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CROSS LAYER DESIGN CHALLENGES IN WMC SYSTEMS

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Abstract: **In wireless multimedia communication (WMC) systems, data transmission inherits also all the characteristics and constrains related to the propagation to the free space.The layered architecture is a reasonable way to operate wireless networks. In an attempt to improve the performance of wireless networks, there has been increased interest in protocols that rely on interactions among different layers. It's being focused on the cross-layer design for efficient multimedia delivery with quality of service (QoS) assurance over wireless networks, utilize the differentiated service architecture to convey multimedia data. Information is exchanged between different layers, while end-to-end performance is optimized by adapting to this information at each protocol layer.This paper examines the issue of cross layer design for multimedia transmission over wireless networks. This paper also presents the identifying reasonable assumptions and challenges in design and implementation of cross layer adaptation schemes for multimedia transmission over wireless networks. In addition this paper presents the most important parameters and constrains that should be taken into consideration when attempting cross layer adaptation in wireless networks that involves different protocols in the overall protocol stack.**

Keywords- **wireless communications, wireless multimedia systems, protocol stack, cross layer design,**

I.INTRODUCTION

Nowadays we are moving from the static connectivity of the wired networks to the "anytime any where mobile applications". In addition we are facing important increase in the usage of wireless access networks either in the form of PAN (Personal Area Networks e.g. Bluetooth), LAN (Local Area Networks e.g. IEEE 802.11) and MAN (Metropolitan Area Networks e.g. IEEE 802.16) or in the form of current 3G and future 4G mobile networks and important increase of mobile multimedia applications like voice over IP, Video on Demand, videoconference, Media streaming, etc. Cross layer design will facilitate the above important changes by providing a unify scheme which will allow the incessant usage of networked media by adapting the media transmission to the specifically needs of the wireless networks and the mobile terminal (e.g. laptop, PDA, mobile phone). Future wireless multimedia-communications (WMC) systems are envisioned to offer higher data rates, higher mobility support and seamless communication [1] .They will have to utilize a common platform that will unify a variety of evolving access technologies, seamless interworking and interoperability solutions and adaptive multimode user terminals. As shown in fig [1], the evolving 4G wireless technology is a common umbrella that covers and integrates all these requirements. 4G is not a system designed from scratch nor it offers completely new technical solutions. 4G is more a concept whose major goals are integration and convergence [2,3]. The integration should offer seamless interoperability of different types of wireless networks with the wireline backbone. The convergence relates to the convergence of different traffic types (i.e. voice, multimedia and data) over a single IP-based core network, different technologies (e.g. computers, consumer electronics and communication technology), different media (e.g. TV, cellular networks, Internet-based applications), different services (e.g. television and satellite communications) etc.

4G systems will deliver all digital, all-IP communication,Scalable composite reconfigurable environment,End-to-end QoS guarantees,Quickly deployable user services (anytime, anywhere and from any device) in a cost-effective manner, under one billing mechanisms,Efficient spectrum sharing and dynamic spectrum allocation, Advanced cross-layering techniques[4] (e.g. link layer adaptations, various protocol information piggybacking, cross-layer based MIMO etc.),Support for huge multimedia traffic (from several tens of megabits per second to 100 Mbps for outdoor and up to 1Gbps for indoor environments),Increased level of security, Increased personalization, Integration of navigation and communication systems in order to offer a variety of location /situation/on text aware services, Diversified radio access (e.g. cellular, WLANs, ad hoc networks), Provisioning of advanced resource and mobility management, Adaptive multimode user terminals fully exploiting the cognitive networking approach [5].Seamless and transparent user roaming with full support for various vertical handovers. This paper is organised as follows. Section 2 describes overview of identifying reasonable assumptions for cross layer design. Section 3 explains the motivation for the cross layer design and section 4 explains about the cross layer design challenges for WMC sytems.And finally conclusions made in section 5.

II.IDENTIFYING REASONABLE ASSUMPTIONS

One first striking difference between wired and wireless networks is the cause of packet losses. Packet losses in wired networks occur mainly due to congestion in the path between the sender and the receiver, while in wireless networks packet losses occur mainly due to corrupted packets as a result of the low Signal to Noise Ratio (SNR), the multi-path signal fading and the interference from neigh boring transmissions. A second difference between wired and wireless networks is the “mobility factor”. Mobility in wireless networks introduces a number of additional barriers in multimedia data transmission.

Research has been done in the PCC/4GW to forecast what service requirements will be around forcoming years for the personal computing and communication. The research model used in the 4GW project is outlined in fig [2]. In which three scenarios were presented [6]: “Anything goes!”, in which a totally flexible and competitive market drives the mobile communication to extremely low cost.“Big brother”, in which security issue is the major concern for the communication system, prohibiting the technology and market development pace.“Packet computing”, in which consumers are segmented to either enjoy advance communication services or have little access to them. Several working assumptions have been made according to the scenarios above. Among them “Adhoc,unlicensed operation” is one of the key services the future infrastructure Our cross-layer approach is quantitatively evaluated by simulations on community wireless networks, and compared with designs that decoupled the layers.

