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Research Article

Significant Throughput Improvement in Hybrid Wireless Network using PMRC and PSDC

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Abstract

In this paper, propose a new Distributed Cooperation and Diversity Combining framework, focus is on heterogeneous networks with devices equipped with two types of radio frequency (RF) interfaces: short-range high-rate interface, and a long-range low-rate interface (e.g., cellular) communicating over urban Rayleigh fading channels. Within this framework, propose and evaluate a set of distributed cooperation techniques operating at different hierarchical levels with resource constraints such as short-range RF bandwidth propose a Priority Maximum-Ratio Combining (PMRC) technique, and a Post Soft-Demodulation Combining (PSDC) technique. The proposed techniques achieve significant improvements on Signal to Noise Ratio (SNR), Bit Error Rate (BER) and throughput through analysis, simulation, and experimentation on software radio test bed .results also indicate that, under several communication scenarios, PMRC, PSDC can improve the throughput performance by over an order of magnitude.

Keywords: *Diversity, cooperation, hybrid wireless networks, PMRC, PSDC, BER*

1. Introduction

Wireless communication networks are enabling an ever increasing set of applications. The service quality and scalability of these applications is limited by fundamental constraints. These include a scarce radio-frequency spectrum, signal propagation effects, such as fading and shadowing, resulting in areas with limited coverage, the small form factor of mobile devices with limited energy capacity, antenna diversity. Recently, due to the increasing demand of mobile services such as mobile cloud computing video streaming, improving the robustness, throughput of cellular systems has become more critical. Many technologies including dynamic power control, adaptive coding and modulation, smart antennas, have been proposed or adopted nevertheless the cooperation gain 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 strategy is ineffective and costly. In this paper, propose to explore a new communication model, where multiple mobile nodes cooperate with each other and with the base stations. Investigate communication strategies that exploit the channel diversity across a set of cooperating mobile nodes equipped with multiple radio interfaces. A short-range radio interface is used the cooperating nodes to combine the long-range radio interface signals and boost its performance.

Currently, most smartphones are equipped with a Wi-Fi interface besides their cellular interface. High speed local network makes the distributed cooperation with a channel conditions and resource constraints. It consists of three levels of combining techniques: Pre demodulation Combining, Post Soft-Demodulation combining, Decode-and Forward and implementation of Pre-demodulation combining technique, called Priority Maximum Ratio Combining (PMRC), and an implementation of Post Soft-Demodulation Combining technique. An order of magnitude improvement of the SNR, outage probability, BER, throughput can be achieved, even with a limited short-range bandwidth most of the benefit of the traditional single devices.

Maximum-Ratio Combining can be exploited by PMRC or small group of nearby users possible. But very little research has been done for distributed wireless systems with multiple types of air interfaces and considering the unique characteristics of each interface. With the increased hardware integration, faster computation, high users density, the cooperation between devices is becoming possible even necessary given the increased demand for bandwidth.

RF-channel diversity is a general mechanism to improve the robustness, efficiency of wireless communication systems have been studied for many years. Many existing technologies traditional diversity paradigms, 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, energy consumption. It exploits both the

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*Corresponding author **M. Saranyadevi** is a 2nd year CSE student and **R. Suresh M.E** is working as Asst Prof antenna gain the channel independence this type of cooperation can significantly improve the Signal to Noise Ratio (SNR), Bit Error Rate (BER), throughput even with reasonably limited short range bandwidth. It leads to an improved coverage, capacity boost, and reduction of interference.

To the best of knowledge, it is the first to consider a heterogeneous architecture to combine multiple long-range links at the physical layer for diversity purpose first present system model the Hierarchical Priority Combining (HPC) framework .In propose a strategy of Pre demodulation Combining PMRC, Post Soft-Demodulation Combining PSDC. In Section 3, present the evaluation model used in analysis. In Section 4, present the performance evaluation results for PMRC, PSDC in terms of outage probability, Bit Error Rate, throughput, local bandwidth usage, and delay. Finally, present prototype implementation of PSDC on using GNU Radio, show the experimental results.

