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Quality of Service in Cross Layered Framework

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***Abstract*:** Quality of Service (QoS) is the rate of complete performance of a service, such as computer networking or services in the area of cloud computing. Quality of Service is an important factor and point of consideration in the development of cross layered frameworks or cross layered architectures. With the increase in use of cross layered technology QoS is a highly critical parameter which has been subject to vast amounts of research.

Data aggregation is one of the most important techniques to increase bandwidth utilization and energy efficiency in WSNs (wireless sensor networks). There are a lot of research activities being carried out in this field, but a majority of them have a disadvantage that they cannot meet practical requirements in an optimal manner, such as the requirements of latency and heterogeneity of application data. Providing Quality of Service (QoS) in an efficient manner is highly important for some networks (WSNs), since they are required to provide present-time services like audio, video, and VoIP which is nothing but Voice Over IP other than the conventional data service approach. Many solutions have been proposed to provide soft QoS over networks that are wireless and are multihop from other layers in the pack of network protocols.

Somehow, the concepts of layers were primarily created for networks which are wired, and wireless networks that are multihop oppose stricter layer based design because of their varying nature, architecture which are infra structure less & time-varied unstable connection topology and links. The idea of cross-layered design is premised on the architecture where several layers can exchange content or information in order to enhance the complete performance of the network. Accurate results could be obtained by optimizations in cross-layered that brought about considerable research in this area. This paper aims to research the current works on the cross-layer approach for QoS support in the realm of wireless networks which are multihop.

Keywords— Cross-layer design, multihop wireless networks, Wireless sensor networks (WSNs), cross-layer optimization, quality of service (QoS) support, data aggregation, QoS, MAC protocol

I. INTRODUCTION

There is a need for multihop wireless networks which has emerged in recent times, to provide services on a larger scale and WSNs have evolved as next generation key technology which is dynamically self-sustained and self-configurable.

Wireless Sensor Networks bring several importances to multi-hop networks like robustness, easy maintenance, reliable cost, and reliability services. Several types of multihop wireless sensor networks are developed for several application scenarios. In an ad hoc network that is wireless, each node is responsible to act as router and send packets to other nodes.

The ranges of transmission in the nodes are generally very limited; hence multihop delivery is a necessity for outside the transmission range for communication among the available nodes. Because of the node departures, the node mobility and the arrival of new nodes, the design of an adhoc network is generally dynamic because among the other nodes the connectivity may vary.

Here there are two types of nodes in mesh networks that are wireless. They are: Mesh Clients and Mesh Routers. As compared to routing capabilities or gateway/bridge functions as in traditional routers the mesh router has extra routing capabilities to provide support to mesh networking. The mesh routers consume much lesser transmission power for the communications between the nodes as compared to traditional multi-hop communications.

Various applications utilize Wireless Sensor Networks (WSNs) such as system surveillance, underwater and habitat monitoring. The model here has served great for networks that are wired in the past; although, these days with the all- upcoming wireless networks and technologies that are evolving, the layered architecture is not the efficient solution for the architecture and implementing an efficient wireless network. Wireless networks, such as mobile ad-hoc networks (MANETs), wireless local area networks (WLAN), the cellular networks, and wireless sensor networks (WSNs) all have the same theme and their usage of this wireless channel. The wireless channels are a distinct medium for communicating due to its vulnerable nature caused by mobility, interference, shadowing, multipath fading, and high signal attenuation, etc. Also, because of the broadcast characteristic of the wireless channel, sophisticated media access control (MAC) protocols are required for accessing a channel. Due to several special characteristics such as this it is very difficult to devise protocols for wireless networks. The major idea underlying the cross-layered design is by exploiting the communication amongst two or several more layers in order to optimize the flow and control of information amongst the protocol layers by achieve high performance improvements in order to support QoS i.e. Quality of Service for apps that require higher rates of data flow on wireless networks with varying characteristics for transmission. A Cross-layered design can help in energy efficiency, increasing the network capacity, and support of QoS for a broader range of services.

