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A New Framework Based on Distributed and Diversity Combination using Priority and Post Soft Modulation Technique for effective Mobile Communication

Ayyadurai.M[1], Lakshmi Priya.J[2],
Divya M[3], Jayashree S[4]
, Associate Professor[1], UG Scholar[2,3,4]
Department of Electronics and Communication Engineering,
Jeppiaar Maamallan Engineering College, Chennai, India.
Email: ayyaduraiece@gmail.com[1],
jayaramlakshmi0102@gmail.com[2],
diyashree@gmail.com[3],
sjayshree123@gmail.com

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Abstract

In this paper, we propose a new Distributed Cooperation and Diversity Combining framework. Our focus is on heterogeneous networks with devices equipped with two types of radio frequency (RF) interfaces: short-range high-rate interface (e.g., IEEE802.11), and a long-range low-rate interface (e.g., cellular) communicating over urban Rayleigh fading channels. Within this framework, we propose and evaluate a set of distributed cooperation techniques operating at different hierarchical levels with resource constraints such as short-range RF bandwidth. We propose a Priority Maximum-Ratio Combining (PMRC) technique, and a

Post Soft-Demodulation Combining (PSDC) technique. We show that the proposed techniques achieve signicant improvements on Signal to Noise Ratio (SNR), Bit Error Rate (BER) and throughput through analysis, simulation, and experimentation on our software radio testbed. Our results also indicate that, under several communication scenarios, PMRC and PSDC can improve the throughput performance by over an order of magnitude.

***Key Words*:**Diversity, Cooperation, Hybrid Wireless Networks.

1 INTRODUCTION

Wireless communication networks are enabling an ever increasing set of applications. The service quality and scalability of these applications are limited by fundamental constraints [14]. This includes a scarce radio frequency spect4rum, signal propagation effects, such as fading and shadowing, resulting in areas with limited coverage, and the small form factor of mobile devices with limited energy capacity and antenna diversity. Recently due to the increasing demand of mobile services such as mobile computing and video streaming, improving the robustness and throughput of cellular systems as become more critical. Many technologies including dynamic power control, adaptive coding and modulation, smart antennas, have been proposed are being adapted, nevertheless the cooperation gained on the mobile client side has not been exploited yet. To improve the spectrum efficiency, one of the solutions used by operators is to deploy additional base stations, but this tragedy is ineffective and costly [15].

Currently, most smart-phones are equipped with a Wi-Fi interface besides their cellular interface. The high speed local network makes the distributed cooperation with a small group of nearby users possible. RF-channel diversity is a general mechanism to improve the robustness and efciency of wireless communication systems and have been studied for many years [1]. Our approach combines the physical layer information from multiple distributed receivers in heterogeneous wireless network, as well as accounting for the constraints on the local network bandwidth, computation and energy consumption. It exploits both the antenna gain and the channel independence. We show that this type of cooperation can signicantly improve the Signal to Noise Ratio (SNR), Bit Error Rate (BER) and throughput even with reasonably limited short range bandwidth. In this paper we propose to explore a new communication model, where multiple mobile nodes cooperate with each other and with the base station.

2 PROPOSED SYSTEM

We propose a distributed cooperation framework: Hierarchical Priority Combining (HPC) and Priority Maximum Ratio Combining (PMRC). This allows multiple levels of cooperation depending on the channel conditions and resource constraints. It consists of three levels of combining techniques: (i) Pre-Demodulation Combining (ii) Post Soft-Demodulation Combining (iii) Decode-and-Forward. Long-range communication happens on quasi-orthogonal channels. These are mainly limited by shadowing, and channel fading caused by multipath propagation and mobility. These are critical problems in cellular communication as they result in dead-signal areas and localized poor system performance. Our cooperation strategy intends to make use of the RF front ends of a group of geographically separated devices.

A. Hierarchical priority combining:

This hierarchical priority combining incorporates three levels of combining namely decode and forward, post soft demodulation and pre-demodulation.[2] First we give a outline about these three protocols and then study about HOC protocol.

A.1. Decode and Forward:

If at least one of the assisting nodes can demodulate the packet and verify its integrity, then the decoded packet can be relayed to the master node through its short-range link. This level of combining uses the minimum local bandwidth, but can only be used when the overall signal strength is high, and the mobile nodes are experiencing strong uneven fading or shadowing. [3]

A.2. Post soft demodulation combining:

At this level, the signal received by each of the assisting nodes has uncorrectable errors. [3]However, it is already strong enough for demodulation. In this case, some of the assisting nodes with the strongest received signals send the soft-decision output of the demodulator to the master node for bit level combining. Cooperation at this level can be very efficient at correcting errors when the signal strength is relatively high.

