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OUTAGE PROBABILITY OF ENERGY HARVESTING USING DECODE AND FORWARD TECHNIQUE

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Abstract

Energy harvesting technique is important for relay node energy supply in cooperative network with respect to deployment flexibility andmaintanencecharge reduction. To end of this paper focuses on outage probability,SNR and comparison of direct transmission protocol , constant power supply. Decode and forward technique is employed toachieve multiplicative gain and reduced the outage probability. In particular, if there are multiple available relay nodes around the environment cooperative networks, outage probability,energy harvesting, on-off or the energy exhausted probability of relay node is small, it is very profitable. it is potential and profitable to employ energy harvesting relay aided cooperative transmission technique to improve system's outage performance in some fading channel scenario.

Index Terms—relay-aided model, diversity gain, decode and forward technique .

Introduction

Recently, energy harvesting is an efficient way, which can collect energy fromrenewable resources in ambient environment such as solarenergy, wind, geothermal energy and even radio frequency(RF) signal, has attracted much attention.Cooperative diversity is a cooperative multiple antenna technique for improving or maximising total network channel capacities for any given set of bandwidths which exploits user diversity by decoding the combined signal of the relayed signal and the direct signal in wireless multihop networks. A conventional single hop system uses direct transmission where a receiver decodes the information only based on the direct signal while regarding the relayed signal as interference, whereas the cooperative diversity considers the other signal as contribution. That is, cooperative diversity decodes the information from the combination of two signals. Hence, it can be seen that cooperative diversity is an antenna diversity that uses distributed antennas belonging to each node in a wireless network.Besides, the performance of amplifying forward multiple input multiple output (AF-MIMO) system with energy harvesting receiver was analyzed in [9].

According to the state of the art, sufficient energy can be provided for relay nodes by energy harvesting from surrounding environment [10]. However, due to the fluctuation of renewable sources, the harvested energy flow cannot keep stable just like traditional power supply, which may degrade the benefit obtained from cooperative transmission technology. To the best of my knowledge, compared with relay-aided cooperative networks powered by

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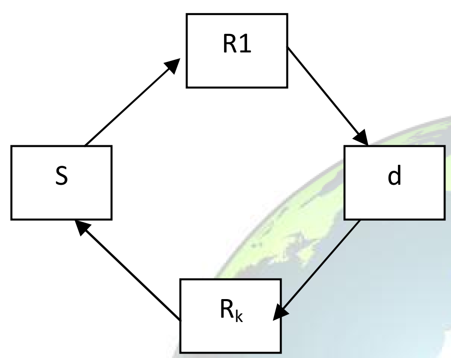
stable energy supply, the performance loss resulted from harvested energy fluctuation. Moreover, whether it is profitable to employ energy harvesting relay-aided protocol compared with simple direct transmission protocol .



Simple structure for energy harvesting relay aided cooperative networks

PRELIMINARY

A. System Structure and Channel Model

Fig. 1 illustrates an example of system structure for energy harvesting relay-aided cooperative network, which consists of one source node, one destination node and *K* available relay nodes, denoted as *S*, *D* and *Rk*(1 _ *k* _ *K*), respectively. Information flow is intended to be transmitted from *S* to *D*. Let's take time-division notation as an example for characterizing the channel model. In a signal block, *xs*[*n*] denotes the narrow-band transmit signal at *S* with zero mean and E[*jxs*(*n*)*j*2] = 1, where E[*·*] denotes statistical mean
operation. For direct linkis assumed that *S* is powered by a traditional stabilized power source *Ps*. In contrast, *Rk*is powered by the energy harvesting module. Besides, in order to isolate the benefit of space diversity, it is assumed that each node is equipped with only one antenna.
baseband-equivalent discrete-time model for the channel *S*□*D* can be expressed as
ys;d[*n*] =√ *Pshs;d*[*n*] _ *xs*[*n*] + *nd*[*n*]*; n* = 1*;* 2*:::N:* (1)

where*N* denotes the length of a whole signal block, *ys;d*[*n*] is the received signal at *D*. Channel fading coefficient and additive noise are denoted as *hs;d*[*n*] and *nd*[*n*], respectively. Christo Ananth et al. [12] proposed a system which can achieve a higher throughput and higher energy efficiency. The S-BOX is designed by using Advanced Encryption Standard (AES). The AES is a symmetric key standard for encryption and decryption of blocks of data. In encryption, the AES accepts a plaintext input, which is limited to 128 bits, and a key that can be specified to be 128 bits to generate the Cipher text. In decryption, the cipher text is converted to original one. By using this AES technique the original text is highly secured and the information is not broken by the intruder. From that, the design of S-BOX is used to protect the message and also achieve a high throughput, high energy efficiency and occupy less area.

