# Chapter 1

# Introduction

The wireless technology brings great convenience to people nowadays. Without the constraints of the wired network, people can surf the Internet everywhere with portable computers and handsets. With the growing use of the wireless communications, the demands on wireless service increase too. The wireless network made the transmission of real-time multimedia data becomes feasible, so that more and more people get online not only just for web browsing, but also for online games, watching real-time videos or skype (Voice over IP). The real-time services require different strict quality of service guarantees which are more challenging in the wireless network. Because of the instability of radio link, the network condition is unpredictable thus leads to high packet loss ratio and low transmission rate.

In order to overcome the channel fluctuation problems, s ome types of user cooperation diversity [1] has been investigated. Spatial diversity, temporal diversity, and frequency diversity could be deployed to go through severe variation in signal attenuation.

In this thesis, a new form of spatial diversity is proposed to improve the performance of 802.11 Point Coordinator Function (PCF).

## 1.1 Cooperative Networks

Cooperative network is a EE concept. In the wireless communications, mobile users' capacity and quality of service are limited by the fact that within the duration of any call, they experience severe variation in signal attenuation. In order to mitigate the effects of channel errors in a wireless system,the use of diversity is necessitated. Diversity is a way of combating the effects of fading, by effectively transmitting or processing more than one copy of the signal. Some well-known forms of diversity are spatial diversity, temporal diversity, and frequency diversity [2]. Spatial diversity relies on the principle that signals are transmitted from geographically separated transmitters, and/or to geographically separated receivers, experience fading that is independent. Space, or multi-antenna, diversity techniques are particularly attractive as they can readily combined with other forms of diversity, and still offer dramatic performance gains when other forms of diversity are not available.

Cooperation between pairs of wireless users can be thought as a mean to alleviate the deterioration of the performance because of channel errors. We combine the concept of cooperative networks with polling-based system, PCF, to improve the uplink traffic performance. Station-to-PC communication is not reliable, therefore relayed by another station is considered. Stations can have partners to share their antennas. As to the cost of transmit power, a station will require more power in order to send both partner's and its own packets. However, a station may require less power because of the diversity gains. It is not clear *a priori* which of the above two factors will be dominant.

## 1.2 IEEE 802.11

IEEE 802.11 plays an important role in wireless LAN technology. Two kinds of basic network configuration modes are provided in the 802.11 legacy standard : an *infrastructure mode*, where transmissions of all stations (STAs) have to go through a central access point (AP) device, and an *ad hoc mode*, where any station can talk to another without an AP.

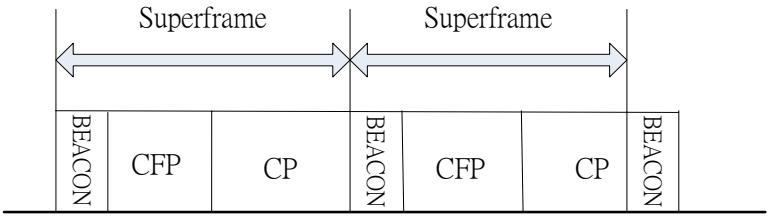


Figure 1.1: Structure in IEEE 802.11 MAC

The 802.11 standard defines the specifications of both PHY and MAC layers to construct a WLAN using either configuration mode. The 802.11 standard was released with three kinds of PHY layer options : an infrared (IR) baseband PHY, a frequency hopping spread spectrum (FHSS) radio, and a direct sequence spread spectrum (DSSS) radio. All three options support 1-2Mbps date rate in the 2.4GHz. Higher-rate PHY extensions were released after like 802.11b, 802.11a, 802.11g, and 802.11n.

The 802.11 MAC layer aims to provide access control function to the wireless medium such as access coordination, addressing, frame check sequence generation, and security. There are several MAC layer protocols extensions, including 802.11e, to enhance QoS performances; 802.11f, proposing an inter-AP protocol to allow stations to roam between multivendor APs; and 802.11i, focusing on enhanced security and authentication mechanisms.

Two medium access coordination functions are defined in the original 802.11 MAC : a distributed control function (DCF), and a centralized point coordination function (PCF). 802.11 MAC process can be divided into *superframes*. Every single superframe is composed of two intervals : Contention Free Period (CFP) is for PCF while the Contention Period (CP) is for DCF. Fig. 1.1 shows the interchange of CFP and CP during a superframe.

### 1.2.1 Distributed Coordination Function (DCF)

802.11 DCF is a distributed access scheme. The basic DCF uses a carrier sense multiple access with collision avoidance (CSMA/CA) mechanism to regulate access to the shared

### 1.2.1. Distributed Coordination Function (DCF)

wireless medium. Before initiating a transmission, each station is required to sense the medium and perform a binary exponential *backoff*. If a station has sensed the medium idle for a time interval called DCF InterFrame Space (DIFS), the station will enter a backoff procedure. A slotted backoff time is randomly generated from 0 to the Contention Window (CW) size. At the first transmission attempt, CW is set equal to a minimum value, $CW_{min}$. It is doubled after each unsuccessful transmission until reaching a maximum value, $CW_{max}$. The CW will be reset to $CW_{min}$ after successful transmission. The backoff timer is decreased by one when the station sense the medium idle for that slot. The backoff timer is frozen when the medium becomes busy, and resumes after the medium has been sensed idle longer than a DIFS again. The station is authorized to access the medium only when the backoff timer expires. If two or more stations finish their backoff timer and sense the medium idle at the same time, they may transmit frames simultaneously; thus, a collision may occur. If an acknowledgement (ACK) is not received within a timeout, the sender would assume that a collision occurred and may schedule a retransmission by entering the backoff process until the maximum retransmission limit is reached.