A.3. Pre De-Modulation technique:

At this level, some of the assisting nodes transmit the sampled down-converted RF-signal to the master node. We introduce Priority Maximum Ratio Combining (PMRC) as the potential candidates for Pre-Demodulation Combining. In PMRC, only the assisting nodes with the strongest SNR relay their received signals to the master. The master then combines its received signal with other gathered signals. Signal combining at this level gives the best error correction capability, but communicating the digitized waveform information requires a large local bandwidth.[4]

The HPC protocol dynamically decides which of the above three combining techniques to use at the time of the reception of the packet. Decode-and-Forward Combining and Post Soft Demodulation Combining can be taken as the lightweight version of Pre-Demodulation Combining as it either sends the complete demodulated data or partially demodulated data with soft-decision values [5]. The advantage of Decode-and-Forward combining is that it uses a minimal amount of local bandwidth, but requires a node to have a strong signal reception in order to independently and successfully decode the packet. Post Soft-Demodulation Combining, on the other hand, performs better due to the freedom of using soft-decision values from multiple sources compared to Decode-and Forward Combining. To achieve the best performance while still minimizing the local bandwidth usage, our HPC strategy uses the received signal quality to decide which combining technique to adopt for each packet.

B. Priority Maximum Ratio Combining:

We introduce Priority Maximum-Ratio Combining (PMRC) as an implementation of pre-demodulation combining scheme. PMRC is based on Maximum Ratio Combining (MRC) , but optimized for distributed cooperation and accounts for the local bandwidth usage.

C. Distributed Diversity Scenario:

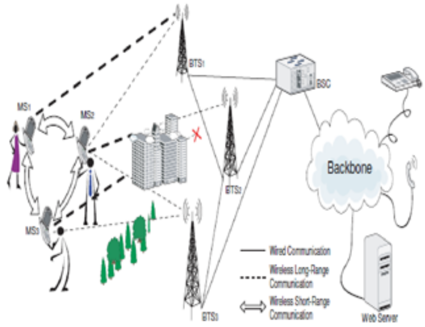
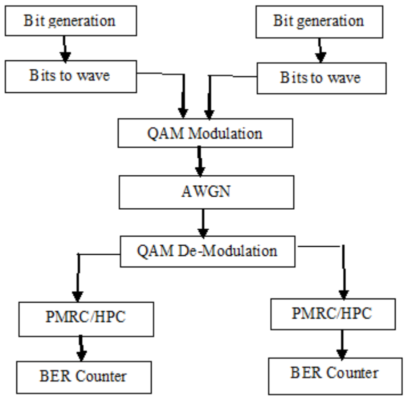


Fig. 1, Distributed Diversity Scenario [1]

Consider the scenario depicted in Figure 1: there are a group of three nearby mobile users each with a cellular phone or mobile station (MS), and base stations or base transceiver stations (BTS). [6][7]The base stations are controlled by the base station controller (BSC), which dictates the carrier frequencies, communication power and rate, etc. The base stations are also connected to the backbone which leads to the telephone network and the Internet. Communication between mobile stations and base stations is through long-range low data-rate links. Due to obstructing objects and the distance to the base station, they suffer from the typical channel fading and path loss (attenuation) that impair urban cellular communication. In contrast, mobile stations can also communicate with each other through short-range high data-rate links. Because of the short distance, their communications are fast and stable. Here we consider a simple topology with single hop communications. For example, a base station BTS1 is communicating with a mobile station MS1 and another mobile station MS2 in the vicinity through long-range low data-rate links; the links from MS1 to MS2, from MS2 to MS3, and from MS3 to MS1 are short-range high data-rate links. With cooperation, the long-range cellular signals are (1) independently received at each of the three nodes, (2) relayed through the high speed local wireless network, and (3) combined at the destination node. This cooperation can signicantly improve the Signal to Noise Ratio (SNR), Bit Error Rate (BER) and throughput. It leads to improved coverage and a system capacity boost.[[8] Furthermore, it reduces interference as the base stations do not have to increase their transmission power to overcome the channel fading in order to reach mobile nodes.[9] For the proposed cooperation strategy to be used in practice, other mechanisms need to be developed to address the important issues of security, privacy, incentives mechanisms to encourage cooperation and enforce fairness. In this paper, we focus on evaluating the potential of distributed diversity mechanisms.

