Channel estimation for Rayleigh frequency selective fading channel and its implementation in Qualnet

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Abstract

Mobile communications and wireless network have experienced massive growth and commercial success in the recent years. As a wireless network simulation, QualNet software is used to develop new communication technologies through network modeling. The technologies that support computer networks are bringing information to people in new and better ways. QualNet improves the design, operation, and management of these networks through virtual networking. However, although it excels many other network simulation software, such as OPNET and NS-2 in wireless physical layer and channel simulation, it still only provide very limited channel simulation support. One limit of the very important wireless network simulations is the absence of Qualnet to simulate the frequency selective fading channel. With the prevalence of higher bandwidth application, such as 3G, WiFi, WiMax, UWB and other such technologies, the frequency selective fading issue becomes more and more important for wireless network simulation. So, it will be of great interest for many researchers to implement more functionality support for channel fading, such as frequency selective fading.

Keyword: Frequency selective fading, Rayleigh fading, Channel estimation, Qualnet

Project Plan

In this project, we will first implement a frequency selective fading channel in Matlab, and then we will design a receiver with equalization and channel estimation to test this model in Matlab, and at last, we will try to integrate our frequency selective fading channel into Qualnet by C/C++.

We will summarize what we will do in detail and what problem we expect to encounter below.

1. Application
   To simulate the channel fading and receiver design, we need to choose the application first. There are many applications may undergo the channel fading and need channel estimation, as OFDM, CDMA RAKE receiver, MIMO technology. We will choose OFDM for our application.

2. Model

There are several models for multi-path fading channels. Different model may use different fading distribution, and thus will cause different results. In our project, we will use Clarke's model for slow fading (both flat fading and frequency selective fading).

3. Algorithm
   To design an equalization or channel estimator, there are many techniques available according to different types, structures and algorithms used. Such as least mean squares (LMS) algorithm, recursive least squares (RLS) algorithm, Kalman RLS, etc. In our project, we will choose LMS algorithm since its lower computational requirement and relatively simple program structure.

4. Design
   Based on the fading channel we proposed above, we will design a channel estimator first for Rayleigh flat fading, and then use it to design an equalizer and channel estimator for Rayleigh frequency selective fading.

5. Integration
   At last we will integrate our frequency selective fading channel into Qualnet.

Since the limited support from Qualnet, and new to Qualnet simulation environment, we may expect to encounter quite a few problems during our integration.

1. How to add new model into Qualnet. To add Qualnet new model, we will use C/C++, although Qualnet itself is based on Java Runtime Environment (JRE) and need support from Java Development Kit (JDK).

2. How to integrate our fading channel model (both flat fading and frequency selective fading) into the Qualnet existing channel model.

3. In Qualnet, the simulator use BER table files for different modulations to decide their error probability. How to get received signal value and channel gain if we want to add equalizer and estimator into Qualnet. That is, how to get $g(t)$ and $h(t)$ from $g(t)=h(t)*x(t)+n(t)$. How to get BER result in fading channel.

4. We need to recompile Qualnet to make our new model workable. We need to make sure the validity of original functionalities.

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