Chapter 2

Architecture Design
Approaches and Issues in
Cross Layer Systems

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ABSTRACT

Wireless communications are a fast growing part of the telecommunication market. While new types of traffic and challenges related to the wireless medium are appearing, the methodologies for designing system architectures substantially remain the same. Under the increasing pressure of market, users, and physical medium issues, designers are in need for new approaches.

Cross Layer becomes, then, a handy solution for coping with such problems. In fact, it allows both tighter optimizations of the existing functionalities, and the introduction of new ones that do not fit within the traditional protocol stack design methodology.

However, Cross Layer also carries a risk due to possibly unexpected and undesired effects. In this chapter, the authors provide architecture designers with a set of guidelines synthesized from an analysis of the state of the art, but enriched with the perspective of the development of future generations of communication systems such as Cognitive Radio.
INTRODUCTION

In the last couple of decades, there has been a strong diffusion of wireless systems. Especially in the last five to ten years, the advent of high-throughput wireless technologies completely revolutionized the traditional concept of networking. Nowadays, users want to be always online, connected over the internet everywhere. The wireless traffic has grown exponentially within recent years, especially after the release of smartphones that allow a comfortable browsing and the usage of multimedia applications. Of course this dramatic increase in wireless traffic sets new needs for the next generation of wireless technologies. But this endless loop of traffic growth/new wireless possibilities is nowadays facing big challenges. This is mostly due to the aging of the traditional internet architecture based on the layered TCP/IP architecture (Stevens, 1994). Let us anyway considered the Open System Interconnect (OSI) protocol stack (Schwartz, 1988) as a generalization for layered architectures in the following of the discussion. Two of the main problems that have to be faced to overcome the OSI limitations are:

1. The extreme dynamism of the wireless medium: due to propagation effects such as fading, multipath, and phase rotations, the wireless medium rapidly varies and it can introduce errors and problems to higher layers of the protocol stack. These effects are emphasized when the users are in high mobility conditions, i.e. moving at high speed.

2. Sub-optimality of the stacked layers: the independent design of the stacked layers is suboptimal when compared to the overall stack. In order to properly face the traffic growth a tighter global optimization of the system is required.

Several years ago, pushed by the aforementioned limitations and problems, researchers started investigating the possibility of optimizing the OSI stack beyond the traditionally layered functionality and independence. This “Cross-Layer” (CL) process is the main core of this book and of this chapter.

Several techniques and approaches have been proposed in literature for improving the performances of specific layers or applications. The goal of the current chapter is to summarize all these techniques by identifying the design approach behind the method rather than listing them individually. The main principle is to provide researchers with a general overview helpful for understanding and designing CL Architectures (CLAs), based on the definition of information flows within the stacked architecture and beyond. This point of view will help the reader understand which are the benefits and the risks associated to each design methodology and how to properly use them to solve his or her own problem.

BEYOND THE STACKED ARCHITECTURE

In the current section, we will discuss the traditional reference architecture for data communications and compare it with the current problems and needs of modern wireless communications. It will be evident in the end of the section that new architectural design methodologies are needed in order to provide the market with more efficient technologies that keep into account the user satisfaction as well as the efficiency of the technology itself.

For these reasons, it is required to go beyond the stacked architecture, re-inventing the design approaches as well as the standardization ones in order to have the same flexibility and longevity of the traditional OSI model while having a tighter global optimization of the system.