1.1 Contributions

Propose a distributed cooperation framework Hierarchical Priority Combining strategy, which allows multiple levels of cooperation depending on the channel conditions, resource constraints. It consists of three levels of combining techniques: Pre demodulation Combining, Post Soft-Demodulation Combining, Decode-Forward .propose an implementation of Pre demodulation Combining technique, called Priority Maximum Ratio Combining (PMRC), an implementation of Post Soft Demodulation Combining technique. Order of magnitude improvement of the SNR, outage probability, BER, throughput can be achieved, even with a limited short-range bandwidth.

1.2 Related Work

While, cellular communications has been benefiting from continuous improvements of the physical/link-layer between a mobile station (MS) one or multiple base stations (through various coding, modulation, and antenna technologies), it is only recently that distributed cooperation started to attract more interest from the wireless communications networking research community. Most previous work on signal combining focused on the centralized scenario of a smart antenna system with multiple elements. Techniques such as Maximum Ratio Combining Generalized Selection Combining (GSC) were carefully analyzed in. The proposed PMRC technique is an extension of GSC where the master node signal is always included. The major difference between work previous works is considering a distributed cooperation setup, where the local bandwidth is the main bottleneck. Compare PMRC with a PSDC that significantly reduces the local bandwidth requirement with only limited performance degradation. In addition to the analytical simulation results, experimentally evaluate the proposed techniques.

Some studies have investigated specific cases of distributed cooperation such as diversity with homogeneous interfaces where the combining occurs over the air. Other approaches demonstrate the benefits of distributed cooperation in ad hoc networks with homogeneous wireless interfaces challenged the community to investigate the full benefits of distributed cooperation. A theory of distributed MIMO in ad hoc network has been studied. The use of cooperating heterogeneous air interfaces was advocated. A distinguishing feature of work is aim at improving the performance of a long-range link (i.e., cellular) using cooperation over bandwidth constrained short range links in heterogeneous wireless network .propose several techniques, analyze their theoretical performance ,confirm their feasibility with a real-world prototype. In previous work, introduced Threshold Maximum Ratio Combining studied its performance. In this paper, significantly extends our previously proposed distributed cross-layer diversity framework to hierarchical combining (HPC) introduce PMRC, PSDC substantially superior combining techniques.

2 Approach

A hybrid network where the mobile nodes are equipped with two radio interfaces: a long-range, low data rate cellular interface ,a short-range, high data-rate interface .study is in the case where the long-range communication happens on quasi-orthogonal channels is mainly limited by shadowing, channel fading caused by multipath propagation, mobility. These are critical problems in cellular communication as they result in dead signal areas localized poor system performance. Strategy intends to make use of the RF front ends of a group of geographically separated devices.

2.1 Distributed Cooperation Framework

Consider the scenario depicted in Fig. 1: there are a group of three nearby mobile users each with a cellular phone or mobile station, base stations or base transceiver stations (BTS). The base stations are controlled by the base station controller (BSC), which dictates the carrier frequencies, communication power rate, etc. The base stations are also connected to the backbone which leads to the telephone network the Internet. Communication between mobile stations base stations is through long-range low data-rate links. Due to obstructing objects the distance to the base station, they suffer from the typical channel fading path loss (attenuation) that impairs 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 stable. Here, consider a simple topology with single hop communications. For example, a base station BTS_1 is communicating with a mobile station MS_1 another mobile station MS_2 in the vicinity through long-range low data rate links; the links from MS_1 to MS_2, from MS_2 to MS_3, from MS_3 to MS_1 are short-range high data-rate links.

With cooperation, the long-range cellular signals are 1) independently received at each of the three node.2) relayed through the high speed local wireless network, 3) combined at the destination node. This cooperation can improve the Signal to Noise Ratio, Bit Error Rate, and throughput. It leads to improved coverage a system capacity boost 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.

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 enforce fairness. In this paper, focus on evaluating the potential of distributed diversity mechanisms.