However, there is skepticism regarding the elimination of modularity and transparency and the increase of complexity in the protocol stack due to the introduction of cross-layer design. Protocol Network is essentially a dynamic network lacking in infrastructure and because of this there can be a change in their position [1].

Generally the devices connected in here are usually battery operated, and optimizing the battery consumption is a larger issue. It becomes an a major and key factor when it comes to examining the efficiency of the routing protocols, and such routing protocols that are majorly energy efficient can affect the node lifetime.

II. QOS SUPPORT IN LAYERED PROTOCOL WITH CROSS LAYERED FRAMEWORK/DESIGN

QoS is defined as the capability of a particular network to give better service to the chosen network traffic over several underlying technologies like routed networks, IP etc.

QoS in complete network involves capabilities in the:-

1) The networks that hold the data being sent to and fro from one host, the sender to another host, the receiver.
2) End system software running on a PC, for example the OS.

Several formal metrics for QoS measurement are:-

a) Availability of Service
b) Delay
c) Packet loss rate
d) Delay Jitter
e) Throughput

Need for QOS:-

Networks these days need to support many kinds of traffic over a single network. Different types of traffic in the network demand different approaches. Therefore, the need to design networks which are capable of:-

1. Networks should be Scalable
2. Networks that can support mission critical applications and emerging network intensive
3. Networks can deliver multiple classes of services.

The purpose of making a QoS enabled network architecture is to bring closer the connected end hosts through the reduction of delay in the underlying network and by improving performance.

Few service models have already been proposed and are also implemented:-

a) Integrated services
b) Best Effort services
c) Differentiated services

A. QOS-AWARE MAC

In recent years, several MAC schemes were proposed with objectives such as support for QoS support in real-time applications. The MAC protocols generally depend on a control that is centralized, which is applicable only for architectures based on infrastructure [2].

Some researchers think that a typical methodology for clustering virtually is present to ascertain multiple roles of the node akin to the leaf nodes and cluster heads. Usually, a node pertaining to a larger layer in the structure of clustering will obviously be given a better priority to access the channel compared to a node in the smaller/weaker layers.

The mechanism named Black-Burst has been implemented in the classification of priority as higher and lower priority. Based on the BB mechanism, stations with greater priority occupy empty or free channels first, and others need to be on hold based on the priority.

Because of multiple channels available in recent times such as in radio, MAC multichannel bidirectional protocol is proposed to split the bandwidth into multiple data channels instead of a single channel, hence providing more efficiency and transmission speed as compared to a single channel.

B. INTERDEPENDENCE & COMMUNICATION BETWEEN MULTIPLE LAYERS WITHIN THE CROSS-LAYERED ARCHITECTURE

In the premature stages, wireless network protocol designs are mostly premised on a layered architectural approach, wherein every layer in the protocol stack is developed and operated without any interdependence, with corresponding interfaces within mostly static layers [3].

This paradigm has made the otherwise complicated design of the network and led to the robust and amazing protocols that are scalable across the Internet. Although, the sub optimality & utter inflexibility of this approach results in very poor efficiency generally for wireless multihop networks, specifically when the applications require large bandwidth and strict delay constraints or limitations. A fairly latest study on these kinds of networks proved that in order to meet these QoS requirements, a cross-layered paradigm can significantly and consistently improve the system's performance.

Cross-layered architectures tend to break away from our traditional network design where each layer of the protocol stack operates mostly independently [4]. This approach tries to improve the system performance by conjunctly designing Layers of multiple protocols. The policy results help to provide better constrained resources and QoS support given the network dynamics.

It is also known that most system parameters are controlled in a well-defined layer in the wireless network (Fig. 1). For example, the power control and modulation adaptation in the first layer (physical layer) will change the overall topology of the system. The channel management and scheduling of the MAC layer will affect the space and time reuse in the network.

Careful consideration & the attention should hence be paid while applying the control in non-similar layers. An example, assigning the channels to some of the inter-network interfaces can change the involvement rates between transmissions across the neighbors. All of the above, it also consecrates the topology of the network which might also influence routing.

