "TCP in Wired-Cum-Wireless Environments", *IEEE Communications Surveys*, vol. 3, No.4, pp.2-14, 2000.

[4] T S Rappaport *et al.*, "Wireless Communications: Past Events and a Future Perspective," *IEEE Communications Magazine,* vol. 40, pp. 148 – 61, May 2002.

[5] V Srivastava and M Motani, "Cross-layer design: a survey and the road ahead," *IEEE Communications Magazine,* vol. 43, No.12, pp. 112 - 119, Dec. 2005.

[6] Bo Fu *et al.*, "A Survey of Cross-Layer Designs in Wireless Networks, "*IEEE Communications Surveys & Tutorials,* vol. 16, No.1, pp. 110 - 126, August 2013.

[7] V Kawadia and P R Kumar, "A Cautionary Perspective on Cross-layer Design," *IEEE Wireless Communications,* vol. 12, No.1, pp. 3 - 11, Feb. 2005.

[8] S Shakkottai *et al.,* "Cross-Layer Design for Wireless Mobile Networks, "*IEEE Communications Magazine*, vol. 41, pp. 74 - 80, 2003.

[9] Andrew S. Tanenbaum and David J. Wetherall, *Computer Networks, Fifth Edition*. Pearson Publications, 2014.

[10] K M El Defrawy *et al.*, "Proposal for a cross-layer coordination framework for next generation Wireless networks", *ACM International Conference on Communications and Mobile Computing*, pp.141 – 146, 2006.

[11] U Korger *et al.*, "QOS implications of power control and multiuser detection based Cross-layer design," *EURASIP Journal of Wireless Communications & Networking*, June 2011.

[12] Z Chang *et al.*, "Infrastructure for Cross-Layer Designs Interaction", *IEEE 16th International Conference on Computer Communications and Networks*, Honolulu, Hawaii USA, 2007.