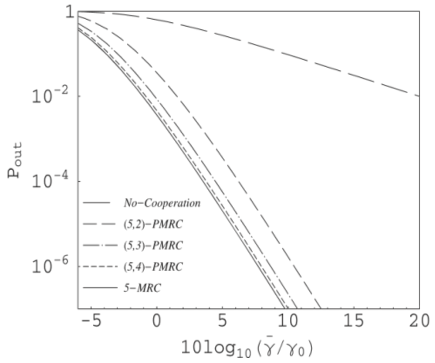


Fig 1 Outage probability of PMRC versus MRC And noncooperation

2.2 Hierarchical Priority Combining

In this part, introduce a distributed cooperation framework Hierarchical Priority Combining. It incorporates three levels of combining: Decode-Forward, Post Soft-Demodulation, Pre demodulation. First outline the three combining techniques used in HPC; then describe the proposed HPC protocol; followed by the performance analysis.

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

Phase I: The master node broadcasts a cooperation request beacon if it is unable to decode the packet. Upon receipt of the cooperation-request beacon, the assisting nodes measure the SNR of the received signal (denoted by) from their long-range air interface compare it with a predefined threshold D. (D is the threshold above which demodulating the packet is feasible.)

If < D, the assisting nodes broadcast the SNR to others. Otherwise, they will try to demodulate the packet independently verify its integrity using a CRC-like checksum. Finally, the assisting nodes broadcast both the SNR the CRC verification result. Each node is assigned a particular time slot during the phase I to avoid collision.

Phase II: In this phase, each node makes a decision after hearing the report of signal quality from other assisting nodes. If at least one assisting node can demodulate the long-range RF signal pass the CRC check one of them with the highest ID will relay .the decoded packet to the master, that is the Decode-Forward case no one passes the CRC check the total number of assisting nodes with > D is more than a predefined value, the top 1 nodes with the strongest SNR transmit (in the order of their ID) their soft-decision values to the master for Post Soft-Demodulation Combining. S_{oft} is a preset system parameter, the transmission size S_{oft} 1 is limited by the local bandwidth. In the end, if none of the above cases happens, then the assisting nodes send the sampled long-range radio waveform to the master node for Pre demodulation combining.

2.3 Priority Maximum-Ratio Combining

Introduce PMRC as an implementation of pre demodulation combining scheme. PMRC is based on Maximum Ratio Combining, but optimized for distributed cooperation accounts for the local bandwidth usage. In PMRC, a subset of the assisting nodes with strongest SNR relay their signals to the master to combine with the signal received at the master node, Modified slightly to avoid the hidden node problem. In this case, if an assisting node fails to hear all other nodes' broadcast messages in Phase I, it should exclude itself from cooperation for that around. MRC is a linear combining technique to combine multiple independent signal branches. Let n be the total number of signal branches for combining. The signal received from the ith branch, where r_i is signal amplitude i is the signal phase.

In MRC, a weight is applied at the Itch signal branch. If the fading channels are independent identically distributed root of the by SNR choosing for each a proper branch weight to be the square root of the SNR for each branch .the SNR of MRC scales linearly with the number of independently signal branches,

Consider a system of M mobile nodes in cooperation. For each packet (or time slot) PMRC first identifies the N 1 strongest signals out of the M 1 cooperating neighbors then combines their sampled signals with the signal received by the master node (destination) before demodulation. The selected signals are combined by MRC.

2.4 Post Soft-Demodulation Combining

Pre-demodulation combining techniques such as PMRC, the signal is first down converted to the intermediate frequency then sampled using an analog-to-digital converter (ADC). However, this sampled signal can be substantially large. Therefore, directly transmitting the sampled signal is not very efficient should be avoided if possible.

A more efficient solution is to use the soft-decision values from the demodulator instead of the hard values. A soft decision value SV is a real number in ½1; 1. In the case of binary, if SV < 0 of being 0 or 1. Due to the extra information they provide, they can have better error correction ability in comparison with the hard values. Upon receiving a set of soft-decision values from the assisting nodes, the master node needs a method to combine those values the value from itself, output the most likely initially transmitted value. One simple solution is to take the value which has the highest confidence. Another simple solution is to take a majority vote or the sum of all the soft values. However, these are suboptimal combining techniques. Introduce Maximum Likelihood Soft Combining algorithm to combine the soft values from multiple signal sources. The Maximum Likelihood Soft Combining algorithm produces the value with the lowest error probability.