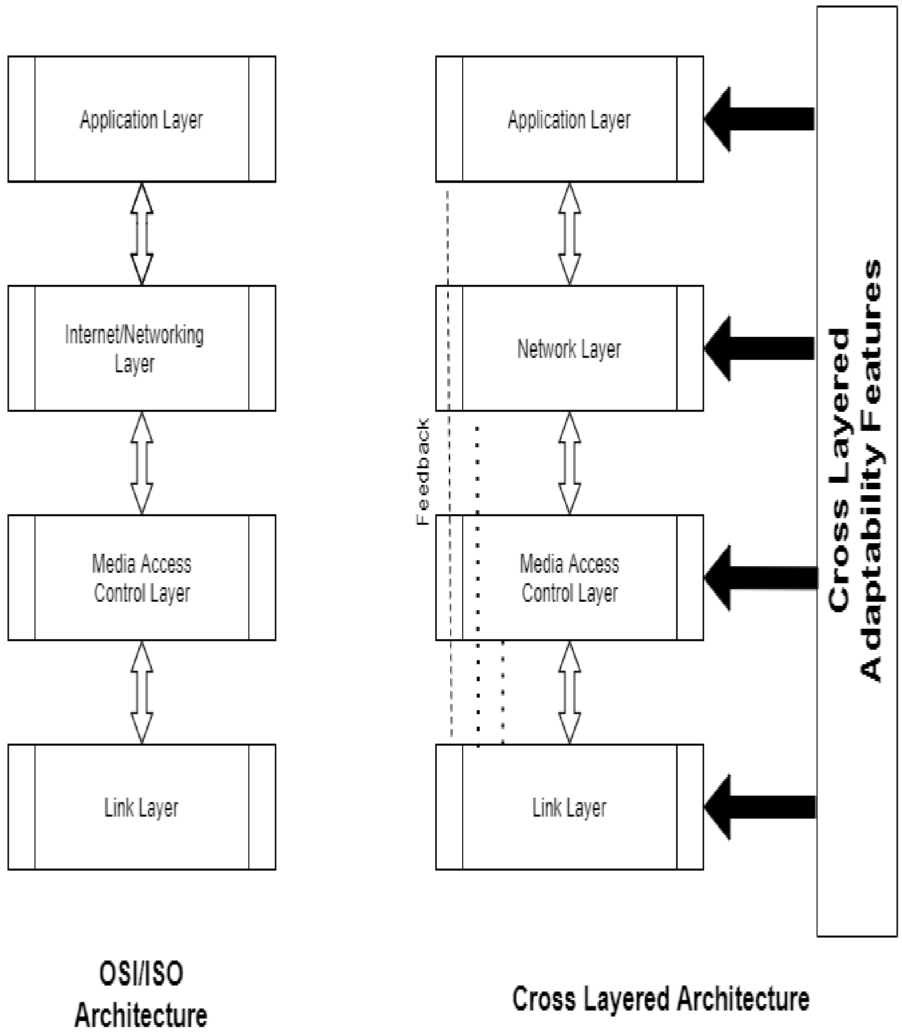

Fig 1. Cross Layered Architecture Interdependence

The ability to support good QoS over multi-hop networks that are wireless will significantly takes an advantage from this design of cross-layered architecture. This design and interdependence among the layers are mostly characterized and sometimes thoroughly challenged by considering the data exchanged between the layers and by building accurate amounts of robustness in turn concreteness into each and every single layer here.

For instance, routing protocols can safely ignore the links experienced by deep fading, or the transport layer can then adapt its rate of the transmission underpinning on the current condition of the network. Thus, Fig. 1 illustrates the framework of the cross-layered architecture and the possibility of strong interaction with those layers. Many strong interactions with multiple layers can be depicted through the arrows.

C. CAPACITY PLANNING & JOINT ROUTING WITH ALLOCATION OF RATES FOR STREAMING OF MEDIA IN CROSS-LAYERED NETWORKS

Some of the major objectives in the design of multihop networks which are wireless is the notion of planning the capacity. Capacity of the network is particularly associated with the development and deployment of a robust and efficient infrastructure for communication in a cost-effective manner to provide considerable throughput, area cover, and support for QoS for its clients or other users. Among these, the QoS needs are typically represented as modules of end-to-end requirements or needs [5].