Then, the received information is retransmitted from *Rk*to *D* in the following sub-phase, which is
yrk;d[*n*] =√*Prhrk;d*[*n*] _ *xrk*[*n*] + *nd*[*n*]*; n* = *N*=2 + 1*; :::N:*(3)

where*xrk*[*n*] denotes the transmit signal and *Pr*denotes thetransmit power at *Rk*. *hrk;d*[*n*] is the channel fading coefficientbetween *Rk*and *D*.It is reasonable to assume that *hi;j*[*n*], where *i 2 fs; rkg*and *j 2 frk; dg*, keeps the same during a signal block andchanges independently between different blocks. In Eqn. (1)-3), *hi;j*[*n*] captures the effect of path loss, shadowing andsmall-scale fading. Since small-scale fading is the main factorfor outage event and

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path loss can be compensated by powercontrol, this paper concentrates on the effect of small-scalefading. Without loss of generality, *hi;j*[*n*] is modeled as zeromean, independent, circularly symmetric complex Gaussianrandom variable with variance _2*i;j*in this paper. Besides,*nj*[*n*] is also modeled as zero-mean, independent, circularlysymmetric complex Gaussian random variable with variance.

B. Relay-aided Cooperative Protocol

Since the exact capacity region of relay channel is still anopen problem [11] and the main purpose of this paper is toevaluate the benefit generated by energy harvesting relay-aidedcooperative transmission, we only consider some simple relaystrategies in this paper instead of attempting to obtain someoptimal transmission strategies. Before presenting the specificcooperative protocol, let's introduce the definition of directtransmission protocol firstly to serve as a baseline.

Definition 1: In direct transmission protocol, only the directlink between S and D is available. Thus, all the time slots ina signal block are used by direct link.Thus, if direct transmission protocol is employed, the overalldata rate from *S* to *D* can be given in Eqn.(4), whichcan be achieved by zero-mean, circularly symmetric complexGaussian inputs [1].

Rs;d= *W* log2(1 +*jhs;dj*2*Ps*_20)(4)

where*W* denotes the frequency bandwidth, and the index *n* isignored for description convenience in the sequel of this paperwithout any specific declaration.Assuming the minimum acceptable rate is *R*0, the outageprobability *Pr*[*Rs;d*< *R*0] under direct transmission protocol.

In order to improve the outage performance of system,relay-aided cooperative technology is an effective way. Thecooperative protocol employed in this paper is presented asfollows.

Definition 2: In relay-aided cooperative protocol, both directlink and relay links are available for information transmission.One relay-aided link with enough available energyamong Ks will be set up if and only if direct link is toodeteriorated leaded by deep fading.

Namely, the cooperative protocol contains two steps:

• Step 1: The system tends to transmit information overdirect link. If *jhs;dj*2 is bigger than the threshold value,direct link shown in Eqn. (1) is sufficient to support thedata rate *R*0 and relay link won't need to be set up;Otherwise, go to Step 2.

• Step 2: One relay link among *K*s as shown in Eqn. (2)-(3) will be selected and activated to provide an alternativelink instead of direct link. If it also fails, an outage eventwill occur.

Two reasons motivate us to employ this strategy: firstly, thisstrategy is more feasible than other possible ones, since relaylinks should be activated as less as possible to save time slotsand reduce the overhead information [13]. Besides, the workin [2] has already proved that the selection strategy with stablepower supply can achieve the maximal diversity gain value,which is equal to the number of available relay node underi.i.d Rayleigh fading channel.

ENERGY HARVESTING MODELING

From a perspective of transitterRk at beginning of each second half phase for relay-aided transmission, *Rk*only consider whether there is enough energy in the buffer for waking up itself and retransmitting the

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current signal block, not the specific value of energy buffer status.

preposition1: For the cooperative protocol system that relay-aided link will wake up if and only if the direct link is too bad and the current available energy at relay node is more that Pr, the energy harvesting module at Rk can be characterized by the parameter pair (Pr; pexk), which can captures the

When$pex1 = 1$, it is equivalent tothe traditional system with direct transmission protocol. Andwhen $pex1 = 0$, it is equivalent to the system in which the relaynode is powered by constant power source.The outage probability of cooperative networks as a function of SNR when the number of available relay nodes K is 0, 1, 2 and 3, respectively, where ($pex1 ;pex 2 :::pexN$) = $\mathbf{0}{:}\mathbf{1}$.It can be observed that the systemperformance can be improved significantly as the incrementof K. Due to the low-cost of relay node powered by energyharvesting, it is possible to deploy large amount of relay nodesaround the environment. Thus, it is profitable to improve theoutage performance by this way. The outage probability of the cooperativesystem as a function of energy-exhausted probability at relaynode when the SNR is 20 dB and $K = 1$. Besides, served as twocomparisons, the outage probabilities of direct transmissionprotocol and cooperative networks with constant power sourceare also given, which can be regarded as two extreme casesof the cooperative networks with energy harvesting relay. Thecooperative network with energy harvesting bridges the twoextreme cases.

CONCLUSION:

This paper mainly investigated the performance of cooperativenetworks aided by energy harvesting relay node in termsof *stochastic property of harvested energy without any loss.*

Proposition 2: In the high SNR regime, the outage probability under the proposed relay-aided cooperative transmission protocol.

SIMULATION RESULT:

outage behavior in slow fading scenario. From a perspectiveof systematic level, an on-off Markov model was proposed tocharacterize the stochastic property of harvested energy flow.With the help of some approximations, the explicit closedformof outage probability of cooperative system has beenderived in the high SNR regime. It can be observed that greatimprovement can be obtained by the proposed cooperative protocol in terms of minimizing outage probability. Besides,the system performance also can be improved by increasingthe number of available relay nodes in the environment. Thus,it is potential and profitable to employ energy harvesting relayaidedcooperative transmission technique to improve system'soutage performance in some fading channel scenario.

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