2.4.1 Maximum Likelihood Soft Combining

First, nee d to transform the soft-decision values into a form that can be used by the combiner For a given soft decision value SV (float), in the case of binary it is 1 if SV >0, if SV < 0. Map each SV into a pair ðy; PeÞ, where y is the hard decision value Pe is the error probability. Inspired by the Maximum-Likelihood receiver, combining technique Maximum-Likelihood Soft Combining is as follows. For a u-ary system; the Maximum-Likelihood Soft Combining decoder combines the n signal sources to produce an outcome that is the most probable (2). Therefore, it minimizes the bit error rate

3 Evaluation Model

3.1 Channel Model

In wireless communications, various types of fading cause the signal power to fluctuate over time, space due to multipath propagation shadowing. This is the case of urban cellular communications, the signal travel through multiple paths due to the reflection from objects such as buildings, trees. The signals from these paths might add up or cancel each other result in weak signals. In analysis, consider a typical channel propagation model for cellular communications, the Ray- Leigh channel, where there is no dominant propagation path between the transmitter the receiver, multiple delayed signals from different paths add up at the receiver. It is usually the case where there is no line-of-sight (LOS). If there is LOS, the fading can be modeled as Rican channel. In this paper, mainly consider the case of Rayleigh channel. The analysis of Rican, other fading channels can be completed in the similar manner. Signal envelope r is Rayleigh distributed . The probability density function (PDF) for r is given by r r2.where ^{2} is the variance, represents the AC power in the signal envelope.

Let N $_0$=2 is the noise power spectral density (PSD). The SNR ¼ r^{2}ðtÞ=N $_0$ is exponentially distributed .assume that the long-range communication is over a licensed band does not suffer from external interference. Interference from devices, base stations internal to the system is thus controlled by the cellular protocols. The probability distribution of the SNR can be modeled as where denotes the long run average SNR the cumulative distribution function. In practice, the average SNR might not be the same for each node, due to shadowing, but as a first step to demonstrate the potential gain analysis assumes equal average SNR for each node with the noise power spectral density N $_0$=2. Due to the spatial separation, the fading channel for each node is independent and the probability that the signals received by all nodes have an SNR less than t.

In PMRC, the master node always combines its own received signal with the N 1 strongest signals from the assisting nodes. Using its own signal does not incur any local bandwidth usage or energy consumption always improves the combined SNR.

Let 0 denote the random variable of the PMRC signal's SNR at the master node, be the random variable of the combined signal SNR from N 1 assisting nodes, be the random variable of the signal SNR of the master node.

Because the master combines the signal from assisting nodes the signals from itself using MRC, Since the probability distribution of the sum of two independent random variables is the convolution of the two random variables, obtain the probability distribution .Computing the SNR probability distribution for higher values of N can be done in the same way. However, it will show that small values of N are sufficient to obtain most of the diversity gain.

3.3 SNR Distribution For Priority Signal Source

The proposed Post Soft-Demodulation Combining uses the soft-decision values from the master a subset of assisting nodes with the strongest signals among all assisting nodes. Let M be the total number of nodes in cooperation including the master node.

For each packet, N 1 assisting nodes with the strongest signals transmit their soft-decision values to the master node for combining. Consider Rayleigh fading as channel model (See Section 3.1).

Let A be the random variable for the SNR at the master node, let X;Y ;Z be the random variables for the highest, the second highest, the third highest SNR among the M 1 nodes. a;x;y;z are the parameters of the probability distribution functions.

In the case of N ¼ 2, the joint probability of the master node the assisting node with the highest SNR .In the case of N ¼ 4, the joint probability of the master node three assisting nodes with the highest SNR .A generalized form can be derived as follows. Let ˜ be a vector of the random variables of the received signal SNR. Let $_i$ be the random variable for the qi 1Þth highest SNR among the M 1 assisting nodes. The joint probability of i nodes (the master node i 1 assisting nodes with the highest SNR)

4. Evaluation Results

In this section, present the evaluation results in terms of outage probability, bit error rate, throughput, local bandwidth usage, impact of short-range link delay ,bandwidth; compare the performance of proposed techniques with existing techniques; compare the performance between PMRC, PSDC.

