Literature Review on Performance Analysis of AF Cooperative Networks

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Abstract- The goal of this review work is to study and analyze various cooperative transmission techniques under the two common relaying signal processing methods, namely decode-and-forward (DF) and amplify-and-forward (AF) through literature review in order to improve the performance of AF Cooperative Networks .Cooperative communication networks have received significant interests from both academia and industry in the past decade due to its ability to provide spatial diversity without the need of implementing multiple transmit and/or receive antennas at the end-user terminals. These new communication networks have inspired novel ideas and approaches to find out what and how performance improvement can be provided with cooperative communications. The scenario that unequal error protection is analyzed to transmit different information classes at the source, a relaying protocol in a single relay network is proposed and its error performance is evaluated. It is shown that by setting the optimal signal-to-noise ratio (SNR) thresholds at the relay for different information classes, the overall error performance can be significantly improved. There is information feedback from the destination to the relays; a novel protocol is developed to achieve the maximum transmission throughput over a multiple-relay network while the bit-error rate satisfies a given constraint.

Keywords:- Amplify-and-Forward (AF) Cooperative Networks.

I. INTRODUCTION

The primary purpose of this research is to briefly review the principal knowledge in the field of study. To this end, this research work provides important background on wireless fading channels [10] and diversity techniques, as well as discusses fundamental concepts of cooperative communications, unequal error protection, and non-coherent communications.

Overview of Communications Systems

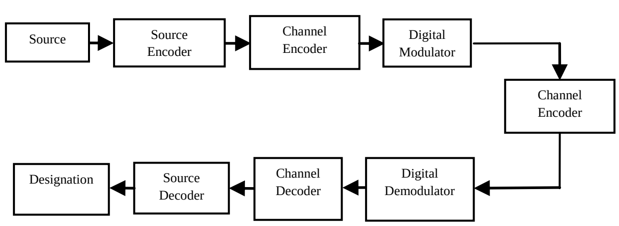


Fig. 1 Basic elements of a digital communication system.

Fig.1. shows that block diagram of a digital communication system, in which information is transmitted from one point to another. The source generates either analog signals such as speech, audio, and video, or digital data such as text or multimedia. The message produced by the source is converted into a binary sequence by the source encoder. The binary sequence is then passed to the channel encoder, which introduces redundancy into the binary sequence in order to overcome the effects of noise and interference encountered during the transmission. The channel-encoded binary sequence (or coded sequence) is then modulated by the digital modulator to generate waveforms for transmission over a physical channel link, such as a telephone line, an optical fiber cable, or a high frequency radio link. At the receiver side, the above procedures are reversed so that the destination can restore the original source information.

For a wireless channel, the communication occurs in a bandwidth W around a center frequency f_c, i.e., in a pass-band of $[f_c - W/2, f_c + W/2]$. The signal transmitted at the carrier frequency fc is called the passband signal. In the special case, when $f_c \approx 0$, the transmitted signal is called the baseband signal. In typical wireless applications, the digital modulator performed at the transmitter side (at the last stage) has to “up-convert” the signal to the carrier frequency fc, i.e., generates the pass-band signal and transmits it via an antenna. Similarly, the digital demodulator performed at the receiver side (at the first stage) would typically “down-convert” the radio-frequency (RF) signal to a baseband signal before making any further processing. Furthermore, most of the processing, such as coding/decoding, modulation/demodulation, synchronization, etc., is actually carried out at the baseband.

Therefore, the baseband equivalent model is usually used to study and analyze a wireless communication system since it is more convenient than the pass-band model. It should be noted that studying the baseband equivalent model basically suppresses the issues of frequency up-conversion and down-conversion, i.e., making it independent of carrier frequencies [1].

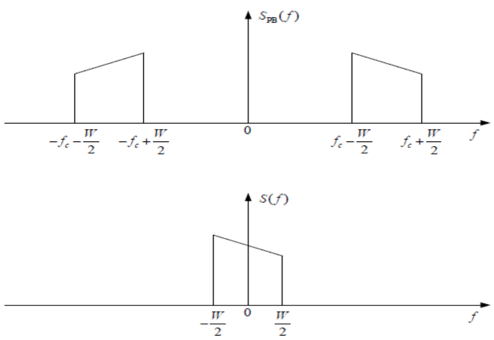


Fig. 2 The relationship between pass-band spectrum SPB(f) and its equivalent baseband spectrum S(f).

