An Extensive Review on Cooperative Wireless Systems over Frequency-Selective Channels

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Abstract - In the last two decades, the fast developing wireless communication innovations have reformed our life and society. Other than making calls and sending messages, it allows utilizing advanced mobile phones and tableting computers to surf the Internet, watching TV programs, have video meetings et cetera. In the meantime, ad hoc and sensor networks have risen to help new applications, for example, catastrophe recuperation, open security systems and war zone reconnaissance. Despite the fact that there has been noteworthy development on wireless communication advances, supporting the exponentially expanded data activity from various wireless applications services still stances huge difficulties. These new highlights or patterns of wireless communication networks expedite us more difficulties execution demonstrating and examination, and furthermore more earnest requests for designing and growing new answers for enhance range productivity. Helpful communication has developed as a promising innovation to enhance spectrum efficiency. This work presents an extensive survey of literature on cooperative wireless systems over frequency-selective channels.

Keywords- wireless networks, cooperative communication, Frequency-Selective Channels, efficient communication, high speed communication.

I. INTRODUCTION

With the inception of wireless communications meeting the ever increasing demand of multimedia streaming traffic, lucrative solutions have been adopted and these solutions have contributed massively towards the design of information exchange in wireless networks and shaping the future of wireless networks. Recent technological advancements and particularly considering wireless communication, have allowed the wireless user to manage an entire business setup (24/7) virtually from anywhere in the globe. From a domestic user perspective, electronic appliances are becoming intelligent and are controllable using small hand-held devices making homes smarter to assist the differently abled and elderly. Building up on the notion of integrating wireless communication into existing infrastructure such as the 'Smart-Grid', where equipment and/or appliances connected to the grid can communicate using the wireless channel. Video teleconferencing, webinars and video recordings are used for remote classrooms and/or training facilities. Moreover, wireless sensors used in smart devices are applicable widely for commercial and military applications.

Considering the widely used wireless standards Wireless Local Area Networks (WLANs), which are capable of providing higher data rates within a small coverage area. Wireless devices that make use of these LANs are usually stationary or moving at pedestrian speeds. Mostly, WLAN users across the globe make use of one of the Industrial, Scientific and Medical (ISM) or Unlicensed National Information Infrastructure (U-NII) frequency bands. Owing to the 'free- to-use' nature of these frequency bands (typically 900 MHz, 2.4 GHz and 5.8 GHz), many systems operate in these bands, causing a lot of interference.

In terms of daily usage, wireless communication has also emerged as an essential require- ment for users in the last decade. Due to its ubiquity and readily manageable aspects, it is now considered as one of the fundamental modes of communication. Whether it is 4G cellular communication (using cellular phones or tablets), Wi-Fi based WLAN communication at work, home or a public place (using laptops, personal digital assistant, smart phones), or a wireless Machine-to-Machine (M2M) communication e.g., Global Positioning Systems (GPS's) in cars, asset tracking systems in shipping and manufacturing sectors, or medical application devices, researchers and scientists are constantly striving to provide solutions for the quickly saturating wireless channel. Depending on the environment, wireless users experience detrimental wire- less channel impairments like path loss, scattering, reflections and shadowing effects, collec- tively called as fading, and illustrated in Figure 1.1.

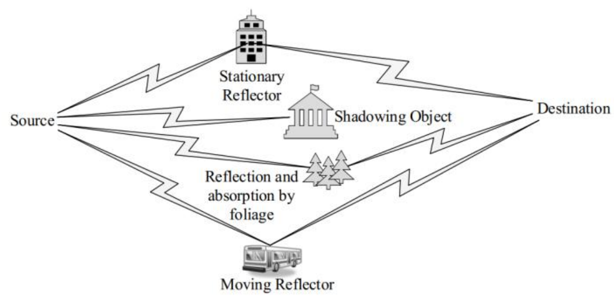

Figure 1.1 Wireless Signal Propagation and Its impairments.