4.1 Outage Probability

Outage probability is a common effective metric to evalu-

-ate the performance of communication systems. Assume that $_0$ is the minimum SNR that can be tolerated by the decoding scheme. Outage probability is defined as P_{out}ðÞ ¼ p_0 ð 0Þ where is the average SNR. Since PMRC operates at signal level, able to compute the outage probability for PMRC. Fig. 2 shows the performance of ð5;NÞ- PMRC for N ¼ 2;3;4 compares it with the non-cooperative scheme the traditional MRC. For example, for a target P_{out} ¼ 10^2, in ð5;2Þ-PMRC the average transmission energy can be reduced by more than 17 dB comparing to non-cooperative scheme, which is 50 times less energy. From this graph, conclude that most of the benefit of the diversity gain can be acquired by requesting the contribution from only a few neighbors with strong signals studied the impact of the number of cooperating nodes on the outage probability. Fig. 3 shows that increasing M significantly reduces the outage probability. Fig. Impact of M on the performance of PMRC in terms of BER. For example, although 5-MRC outperforms ð5;3Þ-PMRC, increasing M by 1 gives ð6;3Þ-PMRC which not only outperforms 5-PMRC (by 2 dB at P_{out} ¼ 10^7) but also requires only two cooperating nodes to send their contributions instead of totally four nodes in the case of 5-MRC. Therefore, 5-MRC requires 100 percent more bandwidth for lesser performance than ð6;3Þ-PMRC.observe that when the average SNR increases, ðM^0;1Þ will eventually outperform M-MRC (or any ðM;NÞ PMRC) as long as M^0 > M. Note that M-MRC (i.e., MRC with M branches) is identical to ðM; MÞ-PMRC.

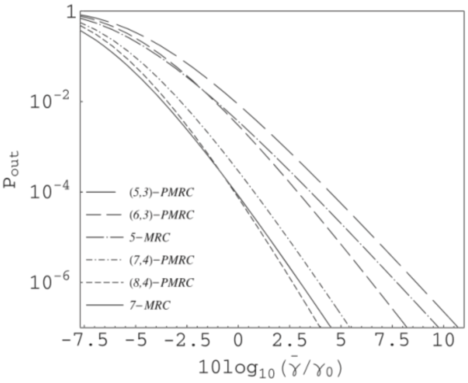


Fig 2 Impact of M on the performance of PMRC

4.2 BIT Error Rate

Bit Error Rate is another important performance metric of communication systems. Determining the BER requires considering a specific modulation scheme .use the coherent Minimum-Shift Keying (MSK) modulation, which is similar to GMSK used in GSM system, with un coded communication. To compute BER, assume a pulse shaping transmission with bit duration equal to 1=W such as raised cosine pulses[1] with ¼ 1 (where W is the used frequency BER ¼ Qðq bandwidth).Therefore, obtain E Similar=N 0 ¼ results con-the sideling Binary Phase Shift Keying (BPSK) modulation.

First, compare the performance of PMRC to the non-cooperative mode the traditional MRC.BER performance of PMRC is consistent with the outage probability. Fig. 4 shows that for a target BER of 10^3, ð5; 2 Þ-PMRC requires 20 dB (100 times) less power with the contribution from only one cooperating neighbor. Higher gains are achievable when the target BER is lower. Analytical result indicates that most of the gain of MRC.

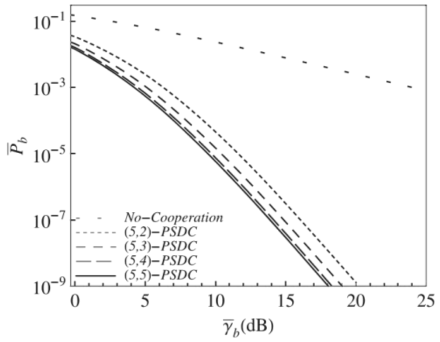


Fig 3 Bit Error Rate of coherent MSK demodulator under PSDC (N ¼ 2;:::;4) versus MRC and noncooperation.

