4 Spectrum Management Algorithms

The aim of this work is the investigation of spectrum management methods for IEEE 802.11a based networks, as they are introduced by the 802.11 h standard. As shown in the previous chapter, the standard defines Dynamic Frequency Selection and Transmit Power Control. The standard, however, only defines the signalling which is needed to maintain these spectrum management extensions. It does not specify the decision algorithms which select the frequency channel and the transmit power to be used. The standard only covers the topics which are important for the interoperability between hardware of different manufacturers. In this chapter, different methods to maintain Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC) are introduced. The Transmit Power Control is extended by Link Adaptation (LA), which is not specified in the standard as well. Existing WLAN hardware rarely supports spectrum management by DFS and TPC according to the 802.11h standard. Link Adaptation is usually provided as a proprietary extension.

In this section, algorithms for DFS and TPC are discussed; in case of TPC, two algorithms with a centralised and a distributed control are shown which rely on channel measurements and signalling between the access points and the mobile stations as provided by the 802.11 standard. For TPC, the extension by Link Adaptation is introduced. Error recovery for the 802.11h based operation is considered which is not defined by the standard, however required for a proper function of the spectrum management algorithms. The algorithms discussed here are implemented in a simulator for validation which is described in detail in chapter 6.

4.1 Dynamic Frequency Selection

The purpose of the Dynamic Frequency Selection is the automatic selection and, if necessary, the automatic change of the frequency channel of all stations inside a BSS without user intervention. In legacy 802.11a networks, a BSS will remain on the same channel unless the configuration of the stations is changed by hand, which has to be done for all stations inside the BSS. If more than one network have to share the same channel, the available airtime for each network is reduced because some of the airtime is occupied by the other networks. Moreover, collisions can occur if at the receiver, the signal from the corresponding station is interfered by
another station which transmits at the same time. These effects can result in a severe performance degradation of the network, in particular in an increase of the delay and a reduction of the throughput. To cope with this problem, the network measures the interference situation on the currently used and the other channels. If measurement results have been collected for all channels, the DFS algorithm decides either to keep the current channel or to switch to another one.

Since the acquisition of measurements plays a vital role in the DFS mechanism, this topic is discussed first. After that, different DFS algorithms are introduced.

### 4.1.1 Acquisition of Measurements

#### 4.1.1.1 Measuring Sequence

Measurements of the individual frequency channels are the basis for the DFS algorithms to select the most suitable channel. Channel measurements can either be taken on demand, for example if the quality-of-service parameters like delay and throughput become too low, or on a regular basis. The disadvantage of measurements on demand is that the delay between a change of the channel conditions and the response of the system can be too slow. This can result in a reduced link quality or an entire link disruption for an unnecessary long time. Hence, for this analysis, a regular interference measurement is supported. The DFS owner, see section 2.4.1 regularly sends Measurement Requests to each of the MTs for each frequency channel. The Measurement Requests are sent as unicast packets, so all stations are polled in turn. This polling is done for each of the available frequency channels. Each station to which a Measurement Request is sent executes the measurement on the specified frequency channel and for the specified time; during the ongoing measurement process, the station suspends all sending activity. After having taken the measurement, the station reports the results back to the DFS owner by a Measurement Report. The details of the signalling were introduced earlier in section 2.4.1. This signalling scheme is used in the DFS procedure to query the measurements from the stations. The Figure 2.19 in the mentioned chapter shows the sequence how the DFS owner polls the different stations.

In the measurement process, two cases have to be distinguished: measurements on the currently used frequency channel and on other frequency channels. If a station is requested to measure on another frequency channel, it switches to this channel, takes the measurement and returns to the currently used channel. All other stations in the network can continue their activities without restrictions. The situation is different if the measurement has to be taken on the currently used channel: in this case, no stations of the network should be transmitting, otherwise the signals