The baseband equivalent signal for a pass-band signal should be such that when shifted up by fc, one should obtain the pass-band signal. In general, the relationship between the pass-band signal $xPB(t)$ and the equivalent baseband signal x(t) can be written as $[C2-1]$:

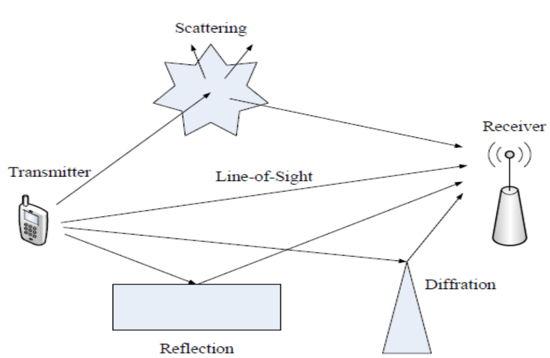
$$x_{pb}(t) = R\{x(t)exp(j2\pi f_c t)\}$$

where R{·} takes the real part of the signal. The relationship between the spectrum of $xPB(t)$ and $x(t)$ is illustrated in Fig. 2.

In what follows, we discuss the wireless channel and its baseband equivalent channel model. Such a model is largely used in this thesis.

Wireless Channels

The key distinction between wireless and wire line communications lies in the physical properties of the channels. When a radio-frequency (RF) signal is transmitted over a wireless channel, due to the presence of multiple propagation paths between the transmitter and receiver, there are multiple copies of the transmitted signal at the receiver.



Fie. 3 Example of a wireless channel in which there are multiple propagation paths between the transmitter and receiver.

The multiple paths arise due to reflections, scattering, diffractions from objects in the environment as illustrated in Fig. 3. The combination of multiple copies of the transmitted signal affects many characteristics of the received signal. In general, the effects of a wireless channel can be categorized into two types: large-scale fading (or path loss, attenuation) and small-scale fading (typically referred simply to as fading). The large-scale fading is due to signal attenuation by large objects such as buildings, hills, etc. The small-scale fading is due to the constructive and destructive combinations of the multiple signals arrived over different propagation paths at the receiver. Dealing with small-scale fading is one of the most challenging issues in designing a robust wireless communication system. Hence, in what follows, we discuss a channel model for the wireless link that is affected by the small-scale fading.

Input / Output Model of a Wireless Channel

Consider a communication system in which one source communicates with one destination over a wireless fading channel. Given the baseband input signal x(t), which is assumed to be band limited to W/2 Hz, and ignoring the interference by other users in the system, the continuous-time baseband received signal at the destination can be mathematically expressed as [2]

$$y(t) = \sum_i a_i(t) \exp\big(-j2\pi f_c \tau_i(t)\big)\, x\big(t-\tau_i(t)\big) + z(t),$$

where $a_i(t)$ and τ_i (t) are the overall attenuation and propagation delay at time t from the source to the destination on path i, respectively. The term z(t) represents ambient noise and is typically modeled as zero-mean additive white Gaussian noise (AWGN) with two-sided power spectral density N0/2. It can be seen that the baseband output is a sum, over each path, of the delayed replicas of the baseband input and the noise. Without the noise component, the input/output relationship in (2.2) is that of a linear time-varying system, i.e., it can be described by the baseband equivalent channel impulse response $h(\tau,t)$ at time t to an impulse transmitted at time $(t-\tau)$. In terms of $h(\tau,t)$, the input/output relationship is written as

$$y(t) = \int_{-\infty}^{\infty} h(\tau,t)x(t-\tau)d\tau + z(t),$$

Comparing (2.2) and (2.3), one can see that the baseband equivalent channel impulse response $h(\tau,t)$ is a weighted sum of delta functions (see Fig. 4). That is

$$h(\tau,t) = \sum_i a_i(t) \exp\left(-j2\pi f_c \tau_i(t)\right) \delta\left(\tau - \tau_i(t)\right),$$

where $\delta(.)$ denotes the Dirac delta function.