Multiple networks capacity planning and designing schemes are proposed for several varied designed objectives using which an optimization of internal network can be done, For example, minimizing the total energy consumption, minimizing the end-to-end lags or maximizing system throughput.

More often than not, the physical layer is typically abstracted to a mixture of Elementary Capacity Graphs or ECGs for short. ECGs are more of a theoretical and diagrammatic concept based on simulation. An ECG is mainly a graph of capacity that shows a physical layer state, which inturn corresponds to arranging of the concurrent links which are active among the respective neighboring nodes [6].

By harnessing the concept of sharing the time among many physical states, at the Media Access Control layer as shown in Fig 1, combinations which are convex among the ECGs could be obtained, thus helping in presenting a working-set of currently supported composite capacity graphs to the upper layers.

Internet or network layer without question transforms the E2E traffic demand into a link-to-link traffic model, which is a capacity supported graph.

Combining these components, the optimization of the iterative cross-layer design is proposed. There are two goals, to minimize accumulated congestion measures and to minimize energy consumption, which are the premise of this document. In order to solve the default wired, multi-radio, multi-hop, multi-channel wireless or wired network capacity planning problem, as depicted in Kodialam *et al* [7]. Algorithms have been developed to jointly optimize scheduling, channel assignment, and routing to obtain the upper and lower limits of the content area of a given objective function, such as QoS requirements.

The authors deliberately developed a network model assuming that the number of orthogonally essential channels is limited and with several radio devices at every node. This proposed model provides both sufficient and necessary predicates for a feasible channel allocation strategies and scheduling in the network. Both the lower limit and upper limit of the system capacity are given in this paper.

Multihop wireless networks with the omnipresent mesh topology could most often be characterized as a multitude of routes among or between a given source and destination node which is clear and predefined. In simple terms, multipath streaming has the below mentioned benefits over traditional single path streaming.

Firstly, potentially it might give a higher average bandwidth to some applications (assuming that the paths which are multiple are usually never explicitly sharing the same performance bottlenecks). Secondly, the dividing of data around several paths can reduce the short-term correlation of loss in scenarios considering real-time traffic, thereby substantially escalating the performance of the aforementioned streaming application. Finally, the very presence of multiple paths can greatly help to reduce the chances of interruption of the service which is streaming which may be caused by node mobility which in today's network design methods is an unavoidable factor [8].

Hence, a methodology that implicitly takes advantage of such many paths is without doubt going to perform well in the QoS than the conventional approaches which are single-path. For a process such as this, selecting a path or routing is of utmost importance for allowing sessions which are multimedia on multifold paths.

A centralized single-point solution which is built upon optimal flow assignment is conceived as a loose higher or upper bound to the efficiency. A distributed system is also proposed, wherein the measure of allocation at each of the streams depends not just on the characteristics like the rate of distortion of the video instead, it also depends on the network congestion factor.

To support the multipath streaming better, some believed that the loss of packets due to different kinds of reasons. Boonchai *et al*. [9] stated the reasons such as the network congestion, channel errors, and route break/change due to manipulation or spoofing etc should be differentiated.

As an example, In a wireless channel when there is increasing packet loss, the application that streams has to improve the level of control in the error; if the increment in rate of loss is caused by congestion, if error control level is increasing then it might not be of any use and decreasing the rate of sending might be the correct decision to take; suppose the increment in the rate of loss is because of break or change in route, then stopping the transmission of a particular data until the formation of new path (or if the old route is reconnected) is the correct reaction [10].

Referring to some of the observations such as this, an Ad-hoc Multipath Streaming Protocol (AMTP) was proposed. AMTP, which is strongly integrated with a routing protocol that is multipath, can help exploit the cross-layered information such as path status and routing to precisely detect states which are different from the network thereby differentiating packet losses and their types.