In view of the design requirements required to overcome the challenges in wireless com- munication, new ideas are presented to address the needs and overcome the adverse effects of fading and interference. Addressing these effects in the past led to some trade-off's in terms of degraded performance, but now, much emphasis is laid upon exploiting these features in achieving the desired performance.

II. COOPERATIVE WIRELESS COMMUNICATION

Addressing the highlighted limitations to wireless communication, cooperation in wireless networks is one of the key developments in recent years to exploit the spatial diversity by employing terminals/nodes called 'relays'. Relay nodes are an integral part of the cooperative process, interconnecting source and destination to achieve better performance.

Depending upon the design considerations for a relay network, capacity remains one of the open problems. Using the concept of space-time block codes (STBC's), a transmit diversity technique to improve performance of the wireless communication was presented [6]. Research in relay networks, with a few exceptions, remained dormant until the work on cooperative diversity renewed interest in relaying and cooperation [7]. Cooperative communication, which is a form of mutual relaying between the network nodes, not only extends the coverage area and reliability but also improves the capacity of a fading channel. So, an efficient relay selection scheme based on a precise channel estimate in a time varying channel still remains an open area for research and can contribute towards resolving the above mentioned issues pertaining to wireless channel.

Wireless communications has observed tremendous technological advancements over the last decade. Albeit distant by a few years, significant improvements are observed in terms of achieved data rates, hardware size, and battery lifetime, with every new generation of wireless devices. More recently, technological progression has encouraged researchers to think out of the box to propose wireless network protocols and develop associated architectures that tergiversate from the traditional point-to-point communication with a central controlling node. As an example, emergence of ad-hoc and cooperative wireless networks, where the canonical taxonomy is relaxed to allow information exchange using any node, hence regulating additional communication links involving multiple wireless hops. The broadcast nature inherent to the wireless channel is the most emanating feature and is attracting new research directions aimed at enhancing the overall performance. It also entails that this broadcast nature is exploited in case the transmission from source node cannot reach the intended destination and hence, reasonable performance gain is achieved. Such a canonical information flow facilitates the development of new ideas on distributed communications using node cooperation.

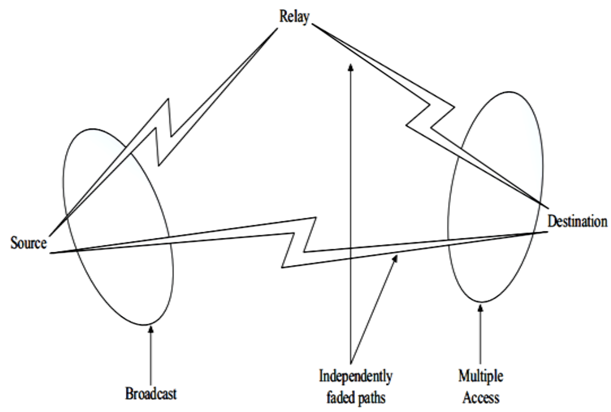

Figure 2.1 Basic Three Node Relay Channel.

III. LITERATURE REVIEW

SR. NO.	TITLE	AUTHORS	YEAR	APPROACH
1	Phase-precoding scheme for cooperative wireless systems over frequency-selective channels,	M. Ayedi, N. Sellami and M. Siala,	2016	An efficient precoding technique for cooperative wireless systems
2	Complex field network coding with OFDM in distributed wireless networks	R. Khan, G. K. Kurt and İ. Altunbaş,	2016	A thorough analysis of CFNC in distributed wireless networks
3	Effects of imperfect channel estimation in three-node cooperative wireless network	J. M. Choi and J. S. Seo,	2015	Analyze the effect of the imperfect channel estimation on the equalization performance in three-node cooperative wireless networks
4	Differential Distributed Space-Time Coding With Imperfect Synchronization in Frequency-Selective Channels	M. R. Avendi and H. Jafarkhani,	2015	A new differential encoding and decoding process for D-DSTC systems with multiple relays over slow frequency-selective fading channels with imperfect synchronization
5	A limited-feedback-based optimal	D. Zhou and B. Hu,	2014	a practical limited bits feedback precoding