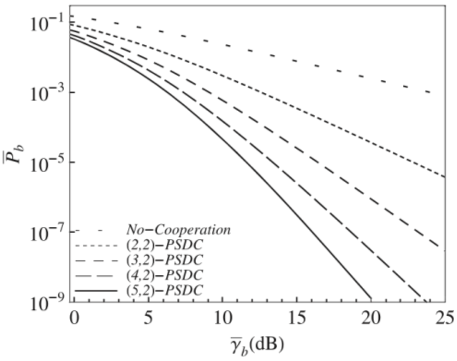


Fig 4 Impact of M on the performance of Post-Soft Demodulation combining in terms of bit error rate

MRC obtained using the two to three strongest signals from neighboring nodes. This is in line with the principle of diminishing return of diversity in multi antenna systems. Fig. 5 shows the impact of increasing. Similarly to the outage probability, increasing the number of cooperating node outperforms the benefit by increasing, the number of nodes who are effectively sending their contributions.

For a target BER of 10^3, ð5; 2 Þ-PSDC requires 17 dB less power with the contribution from only one cooperating neighbor (See Fig. 6). Higher gains are achievable when the target BER is lower. Observe most of the diversity gain can be obtained by using a few (two to three) strongest neighbors. Fig. 7 shows the impact of M on the BER performance. the parameter M has a more dominant effect on the BER than N. So, it is always better, if possible, to include more nodes as potential contributors rather than increase the number of actively cooperating nodes (who are relaying to the master). Since PSDC is similar to PMRC, PSDC aims at reducing the local communication footprint, want to determine how much performance loss it causes. Fig. 8 shows that the BER of PSDC is slightly higher than PMRC under the same configuration. This can be explained by the fact that PSDC only benefits from the diversity gain; in contrast PMRC exploits both the diversity gain the energy (antenna) gain.

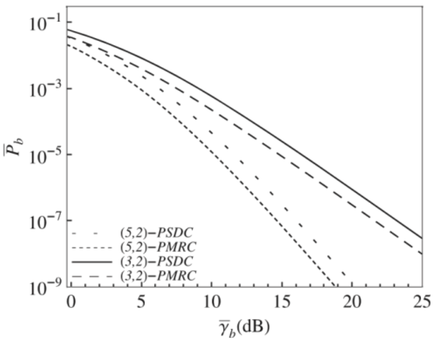


Fig 5 BER comparison between PSDC versus PMRC

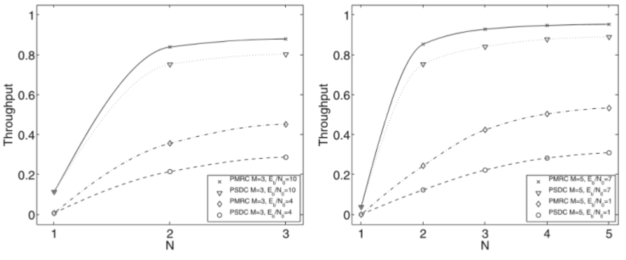
4.3 Throughput

To measure the throughput of PMRC PSDC, consider the packet overhead of 32 bits CRC necessary for error detection. The throughput can be calculated as

$$\text{Throughput ¼}\frac{\text{ðL OHÞð1 BERÞ}^{L}}{\text{L}}; \quad \text{ð24Þ}$$

Where OH is the CRC length L is the frame length. Determine use the value of L that maximizes the throughput. For fairness, the packet size is normalized to maximize throughput.

Fig. 9 shows that the throughput of the master node can be tremendously increased by signal combining with a limited number of cooperative nodes in PMRC or PSDC .find that PMRC gives comparable performance of MRC by using fewer active branches For example, for N ¼ 3 M ¼ 5 (Fig. 9c), besides the master's branch it uses only two active branches out of the four external diversity branches, but it still achieves a throughput of more than 0.9 with a fairly low E_b=N $_0$ (4 dB or above). This tells us that its throughput performance must be at least 90 percent of the performance given by MRC (the maximum is 1) while it uses only half of the bandwidth required by MRC. With a very low E_b=N $_0$ at value 1, it still maintains the throughput at 0.65.

