

Chapter V

Adaptive Codec Selection for VoIP in Multi-Rate WLANs

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ABSTRACT

This chapter introduces the problems caused to voice over IP calls on 802.11 networks due to the link adaptation mechanism of them. It provides an overview of all the components participating in this study with special emphasis on the multi-rate anomaly. Furthermore, it reviews the literature on recent works on the specific area of link adaptation and codec selection. The authors finally propose as a solution to the multi-rate problem a codec selection mechanism, which, by changing codec of some of the calls at the moment of the rate change, has as an objective to maintain delay and packet loss values in acceptable levels and provide the desired QoS for the voice flows.

VOIP OVER WLANS

Voice over IP (VoIP) over wireless LANs (WLANs) has been a hot research topic during the past years due to the widespread deployment and ease-of-use of both technologies. The capacity of a wireless cell in terms of number of supported calls, as well as the quality of the voice transmis-

sion over the wireless link under different channel conditions, are crucial for deciding whether this technology can be widely deployed and accepted for voice service. In spite of all the research efforts in this area, there are still unsolved issues concerning the quality of VoIP calls, most commonly caused by the specific wireless network characteristics listed below (note that the purely

physical effects, such as meteorological impact on channel conditions, are beyond the scope of this chapter):

1. Unfairness between uplink and downlink streams
2. High protocol layer overheads
3. Fast VoIP degradation in presence of TCP flows
4. Variable capacity due to multi-rate transmissions

Although the first three problems have been widely analyzed in previous works, there is scarce bibliography considering the last problem. Multi-rate transmission is one of the key features of the IEEE 802.11 PHY/MAC specifications, which allows each mobile node to select its physical layer parameters (modulation and channel coding) to optimize the bit transmission over the noise/fading-prone channel. These sporadic rate changes occurring on the mobile nodes as they move around the cell due to the link adaptation algorithm of the 802.11 specification have an impact on the transmissions of all active calls and produce a general degradation of the network performance.

This chapter intends to provide an overview of the impairments observed on voice flows due to the multi-rate characteristic of 802.11, and discuss some of the solutions that have been proposed so far, with particular focus on a codec adaptation solution. Main goals are:

1. To give some background on VoIP over WLAN systems and analyze the source of the various problems and how they affect the voice transmission in terms of total cell capacity and quality of service
2. To describe what is a multi-rate wireless LAN and its impact on VoIP calls
3. To review the literature on how to best cope with the multi-rate problem and introduce the benefits of a codec adaptation solution

4. To present a cross-layer codec adaptation algorithm and demonstrate how it is able to satisfy the QoS needs of VoIP traffic
5. To examine the suitability of proposing some future enhancements to the SIP architecture to better cope with this issue

Voice over IP Systems: From Encoding to Media Transmission

What Composes a VoIP System?

In order to better understand what the impact of a multi-rate 802.11 environment on a VoIP system can be, it is necessary to review the elements that compose such a system, and which among them are prone to interact with 802.11 in order to provoke alterations on the VoIP quality. According to Figure 1, the main elements of a VoIP system are:

- **Human voice:** Pretty obviously, the foremost element of a VoIP system is human voice, or in general an audio source (music from a CD or a stored speech, for example). Throughout this chapter, and since the main impact of 802.11 will be over real-time transmissions, as will be explained, an interactive speaker is assumed.
- **A microphone and speakers:** Or, in general, some device to capture human voice and transform it from a pressure wave to a continuous electric signal, which can be processed by a computer. Conversely, at the reception point, the inverse procedure must take place, and hence some speakers or headsets are highly desirable.
- **A sampling and encoding device:** In order to adapt an analog signal to be transported over a packetized data network, a dual process must occur: First, the analog signal must be transformed into a train of discrete samples, so that one or more of

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