III MOTIVATIONS FOR CROSS-LAYER DESIGN

Consider a wireless network which must provide high rate and high QoS communications and control information as detailed in and as shown in figure [1] the Cross layer system modelling diagram .The branch units (users) communicate to the headquarters through a gateway. Multiple users are connected to the gateway over wireless channel using TDM/TDMA. Now the question arises- What motivates designers of wireless networks to violate the layered communication architectures? There are three broad motivations. Several cross-layer design proposals aim to solve some unique problems created by wireless links. An example of such a problem is the classic case of a TCP sender mistaking a wireless error to be an indication of network congestion .Another category of cross-layer design ideas aim to exploit the fundamental characteristics of the wireless medium opportunistically, for example by utilizing channel variations from fading at the higher layers. This is in line with the general goal of an adaptive protocol stack that responds dynamically to the changes in the network conditions. Yet another category of cross-layer design ideas make use of the new modalities of communications that wireless medium creates and that cannot be accommodated within the constraints of layering. An example here is node cooperation,. Cross-layer designs with all three motivations are important in the context of cognitive networks of the future [11]. Apart from clarifying the main motivations for cross-layer design, taking relevant examples from the literature also gives a good measure of the wide range of scenarios in which cross-layer design has been applied. Since there is no overarching layered architecture that is followed in all communication systems, the reference layered architecture we assume is a five-layer hybrid reference model presented in figure [2] which indicates the cross layer design for adhoc networks. This model 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; we assume that all the layers perform their generally understood functionalities.

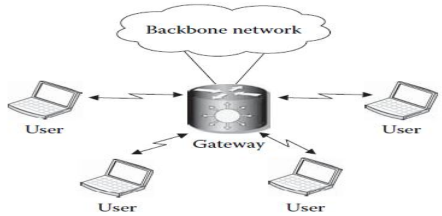

Fig 1 Cross layer modelling system diagram

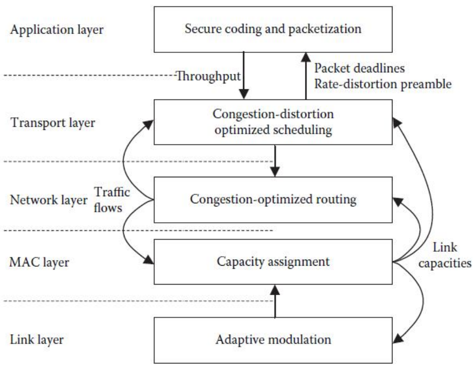

Fig 2. Cross layer design for adhoc networks

III. CROSS LAYER DESIGN CHALLENGES FOR WMC SYSTEMS

Cross layer adaptation is a very challenging process due to the numerous parameters involved in the whole procedure [12]. This section outlines the most important parameters and constrains that should be taken into consideration when attempting cross layer adaptation in wireless networks that involves different protocols in the overall protocol stack. They are

A. Network elements involved in the adaptation process
B. Layers involved in the cross layer adaptation (Interlayer optimization)
C. Parameters involved in cross layer adaptation (Intralayer optimization)
D. Signaling amongst the various layers
E. Adaptation strategy
F. Devices constrains

A. Network elements involved in the adaptation process:

In multimedia transmission three entities can be distinguished that take part in the information exchange procedure: the sender, the core network elements (links, routers) and the receiver. The term sender includes either a multimedia server or an individual host which participates in a multimedia data exchange with another remote host. There has been a detailed discussion whether or not all three elements should be involved in an adaptation scheme, targeting at improving the QoS offered to the end user. The most challenging and maybe the most beneficial approach would be the participation of all three elements in the adaptation mechanism especially when the multimedia data are transmitted among various network domains. However, even in the same network domain someone has to decide whether or not both the sender and the receiver should participate in the adaptation process. Someone should also consider that the complexity increases when inter-domain adaptation and policies are to be implemented.

Clearly, there are pros and cons in either approach. With both the sender and the receiver participate in the adaptation process better results are expected as this sender/receiver pair acts as an organized "team" by sharing information related to current network conditions and adapt their behaviors to these conditions. Logically, the total result would provide the highest QoS for given network conditions. On the other hand, by confining the adaptation process only in the sender or the receiver the level of independence is increased between the entities involved in the multimedia transmission. therefore transmission can fall into next four categories.