D. Block diagram:



The input signals are generated as bits either as 0 or 1. These generated bits are transformed as waves. These waves are modulated using QAM modulation technique, where both 0 and 1 is taken into consideration and for better results a type of noise is taken into account which is then demodulated. The resulting wave then using PMRC/HPC modulation technique is taken and the corresponding BER is counted successfully.

E. Circuit analysis:

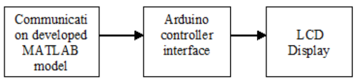


Fig. 3. IR Beacon circuit diagram

E.1.Arduino controller:

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs. It also simplifies the process of working with microcontrollers.

3 RESULTS AND DISCUSSIONS

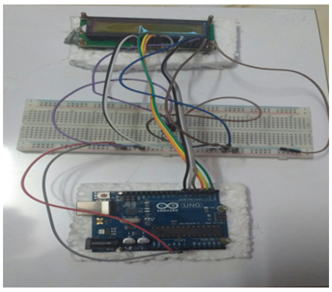


Fig 2. Hardware setup

The initial hardware setup of the device is shown in fig.2, it consist of a Liquid crystal display, a thin flat display device typically consisting of layer of molecules aligned between two transparent electrodes, and two polarizing filters, the axes of transmission of which are perpendicular to each other. It also contains Arduino UNO controller where the communication developed code is dumped and also a potentiometer to maintain or adjust the temperature of the device.

A. Simulated output:

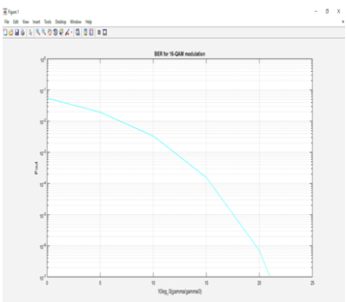


Fig 3. Simulated output (a) BER for QAM modulation

The fig.3, shows the final simulated output of BER using QAM modulation scheme. Determining BER requires a specific modulation scheme [11]. Here we use Quadrature Amplitude Modulation (QAM) scheme. To determine BER we assume a pulse shaping transmission with bit duration equal to 1/w. For an ease of analysis we consider that the transmitter sends all 0s and thus the error happens only when the combiner combines a 1.

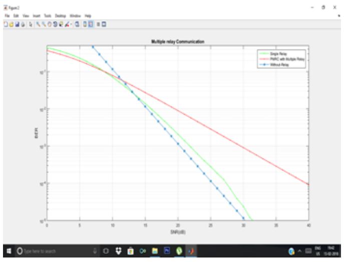


Fig.4. Simulated output (b) SNR calculation

The fig.4. shows the final simulated output of SNR calculation using the number of bits generated. The generated output seems that the signal to noise ratio increases with respect to the input signal which possess the good communication model.

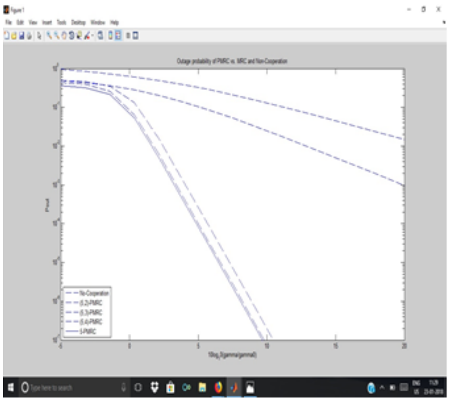


Fig.5. simulated output (c) Outage Probability

The Fig.5. Shows the final simulated output of Outage Probability. Outage probability is one of the common and effective metric in evaluating the performance of communication systems [12]. Here PMRC operates at signal level and hence we are able to compute the outage probability. From this simulation graph we can conclude that diversity gain can be acquired by requesting the contribution of energy from only very few neighbors.

4 CONCLUSION

In this paper we introduced a new framework for effective communication system termed as Hierarchical Priority Combining (HPC) and Priority Maximum Ratio Combining (PMRC). We have analyzed and compared the Bit Error Rate (BER), signal to noise ratio (SNR), and outage probability. Our analytical and experimental results show that cooperation between devices is a promising approach to increase network capacity and also to reduce the effects of shadowing and fading. It in turn allows robust communications even for typical cases [13]. This also opens door for future researches related to security in realistic uses.

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