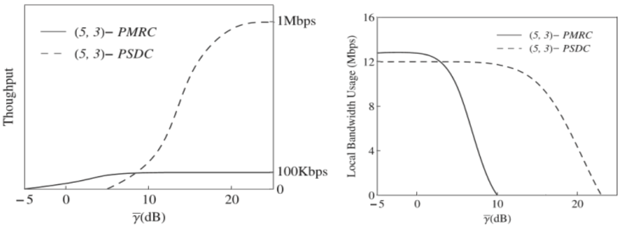


(a) $M = 3$ (b) $M = 5$

Fig 6 Throughput PSDC versus PMRC

4.4 Local Bandwidth Usage

The sole PMRC/PSDC scheme has fixed local bandwidth usage. For ðM;N Þ-PMRC/PSDC, the local bandwidth usage constant is always N 1. Consider a two-level HPC strategy which consists of Decode-Forward Combining PMRC or PSDC. The local bandwidth can be computed by considering three cases: 1) the master can correctly decode the frame/packet



(a) Throughput (b) Local bandwidth

Fig 7 Performance of HPC under PMRC (long-range data rate ¼ 100 Kbps, R ¼ 64)

PSDC (long-range data rate ¼ 1 Mbps, R ¼ 6). Packet Length is 1,500 B. Distributed multiracial systems can boost the performance of a group of mobile soldiers. Fig. 11 shows the performance of PMRC, PSDC for these scenarios

(100Kbps versus 1Mbps). The throughput was computed accounting for the implication of higher rate on the receiver E_b=N $_0$. The results show if the signal quality is low (such as ¼ 0 dB), the local bandwidth usage is high for both techniques, because the assisting nodes are transmitting all the time; As the signal quality rises, the local bandwidth usage is reduced sharply. The results also show that when the E_b=N $_0$ starts increasing PSDC becomes more interesting than PMRC for the same local bandwidth constraint.

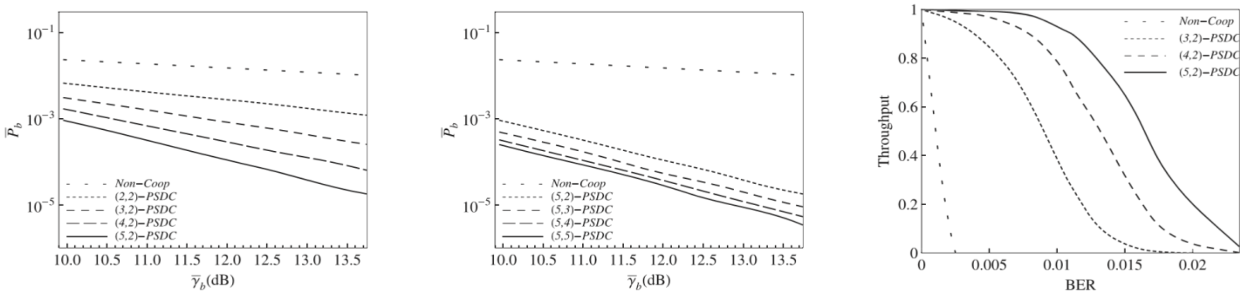
4.5 Local Delay

Cooperation using the short-range link necessitates that the local network capacity is sufficient for the information transfer rates that the delay is small. Excessive delay can result in unacceptable storage requirements for the receivers especially given that every bit of data is stored as several samples or soft values.

The proposed cooperation protocols have two phases. Given the limited amount of data transferred during the first Phase, the delay of phase will dominate. Two extreme approaches (with several variants in between) can be used to limit the delay: 1) using a dedicated hardware protocol stack with a traffic scheduler to minimize the delay, 2) relying on existing wireless local area networks hardware network stacks. In the following, discuss the use of the pervasive IEEE802.11 (ad hoc mode) as the underlying protocol. More dedicated hardware software would provide better performance. To derive the buffer size requirement, take a worst case delay of 100 MS.

5. Prototype Experiments

Implemented a prototype test bed of system on the GNU Radio/USRP platform, have measured the performance of PSDC technique experimentally. GNU Radio is an open-source software-defined radio (SDR) platform the Universal Software Radio Peripheral (USRP) is a popular hardware implementation compatible with GNU Radio.



