Chapter 20
Survey of Cross-Layer Optimization Techniques for Wireless Networks

Han-Chieh Chao
National Ilan University, Taiwan

Chi-Yuan Chang
National Dong Hwa University, Taiwan

Chi-Yuan Chen
National Dong Hwa University, Taiwan

Kai-Di Chang
National Dong Hwa University, Taiwan

ABSTRACT

The explosive development of Internet and wireless communication has made personal communication more convenient. People can use a handy wireless device to transfer different kinds of data such as voice data, text data, and multimedia data. Multimedia streaming, video conferencing, and on-line interactive 3D games are expected to attract an increasing number of users in the future. The bandwidth requirement would be high and the heterogeneous terminals would generally provide limited resource, such as low processing power, low battery life and limited data rate capabilities. These applications would be the major challenge for wireless networks. Although the traditional layered protocol stacks have been used for many years, they are not suitable for the next generation wireless networks and the mobile systems. Due to the time varying transmission of the wireless channel and the dynamic resource requirements of different application, the traditional layered approach to the mobile multimedia communication is full of challenges to meet the user requirement on performance and efficiency. Cross-layer design is an interesting research topic that actively exploits the dependence between different protocol layers to obtain performance gains. The authors performed a survey and introduced the cross-layer design principles and issues for different research topics, including QoS, mobility, security, application, and the next generation wireless communication.

DOI: 10.4018/978-1-61520-674-2.ch021

CURRENT PRINCIPLES FOR CROSS-LAYER DESIGN

The traditional Open System Interconnection (OSI) seven layer protocol stacks have been used for many years. The function of each layer is defined clearly. All those protocol layers are coordinated to complete the network communication. The OSI model could reduce the complex of network implementation and increase the flexibility. However, for the next generation wireless networks and mobile systems, the traditional approach to network design can not satisfy the user requirement on performance and efficiency. Because of the time varying transmission of the wireless channel and the dynamic resource requirements of different application, the mobile multimedia communication is very challenging. Based on limited frequency allocations and channel considerations, Shakkottai et al (2003) depicted the special properties of wireless networks that distinguish them from conventional wire-line networks.

In the layered OSI architecture model, the protocol at each layer is designed independently for the different layers. The layered architecture doesn't allow direct communication between nonadjacent layers. Communication between adjacent layers must follow the pre-defined interfaces through procedure calls and responses.

Cross-layer design is a new research topic that actively exploits the dependence and interaction between different protocol layers to obtain performance gains. Srivastava and Motani made a detail survey on cross-layer design and depicted that there are three main reasons to motivate designers to violate the layered architectures, which are the special problems under the wireless environment, the possibility of opportunistic communication on wireless links, and the new communication models offered by the wireless medium (Srivastava & Motani, 2005; Qusay, 2007).

An important cross-layer design aspect is the management of cross-layer interaction that can guarantee the system operation. Such cross-layer entities may reside within the protocol stack, in which case it is considered as an internal cross-layer entity or an external network node (Foukalas, Gazis, & Alonistioti, 2008). Figure 1 shows that the internal entity may be either an interlayer entity that coordinates the operation of all protocol stack layers or an intralayer entity that is located within a protocol layer. The external cases are illustrated in Figure 2. The external entities may be centralized by a specific network node or distributed over several network nodes.

Figure 1. The internal cross-layer entities