1. Sender based: The sender performs the cross layer adaptation. This approach has the advantage of easy deployment due to the fact that it does not require any support from the network or the receivers. On the other hand this approach has limited capabilities.
2. Receiver based: The receiver performs the cross layer adaptation. This approach also has the advantage of easy deployment due to the fact that it does not require any support from the network or the sender. Again this approach has limited capabilities.
3. Network supported: The network elements are involved in the cross layer adaptation. In a heterogeneous environment such as the Internet, agreements have to be set up amongst the various network domains to ensure any cross-layered implementation across the path between the sender and the receiver. In the same domain the administrator can be define their own policies-mechanisms.
4. Hybrid: A combination of two or more of the above approaches. This approach is the most complicated to be implemented but has the potential to provide better performance.

B. Layers involved in the cross layer adaptation (Interlayer optimization):

While the layers (PHY, MAC and APP)[13,14] have been extensively researched in cross layer adaptation schemes The transport/session layer plays a important role in cross layer adaptation for wireless networks, as a number of adopting mechanisms in this layer (like TFRC for example) have been extensively evaluated in wired networks, revealing adaptation opportunities in wireless networks. Although, the network layer can not be used straightforward for cross layer adaptation it can be used for indirectly cross layer adaptation through QoS schemes implemented at the network layer [15].

C. Parameters involved in cross layer adaptation (Intralayer optimization):

For optimal selection of the adaptation parameters should consider the following two actions:

1. Optimization of the parameters that only affect the layer in which they appear
2. Optimization of the parameters that affect two or more layers

The following table shows the various parameters that can be involved in cross layer adaptation [16].

TABLE I
PARAMETERS FOR CROSS LAYER ADAPTATION IN WIRELESS NETWORKS

Layer	Parameters [a]
PHY	Signal modulation
MAC	ARQ, FEC, QoS
Network	QoS (Diffserv, IntServ), IPv6
Transport / session	Adaptive Transmission Rates (TFRC, DCCP, other mechanisms [27])
Application	Encoding parameters (Layered Encoding, MPEG4)

D. Signalling amongst the various layers:

They are various approaches for cross layer signalling: such as Network Services, local profile, Existing protocols / Packet headers, ICMP (Internet Control Message Protocol) messages. By summarizing the mentioned approaches, the first approach stores parameters to a network server and the second approach stores parameters to mobile device. The third approach utilizes the already exchangeable packets as in-band signalling over the network. The forth approach makes use of extra packets as out-band signalling over the network.

E.Adaptation strategy:

They are various approaches [17] in this field as integrated approach, MAC-centric approach, Top-down approach, Bottom-up approach. The above cross-layer approaches exhibit different advantages and drawbacks for wireless multimedia transmission, and the best solution depends on the application requirements, used protocols, algorithms at the various layers, complexity and limitations. To summarize the above mentioned approaches, we can say that the most appealing approach is the integrated approach. However, this approach is difficult to be implemented due to the increased complexity as a direct result of the big number of possible strategies and the associated parameters involved.

F. Devices constrains:

The decision on the above mention design issues must be done by the constrains. Device constrains, Mobile devices have many limitations when compared to desktop systems. These include display limitations, CPU resources and power consumption. Network constrains include available bandwidth, delay, and QoS support. Application constrains include maximum and acceptable delay, maximum and acceptable delay jitter (especially for interactive applications), maximum and acceptable packet loss ratio and finally bandwidth constrains. In conclusion, the main objective of the optimization process is the optimal selection of the above described parameters in order to provide the best multimedia experience to the end user by taking into account the above described constrains.

TABLE II
PARAMETERS FOR CROSS LAYER ADAPTATION IN WIRELESS NETWORKS

Factors	Constrains
Mobile Device	CPU, display, power
Network	Bandwidth, delay, RTT, QoS support
Application	Maximum and acceptable delay, maximum and acceptable delay jitter (especially for interactive applications), maximum and acceptable packet loss, bandwidth constrains

IV. CONCLUSION

Further research efforts should include Joint source/channel coding and power allocation for multiplexed video services with time scheduling, Cross-layer design for DiffServ-based QoS Cross-layer design for heterogeneous voice/video/data traffic (a cross-layer design approach usually focuses on a specific traffic type). For a CDMA network supporting heterogeneous voice/video/data traffic with different QoS requirements, it is critical to consider the trade-off among cross-layer approaches for different traffic types, and to achieve desired overall system performance with efficient resource utilization. In a multicell environment due to the intercell interference, the schedulers in different cells should not act independently, thus making the resource allocation much more complex. Resource management and scheduling in a wireless OFDM-based downlink can be used to serve multiple users and to support various applications based on a cross layer approach. This paper presents the challenges in designing and implementing cross layer adaptation schemes for wireless multimedia transmission over networks. Cross layer adaptation for multimedia transmission will have important impact both in the research community and in the industry. More particularly, cross layer adaptation will allow better access to media content for users in a variety of locations, contexts and mobility scenarios.

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