(a) BER ($N = 2$) (b) BER ($M = 5$) (c) Throughput

Fig 8 PSDC experiment results

The purpose of software-defined radio is to bring the software as close to the radio antenna as possible. The key benefit can do the entire signal processing in software on a general purpose computer. This allows a tremendous flexibility during prototyping at a relatively low cost.

In experiments, use a GMSK modulation at 500 kbps on the 2.4 GHz ISM band. The GMSK demodulator is modified to output the soft-decision values. In order to obtain reproducible results that are not impacted by external interference from other systems operating over the 2.4 GHz band, use an RF cable to connect the communication boards. This also allow us to precisely control the $\frac{Eb}{N_0}$ .A precise Rayleigh fading channel is difficult to experiment with using relatively large software radio setups, so use a software technique to emulate the Rayleigh fading effect conducted experiments for a long period of time with various transmission power levels. The total amount of recorded data is over 200 GB. Due to hardware limitations, only were able to complete the BER experiments in the range from 10^1 to 10^6, but experimental result can already show a significant improvement in BER on the current hardware .summarize the results. For a target BER of 10^3, ð5;2Þ PSDC requires 15 dB less power than the non-cooperative case with the contribution from only one cooperating node. Higher gains are achievable when the target BER is lower. Fig. 13c shows the system throughput derived from the BER with the packet size 500 bytes a 32-bit CRC overhead. The PSDC technique is able to effectively boost the throughput in the high BER situations those confirm analysis values.

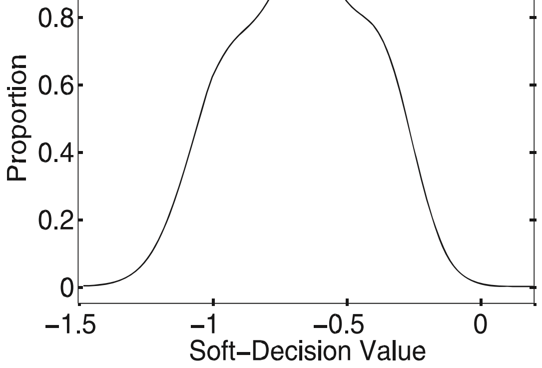


Fig 9 The distribution of the soft-decision values from the receiver if zeros are sent out.

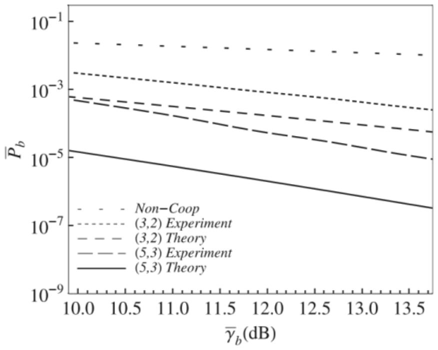


Fig 10 BER of PSDC theory versus experiments

The results for bit error rate are shown fig find that if the soft-decision values are quantized to 6 bits, it has a performance close to a 32-bit float number (the required transmission energy is around 0.25 dB higher). However, it still requires transferring 6 bits for 1 bit of data. When reducing the quantization level to 3 bits, the bit error rate start degrading, however the results are still acceptable considering the amount of bandwidth it saves. Here, use the uniform quantization. In the future, implementation can be further improved by using non uniform quantization, but current experimental results show that the uniform quantization already reaches a good performance.

Conclusion

In this paper introduced a framework for distributed cooperation and diversity over two radio interfaces. proposed a Priority Maximum-Ratio Combining technique, and a Post Soft-Demodulation Combining technique that leverage distributed diversity while limiting the local communications .analyzed and compared PMRC and PSDC in terms of SNR gain, outage probability, bit error rate, throughput, and delay .analytical and experimental results show that the cooperation between devices with a combination of cellular and short-range air interfaces is a promising approach to increase network capacity and mitigate the effects of channel fading and shadowing. It allows robust communications with order of magnitude weaker signals for typical scenarios (e.g., five cooperating nodes and two actively assisting nodes). These types of cooperation also open several directions of future research on security for a realistic use of the proposed mechanism.

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