Implementation of Co-operative Communication using GNU-Radio.

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Abstract:
Co-operative communication uses a technique of combining relay message and direct message to improve the throughput. Ad-hoc communication is one of the common communication scenarios. Ad-hoc networks do not contain any base station. It only has mobile nodes which can communicate with each other. A message from sender to receiver can be sent in one hop if both are in range. If they are not in range usually message is relayed through multiple hops. Receiver can receive only nearby node message or it can receive signals from different relay nodes depending on the protocol. If the receiver receives corrupted signals from let us say two relay nodes, both of them have to be discarded. The sender waits for some time and resends the same message again. This decreases the throughput. If both of the relay messages are combined and an uncorrupted signal is obtained then a considerable improvement in throughput can be observed. We are trying to use GNU-Radio and GNU-Radio Companion to design the communication setup.

Introduction:
USRP is designed to allow general purpose computers to function as high bandwidth software radios. Essentially it serves as a digital baseband and IF section of a radio communication system. The basic design philosophy of USRP is to do waveform specific processing like modulation and demodulation on the host CPU. All high speed general purpose operations such as digital up and down conversion, decimation and interpolation are done on the FPGA.

The combination of flexible hardware, open source software and a community of experienced users make it the ideal platform for software radio development. The USRP has 4 high-speed ADCs each having a bit-rate of 12 bits per sample and a sample rate of 64KHz. Also, there are 4 DACs present in the USRP, each having a bit-rate of 14 bps and a sample rate of 128 MHz. These 4 input and output channels are connected to an Altera Cyclone FPGA. The FPGA then connects to a USB2 interface chip, the cypress FX2 and onto the computer. USRP gives space for daughter boards on the mother board. Here two TX daughter boards and two RX daughter boards. These are used to hold the RF interface or tuner and the RF transmitter. Each daughter board has access to 2 of the 4 high-speed A/D and D/A converters. This allows each daughter board which uses real sampling to have two independent RF sections, and two antennas. When complex IQ sampling is used, each board can support a single RF section, with a total of 2 for the entire system.
GNU Radio:

GNU Radio is a free software development toolkit that provides the signal processing runtime and processing blocks to implement software radios using readily-available, low-cost external RF hardware and commodity processors. It is most commonly used in academic and commercial environments to support wireless communications research as well as to implement real-world radio systems.

GNU Radio applications are primarily written using the Python programming language, while the supplied, performance-critical signal processing path is implemented in C++ using processor floating point extensions where available. Thus, the developer is able to implement real-time, high-throughput radio systems in a simple-to-use, rapid-application-development environment.

Background:

In wireless communication signal loss in channel is a decisive factor for quality of service. In most of the cases when a signal is transmitted by a transmitter it will be reflected by multiple reflectors in the atmosphere. Each reflector will virtually act as a relay. After reflection signal will undergo distortion in time and frequency. Receiver will receive all these reflected signals. At the receiver two types of interference will occur, destructive and constructive. When destructive interference takes place then signal strength gets drastically reduced. This phenomenon is called as fading. In order to overcome fading a concept called diversity is used.

Diversity is obtaining different copies of the same signal from different channels. Some may undergo huge fading others may not so if combined all these channels decision on the information can be made more precisely. Three types of diversities can be realized they are frequency, time and space. For the diversity technique to be implemented more antennas should be used for one mobile node to capture the signals of different fade. In reality it is hard to implement. Mobile devices with more than one antenna are not feasible. In order to overcome this obstacle another technique called co-operative diversity is introduced.
In co-operative diversity mobile nodes which are near to the transmitter are considered as antennas and transmission is done by relaying the signal to the mobile nodes nearby. This exploiting of the mobile nodes in a network and using them to achieve the diversity is called co-operative diversity. Co-operative diversity is of two types Repetition-Based and Space Time Coded.

This co-operative diversity is achieving communication reliability at the cost of power dissipation, routing overhead and traffic. Some of the popular co-operative diversity techniques are amplify and forward, decode and forward.

Experiment:

We are planning to use GNU-Radio platform to conduct experiments and verify amplify and forward technique. GNU Radio companion is used to design the communication blocks. Co-operative communication requires the transmission to be done in two stages. In the first stage signal is transmitted to the receiver and relay. In the second stage, the signal gets amplified at the relay and is again retransmitted from both transmitter and relay. Firstly, we implement this using a predefined packet using GNU Radio companion. After that, we gather all the simulation results we will try to implement this practically using USRP.

Expected results and comments:

In the first case, we observe the effect of fading due to degenerative interference at the receiver. Whereas, in the second case, we implement co-operative diversity techniques such as amplify and forward, and recognize the differences between them.
References:


[3] Chansu Yu, Sangman Moh, A Cooperative Diversity-based Robust MAC Protocol in
Wireless Ad Hoc Networks, IEEE Trans. on Parallel and Distributed Systems


Control Cleveland State University, 2007.

Cooperative Diversity in Wireless Networks, IEEE
Transactions On Information Theory, Vol. 49, No. 10, October 2003