	precoding algorithm for OFDM multi-relay networks,			algorithm is reported
6	Performance analysis of cooperative spectrum sensing for cognitive wireless radio networks over Nakagami-m fading channels,	Q. T. Vien, H. X. Nguyen, R. Trestian, P. Shah and O. Gemikonakli	2014	concerned with cooperative spectrum sensing (CSS) in cognitive wireless radio networks (CWRNs)
7	Two time slots distributed time-reversal space-time block coding for single-carrier block transmissions,	Q. Wang, C. Yuan, J. Zhang and J. Du	2013	A novel two time slots distributed time-reversal STBC scheme for amplify-and-forward relay-assisted single-carrier (SC) block transmissions over frequency-selective fading channel

M. Ayedi, N. Sellami and M. Siala, [1] In this exploration, reported an efficient precoding technique for cooperative wireless systems. The technique aims to reduce the effect of Inter-Symbol Interference (ISI) in cooperative transmissions over frequency-selective channels between two sources nodes, one relay node and one destination node. At each source node, a phase-precoding scheme that changes the phases of the transmitted symbols is applied. At the relay node, received sources sequences are detected, precoded and combined using the Digital Network Coding (DNC) scheme. The destination node uses both direct received signals and relayed signals to estimate the source sequences. For the detecting scheme at the relay and the destination nodes, reported to use a linear filtering equalization based on Minimum Mean-Square Error (MMSE) criterion. Simulation results show that the proposed precoding technique enhances the Bit Error Rate (BER) performance compared to the non-precoded system.

R. Khan, G. K. Kurt and İ. Altunbaş, [2] Cooperative diversity method is a major way to significantly increase the capacity of multi-source distributed wireless networks with improved coverage. On the other hand, complex field network coding (CFNC) helps mitigate the spectral efficiency loss incurred by traditional relaying schemes in larger networks. Considering the frequency selective fading nature of wireless channels, it would be a practical approach to combine orthogonal frequency division multiplexing (OFDM) with CFNC in wireless relay networks. Therefore, in this exploration, make a thorough analysis of CFNC in distributed wireless networks, combined with OFDM. Different relaying schemes such as amplify and forward (AAF) and decode and forward (DAF) are used for evaluating the system performance. Moreover, also consider relay selection technique with both AAF and DAF schemes. Simulation results are presented for uncoded and convolutionally coded relaying schemes for CFNC when OFDM is incorporated in the given setup.

J. M. Choi and J. S. Seo [3] In this exploration, analyze the effect of the imperfect channel estimation on the equalization performance in three-node cooperative wireless networks. Specifically, consider a distributed time-reversal space-time block coded single-carrier (D-TR-STBC-SC) system over frequency-selective fading channels with amplify-and-forward (AF) half-duplex relaying. Through the comprehensive analysis of mean-square-error (MSE), it is shown that, unlike the point-to-point communications, the imperfection of the channel knowledge leads to the unstable performance of channel equalization under the condition of high quality reception from relay-to-destination link. The analytical results show the main reason for such phenomenon. The validity of the theoretical analysis is demonstrated through the computer simulations.

M. R. Avendi and H. Jafarkhani,[4] Differential distributed space-time coding (D-DSTC) is a cooperative transmission technique that can improve diversity in wireless relay networks in the absence of channel information. Conventionally, it is assumed that channels are flat-fading and relays are perfectly synchronized at the symbol level. However, due to the delay spread in broadband systems and the distributed nature of relay networks, these assumptions may be violated. Hence, inter-symbol interference (ISI) may appear. This exploration proposes a new differential encoding and decoding process for D-DSTC systems with multiple relays over slow frequency-selective fading channels with imperfect synchronization. The proposed method overcomes the ISI caused by frequency-selectivity and is robust against synchronization errors while not requiring any channel information at the relays and destination. Moreover, the maximum possible diversity with a decoding complexity similar to that of the conventional D-DSTC is attained. Simulation results are provided to show the performance of the proposed method in various scenarios.