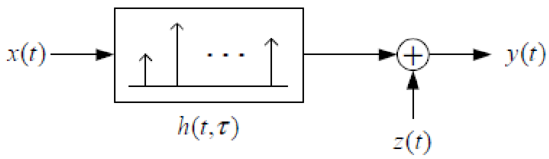


Fig. 4 Channel model in a wireless communication system.

II. SYSTEM MODULE

Diversity Techniques in Wireless Channels

The channel model in (2.12) implies that the error performance of a communication system depends on the strength (quality) of a single channel tap. Unfortunately, this can be in a deep fade with a significant probability. When this happens, the channel magnitude drops dramatically due to the destructive addition of multipath signals. When the channel tap is in deep fade, any communication scheme will likely suffer from errors. A natural solution to improve the performance is to ensure that the transmitted signal arrives at the destination through multiple independent-fading paths. Since independent signal paths have a much lower probability of experiencing deep fades simultaneously, if the multiple received signal copies are combined appropriately, the effect of deep fading is reduced. This technique is called diversity, and it can drastically improve the performance over fading channels. The effectiveness of a diversity technique can be quantified by the so-called diversity order, which is defined as [C2-7, Chapter 1], [C2-1, Chapter 3], [C2-8]:

$$G_d = -\lim_{\gamma\to\infty} \frac{\log\left(P_e(\gamma)\right)}{\log(\gamma)}$$

where Pe(γ) is the error probability obtained with the average received signal-to-noise ratio (SNR) of . In essence, the diversity order indicates the slope of the average error probability curve in terms of the average received SNR in a logarithm to logarithm scale when the average received SNR tends to infinity. From the previous discussion, it follows that the maximum diversity order of any communication scheme is equal to the number of independent signal paths over which the information is received. When the diversity order equals to the maximum diversity order, the system is said to achieve the full diversity order.

There are many ways to achieve independent signal paths in a wireless communications system. Three important techniques that have been extensively studied in the literature and applied in practical systems are [C2-1,C2-7]:

• Time diversity: In this technique, the signal is repeated over different time intervals.

• Spatial diversity: The signal is transmitted and/or received over different antennas.

• Frequency diversity: With this technique the signal is transmitted over different carrier frequencies.

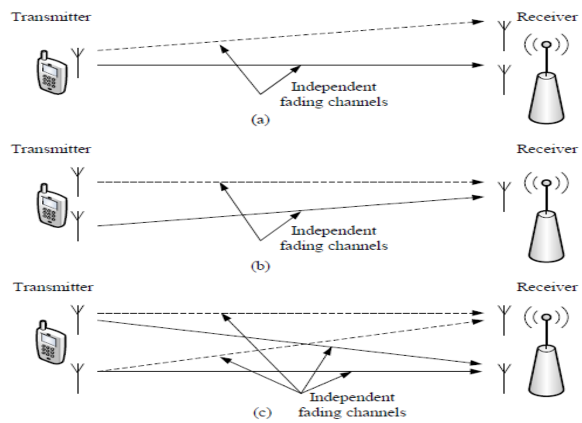


Fig. 5. The spatial diversity techniques: (a) SIMO; (b) MISO; (c) MIMO.

Cooperative Wireless Networks

Although spatial diversity is a very powerful technique to improve transmission reliability over a fading channel, implementing multiple transmit and/or receive antennas to provide diversity might not be a feasible solution due to the size, cost, and hardware limitations. As mentioned before, the cooperative diversity method has recently been proposed to overcome the above limitations. The basic idea of cooperative diversity is that a source node transmits information data to the destination through multiple nodes (or relays) [9]. In this way, the destination can receive the transmitted data with multiple copies that are generally affected by different and statistically independent fading paths. In fact, a virtual multiple antenna system is formed by using antennas from other users (or nodes, relays) within the network. This section provides an introduction to some of the most important cooperative (relaying) protocols and signal processing methods at the relays.