All the more, AMTP can explicitly choose several maximum paths which are disjoint from the subgraphs with the best Quality of service to maximize the ultimate E2E throughput or in other words improve the performance [11]. Author has proposed (NICC) a novel Nature-Inspired algorithm-based Cross-layer Clustering () protocol to find a reasonably better solution for clustering and routing in SF applications. It investigates the idea of a nature-inspired optimization algorithm called Bacterial Foraging Optimization (BFO) with optimal fitness function, which models the trade-off among the energy efficiency and optimal data transmission. Parween *et al*. [12] introduced the objectives and meaning of CLD and its execution strategy in WSN. It shows the few structures for cross-layer plan inside the WSN.

Amrutha *et al*. [13] proposed the effectiveness of Cross Layer Energy Efficient with Scalability LEACH (CLEESLEACH) is examined in view of normal lingering energy and dynamic state of sensor hubs in each round. The proposed model improves energy productivity alongside QoS boundaries. An energy proficient calculation for planning and bunching is proposed and portrayed exhaustively by Rathna *et al*. [14]. The proposed system bunches the hubs utilizing a conventional yet improved on approach of progressively arranging the sensor hubs. Not many significant chips away at cross layer conventions for WSNs are inspected and an endeavor to alter their example has additionally been introduced in this paper with results. Correlation with few unmistakable conventions in this area has likewise been made. Because of the examination one would find out about utilizing which kind of booking calculation for which sort of observing applications.

In the present work discussed about restrictions and the cross-layer configuration has been presented. It permits direct associations between conventions at non-adjoining layers. Author present various sorts of cross-layer plan methods in Wireless Sensor Network (WSN) and talks about a few cross-layer propositions given by specialists. Toward the end, the paper features a few difficulties looked in carrying out CLD in Wireless Sensor Networks

III. FURTHER RESEARCH & OPEN ISSUES

There are a large number of schemes with cross-layered architecture designs which has been implemented for the proposed wireless networks which are multihop, but still we have a couple of open challenges that remain to be solved in the future. Several researches have proved that tremendous gain in the performance can be achieved by a cross-layered network designed approach and also considerably increases the design complexity. Exchange of the information across multiple layers at multiple stations present in the multi-hop transmissions should be taken into account in the multi-hop design for wireless communication systems to achieve high performance in respect to the goals, such as throughput, less latency or energy consumption [15]. In a simple scheme of a sensor network in the wireless environment operating with the power saving MAC protocol Wise MAC, this research paper helps in illustrating, that applying the concept of multi-hop cross-layer design can help in solving various distributed optimization problems and lead to performance gains [15].There is serious attention to cross layered optimization of multi hop wireless networks. Usually in a distributed multi hop networking network, layer wise decisions of nodes are taken with the aim of performance optimization at some other layers, hence in that way the whole network can be completely optimized and efficient. Security issues with cross layered architecture, Safe transmission across multiple layers of the cross layered architecture, Node cooperation between different nodes and performance analysis are some of the areas of research to be carried out in this particular field [8].

IV. CONCLUSION AND FUTURE SCOPE

In this manuscript, we initially defined QoS and the importance of QoS especially in cross-layered frameworks. QoS is a highly critical factor of consideration that has been subject to a humongous amount of research. After establishing a clear theoretical foundation about QoS, we delved deeper into concepts such as application of QoS into multi-hop architectures, QoS Awareness in MAC architectures and consequently the definition of QoS metrics. We also shed some light on the interdependence of multiple layers within the cross-layered architecture. We also demonstrated capacity planning and joint routing with rate allocation for use cases such as media streaming in cross-layered networks. Then we highlighted the importance of further research by depicting some of the challenges and open research problems in the realm of QoS to be implemented in such cross-layered architectures. We have also emphasized on the fact that cross layered architecture provides significant efficiency and performance which can be considered as an advantage though on the other hand it also greatly influences the design complexity which might contribute to overheads for subsequent designs. We conclude by stating that the process of improvement of QoS is an iterative one and is subject to many years of further research and its adaptation to cross-layered networks are an interesting use case that we hope inspired the reader to further improve upon and devise a more efficient methodology for cross layered architectures.

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