D. Zhou and B. Hu, [5] Based on amplify-and-forward cooperative relay under frequency selective fading channels, in order to reduce the feedback load of OFDM-based wireless systems, a practical limited bits feedback precoding algorithm is proposed. Using matrix decomposition method, precoding matrices are designed. The source node precoding need only one precoding matrix per OFDM frame. Source precoder and relay precoder are jointly optimized and quantified. The precoding matrix index is fed back for Clustered subcarrier of OFDM. The algorithm achieves precoding matrices at source and relay nodes with limited feedback. Simulations indicate that the proposed method can improve bit-error-rate performance. The bit error rates are also compared with different relay number.

Q. T. Vien, H. X. Nguyen, R. Trestian, P. Shah and O. Gemikonakli, [6] This exploration is concerned with cooperative spectrum sensing (CSS) in cognitive wireless radio networks (CWRNs). A practical scenario is investigated where all channels suffer from Nakagami-m fading. Specifically, analyze the probabilities of missed detection and false alarm for two CSS schemes where the collaboration is carried out either at fusion centre (FC) only or at both the FC and secondary user (SU). By deriving closed-form expressions and bounds of these probabilities, not only show that there are significant impacts of the m-parameter of Nakagami fading realisation for different channel links on the sensing performance but also evaluate and compare the effectiveness of the two CSS schemes with respect to various fading parameters and the number of SUs. Finally, numerical results are provided to validate the theoretical analysis and findings.

Q. Wang, C. Yuan, J. Zhang and J. Du [7] Distributed space-time block coding (STBC) is a promising technique for future broadband wireless communication system, because of its substantially improving the reliability of wireless channel by exploiting cooperative spatial diversity. In this study, the authors propose a novel two time slots distributed time-reversal STBC scheme for amplify-and-forward relay-assisted single-carrier (SC) block transmissions over frequency-selective fading channel. They first exploit the discrete Fourier transform extended properties to construct a linear preceding matrix. They then employ low-complexity suboptimal frequency domain decision feedback equalization (FD-DFE) to collect potential multipath diversity at high signal-to-noise ratio. Simulation results demonstrate that the proposed scheme provides better performance than the conventional distributed SC-STBC scheme with minimum-mean-square error FD linear equalization.

IV. PROBLEM FORMULATION

Allowing cooperation in wireless communication gives rise to design challenges related to relay selection and channel estimation. Although both these design challenges have been investigated independently and extensively in the last few years, there are still some questions left unanswered that need to be addressed for the development of the cooperative networks

Sharing information such as Signal-to-Noise Ratio (SNR) in a timely and distributed manner and at the same time making optimal selection of multiple relays in a time varying environment has not yet been studied as most analysis of cooperative diversity systems proposed in the literature focus either on pairs of cooperating terminals or consider cooperation to improve the performance of the existing direct transmission.

Multiple relays can help enhance performance in terms of error rate but in terms of practical implementation this configuration requires tight synchronization between relays and appropriate distributed space time codes that need to be further investigated to deal with additional challenges.

V. CONCLUSION

This work brief an extensive survey of literature to provide ubiquitous wireless coverage for the increasing number of wireless devices and exponentially increasing data traffic, both the size and the density of wireless networks increased significantly in recent years. As a consequence, the spatial reuse of the scarce wireless spectrum cannot be avoided, and multihop transmission needs to be applied to extend coverage since data sources cannot always reach their destinations through direct transmission. At the same time, the topology of the wireless networks is becoming less regular with the deployment of smaller cells and device-to-device communication. Most of the works on cooperative communication consider a small three-node network composed of one source, one relay, and one destination

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