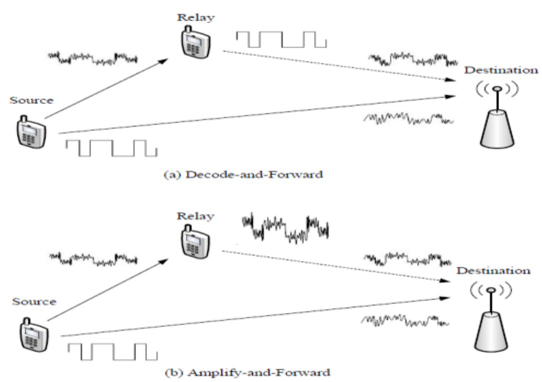


Fig. 6 Amplify-and-Forward and Decode-and-Forward signal processing methods. As mentioned before, our interest is to efficiently apply M-FSK modulation in cooperative networks. Specifically, we are interested in using [7] energy-difference thresholds to improve the BER performances in DF cooperative networks in which FSK modulation is employed for non-coherent communications. In addition, how to decode the transmitted information in AF cooperative networks [8] with M-FSK modulation is another topic.

III. LITERATURE REVIEW

In the year of 2015 El Shafie, A.; Khattab, T.; Saad, H.; Mohamed, A., [1] Investigated on a cognitive setting under the context of cooperative communications, where the cognitive radio (CR) user is assumed to be a self-organized relay for the network. The CR user and the primary user (PU) are assumed to be energy harvesters. The CR user cooperatively relays some of the undelivered packets of the PU. Specifically, the CR user stores a fraction of the undelivered primary packets in a relaying queue (buffer). It manages the flow of the undelivered primary packets to its relaying queue using the appropriate actions over time slots. Moreover, it has the decision of choosing the used queue for channel accessing at idle time slots (slots where the PU's queue is empty). It is assumed that one data packet transmission dissipates one energy packet. The optimal policy changes according to the primary and CR user's arrival rates to the data and energy queues as well as the channels connectivity. The CR user saves energy for the PU by taking the responsibility of relaying the undelivered primary packets. It optimally organizes its own energy packets to maximize its payoff as time progresses.

In the year of 2015 Guangyi Liu; Yao Xiao; Hao Feng; Cimini, L.J.,[2] presented the study of Cooperative relaying takes advantage of spatial diversity to improve the performance of wireless communication systems. In research study, the larger the diversity, the more capability to combat fading. Several cooperative relaying schemes have been proposed in the past. Here we focus on timer-based-best-select, distributed space-time coded, and M-group space-time coded. In this paper, an equal transmission time model and a flexible transmission time model are proposed. The spectral efficiencies with respect to spatial diversity for the three schemes are compared. The results show that, under both models, timer-based-best-select performs better than the other two schemes.

In the year of 2015 Jain, A.M.; Tiwari, N.,[3] Investigated on relay technology has been adopted to improve the coverage, reliability and quality-of-service in wireless network. This paper proposed a new relay selection method with Automatic Repeat request (ARQ) scheme. In this paper, multiple relay are used to transmit the data from source to destination node by using max-relay. To find proper node this paper proposed a new relay selection method based on euclidean distance method. This paper also proposed an Automatic Repeat request (ARQ) mechanism i.e. stop and wait Automatic Repeat request (ARQ) scheme. When any error occurs in the relay at data transmission time then relay use Automatic Repeat request (ARQ) strategy. This new scheme proposed for reduce the packet loss, network loss and delay on the wireless network.

In the year of 2015 Omri, Aymen; Hasna, Mazen Omar, [4] proposed the study of a cooperative communications scheme with interference management is proposed for wireless multi-user multi-relay networks. The scheme is using on demand decode and forward (DF) half-duplex (HD) relaying protocol, a relay selection method which maximizes the signal-to-noise ratio (SNR) of the second hop, and the maximum ratio combining (MRC) technique to combine the direct and best relay links. To avoid the interference problem and enhance the spectral efficiency, the proposed scheme uses a new relaying protocol based on the constellation real parts of the modulated signals. We derive closed form expressions of the power density function (PDF), the average outage probability, and the average bit error rate (BER) for the proposed scheme, and simulations are used to validate the analytical expressions. The results confirm the advantage of the proposed scheme in enhancing interference management and link reliability.