In IEEE 802.11, there are three different kinds of inter frame space: *Short Inter Frame Space (SIFS)*, *Point Inter Frame Space (PIFS)*, and *Distributed Inter Frame Space (DIFS)*. $SIFS$ is the shortest one among them. It is used to seperate a sequence of continuous frame transmissions. For example, after receiving a frame, the receiver will reply an acknowledgement to the sender after $SIFS$. Because $SIFS$ is the shortest interval, no other stations could access the medium during the process. $PIFS$ is for $PCF$, while $DIFS$ is for $DCF$. Since $PIFS$ is shorter than $DIFS$, PC is more likely to win the medium and start the $CFP$ at the beginning of every superframe. So $PCF$ has higher priority than $DCF$ in IEEE 802.11. Fig. 1.2 shows the operations in DCF and the relationship between $SIFS$, $PIFS$, and $DIFS$.

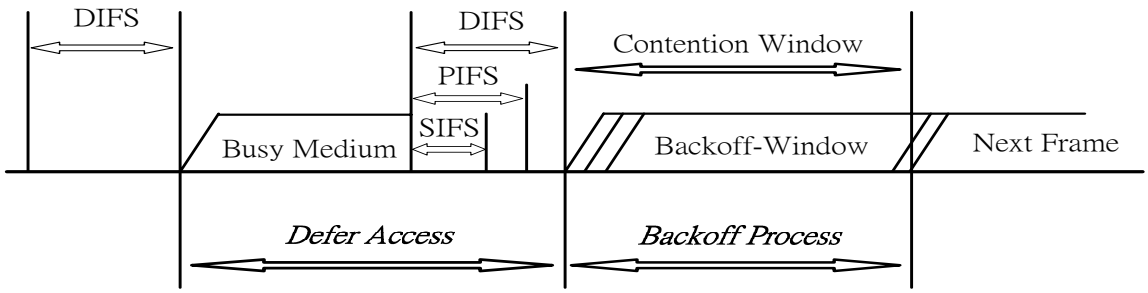


Figure 1.2: IEEE 802.11 DCF Operation

### 1.2.2 Point Coordination Function (PCF)

PCF is a polling-based contention-free access scheme. The dominant component is *Point Coordinator*(PC) which usually resides in the AP. When a WLAN system is set up with PCF enabled, the time used by an AP to generate beacon frames is called the Target Beacon Transmission Time (TBTT). At TBTT, PC can grab the medium and claim that CFP begins if the medium has been idle for *PCF InterFrame Space* (PIFS). During the CFP, the AP maintains a polling-list of registered stations and query each station if it has packet to send by the list. Only after a station is polled can it start transmission. If the polled station does not have any packet to send, it will reply a *Null Acknowledgement* to PC. Without any response from the polled station, PC will then ask the next candidate in the polling-list after a PIFS. PC will terminate the CFP if the interval is long than the predefined *aMaxCFPDuration* or all the stations in the polling-list are already polled. By receiving a *CFP-end* frame broadcasted by PC, all stations will enter CP and start DCF operations.

## 1.3 Background and literature work

Wireless technology plays an important role and affects the style of people's daily life. Portable devices like laptops and personal digital assistants (PDAs) have become ubiquitous. Meanwhile, multimedia applications, such as voice over IP (VoIP) and video on demand

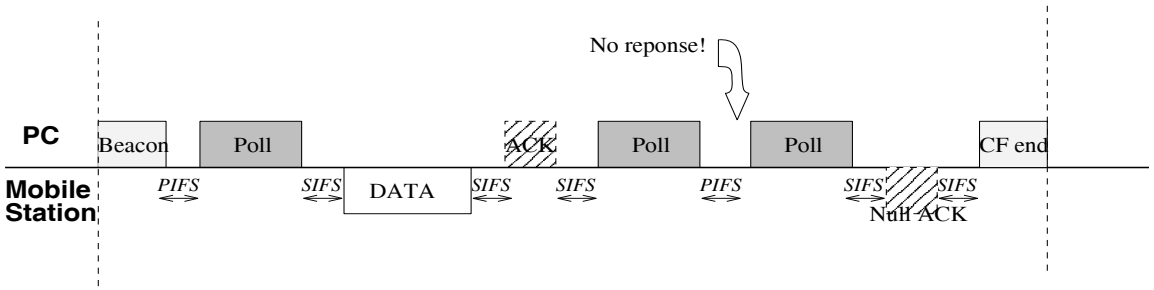


Figure 1.3: IEEE 802.11 PCF Process

(VOD), are increasing tremendously. As widely known, the bandwidth in wireless environment is not as high as in wired network. Besides, radio condition fluctuates with users' mobility and location. The issue of the quality of service in wireless environment has drawn lots of research efforts.

IEEE 802.11 is the most popularly accepted standard. It defines two types of medium access functions: *Distributed Coordination Function (DCF)* and *Point Coordinator Function (PCF)*. DCF is a distributed contention protocol. Stations have to compete for the medium. On the contrary, PCF is a centralized mechanism. A centralized controller, PC, polls the stations according to the maintained polling-list. A station can transmit only when getting polled.

Due to the instability of wireless radio, the fluctuant radio conditions degrade the service of wireless link. Some forms of diversity [3] are proposed to solve the problem. Cooperative network is usually a physical layer concept. Spatial diversity is a common method - transmission of redundant packets over essentially independent channel realizations in conjunction with suitable receiver combining to alleviate the channel effects. In [4], the user cooperation diversity is proved to increase uplink capacity. For improving PCF performance, some researchers proposed completely different polling mechanisms, such as *superpoll* [5] and *multipoll* [6], while others proposed new scheduling algorithm [7] [8] [9] for polling list maintenance. But little literature work deals with the combination of cooperative network

and polling-based systems.