In the year of 2015 Rung-Shiang Cheng; Chung-Ming Huang; Guan-Shiun Cheng, [5] worked on Term Evolution-Advanced (LTE-A) cellular network is designed for human-to-human (H2H) communication. When a large number of machine-to machine (M2M) devices are trying to access the network simultaneously, it leads to a low random access (RA) successful rate and high congestion problem, which may cause the waste of radio resources, packet loss, latency, extra power consumption, and the worst, M2M service error. There is an urge to propose an efficient method for M2M communication on the LTE-A network to resolve the congestion problem. In this paper, we analyze and model the RA procedure on the LTE-A network, try to find out the collapse point in the RA procedure and then propose a scheme named D2D cooperative relay scheme to relieve the congestion problem. Simulation results show that the network throughput and the congestion can be significantly improved using the proposed mechanism.

In the year of 2014 Aanandh, S.B.; Kar, C.; Siddiqui, N., [6] researched the study of Communication needs for public safety networks and the Process Management are compared and the concept of Safety Grid is deduced. The elemental & cognitive functional safety in a System of Systems View is related to Safety Grid. Safety management of chemical storage tank is used to analyze influences of Theory of constraints, Cognitive Safety and Functional Safety. Safety information model is derived as a function of People, Process and Things. People in the context are either Informed (Aware), Associated or Acknowledge (Act). Process is segregated as Rules, Verify, Measure or Simulate. The system structure is modeled with respect to People, Process and Things as related in Internet of Everything with a Thing Architectural Model defined by an OR3C communication interface using transport model.

IV. PROBLEM IDENTIFICATION

The problem Originally, M-relay amplify-and forward (AF) cooperative system with maximal ratio combining (MRC) at the destination and investigate the effects of both the mobile cooperating-nodes speeds and the receivers' channel state information (CSI) estimation rates on the system outage performance. By CSI estimation rates we mean how much the receivers' tracking loops are fast to estimate the channel gains over the individual time slots. Rapidly growing demand for various services of the next-generation wireless communication systems, such as high-speed wireless Internet access and wireless television, the requirements for high data transmission rates and reliable communications over wireless channels become even more pressing. In fact, the past decades have witnessed explosive interest and development from both industry and research community in the design of wireless communication systems to increase the data transmission, improve reliability and optimize power consumption. Such interest and development promise to continue for years to come.

V. PROPOSED METHODOLOGY

Cooperative communication has attracted a lot of research interest because of its ability to achieve spatial diversity without modifications on power and size constraints of mobile devices. This could be achieved by allowing multiple users (called relays) to cooperate and effectively share their antennas and other resources to assist the source forwarding its data to the final destination. Next generation wireless systems are expected to support very high data rates to all users with satisfied quality of service (QoS) under all conditions. Such conditions are related to the estimation process and others related to the fading links characteristics, either quasi-static or time-varying (time-selective). Therefore, it is meaningful to investigate the performance of the cooperative networks considering the estimation process and/or the links temporal characteristics.

VI. CONCLUSION & FUTURE WORK

In this review work we have analyzed the performance of amplify-and-forward multiple-relay networks in which the source transmits to the destination with the help of K relays and the channels are temporally-correlated Rayleigh flat fading. The networks have been studied when M-FSK is employed at both the source and relays to facilitate non-coherent communications. Making use of the orthogonal property of FSK signaling, the destination first estimates the overall channel coefficients based on a LMMSE approach and then detects the information symbol with a (approximate) maximum ratio combiner. Performance comparison reveals that the proposed scheme would outperforms the previously schemes. The advantages of nonuniform PSK constellations, a study on finding optimum thresholds in cooperative networks employing nonuniform PSK constellations is of interest. Thresholds in cooperative networks in which simple BFSK would be employed. Considering M-FSK in a multiple-relay network is an important and interesting extension. In particular, one can investigate how to reduce error propagation with M-FSK to improve the error performance of the network.

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