OUTAGE PERFORMANCE OF RELAYING SYSTEMS IN THE PRESENCE OF CO-CHANNEL INTERFERENCE

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JULY 2018

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by

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Submitted
in fulfillment of the requirements of the degree of Doctor of Philosophy
to the

INDIAN INSTITUTE OF TECHNOLOGY DELHI

JULY 2018

Certificate

This is to certify that the thesis entitled **“Outage performance of relaying systems in the presence of co-channel interference”** being submitted by **Mr. Anup Kumar Mandpura** to the Department of Electrical Engineering, Indian Institute of Technology Delhi, for the award of the degree of **Doctor of Philosophy** is the record of bonafide research work carried out by him under my supervision. In my opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The results contained in this thesis have not been submitted either in part or in full to any other University or Institute for the award of any degree or diploma.

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Acknowledgments

I would like to take this opportunity to express my gratitude towards all the support without which this research would not have been possible.

During my Ph.D. programme at IIT Delhi, which is one of the most learning and rewarding period of my life, I had the opportunity to meet many talented and extraordinary people. Foremost, I would like to thank my supervisor Prof. Shankar Prakriya for his consistent support and guidance throughout this period. I am grateful to him for providing me with technical insight and encouragement during my PhD study. Many thanks for his timely review and critical comments to the various drafts that helped me to improve my work. I would also like to thank the SRC members: Prof. R. K. Mallik, Dr. Brejesh Lall and Dr. Monika Aggarwal for their involvement, support, and feedback that encouraged me to accomplish my goal. Thanks to my friends: Vashist Bist, Somesh Bhattacharya and Kartikeyan Enumalai for their help and support. Thanks also goes to Ph.D students in the DSP Lab: Komal Janghel, Modem Sudhakar, Bhupendra Kumar, Pratik Chakraborty, Hari Krishna Bodapatty, Amit Aggarwal for creating a full-filling work environment. My special thanks go to S. M. Zafaruddin, Dileep Kr. Verma and Kalpana Dhaka for their suggestions and ideas during the period of distress and anxiety. Thanks to my seniors for the nice moments we have had during this period. I am deeply indebted to my parents for their blessings, and unconditional sacrifice. I am also indebted to my elder siblings Dharmishtha Balai, and Manisha Balai for their unconditional support and care. Last but not the least, I would like to thank my wife Monika Verma for being very patient, encouraging, and believing in me during all these years.

Anup Kumar Mandpura

Abstract

The rapid increase in number and type of wireless services has created an acute shortage of spectrum. There have been considerable efforts to increase the spectrum utilization efficiency, and two approaches are known to be most promising. The first approach is to use spectrally efficient signaling techniques, and the second approach is to increase the frequency reuse factor. The first approach could involve use of two-way relays (TWRs). Due to their high spectral efficiency, they are being increasingly studied for use in cellular systems. Relays in general have been incorporated into new cellular standards. Benefits include enhanced coverage, reliability and throughput. Other benefits include power efficiency and reduced overall interference levels. The second approach involving increase of the frequency reuse factor results in increased co-channel interference. Sophisticated interference management techniques (power allocation and user scheduling for example) are needed to ensure desired quality of service (QoS). It is clear that study of TWR and other relaying systems with co-channel interference is well motivated from practical considerations.

In this thesis, the outage performance of various TWR signaling techniques is characterized in the presence of co-channel interference. Such characterization is useful to system designers, and provides a realistic estimate of performance. In addition, it allows for development of sophisticated power allocation algorithms to maximize performance in the presence of co-channel interference. In this thesis, power allocation schemes are developed for two-phase and three-phase TWR based on amplify and forward relays (both fixed gain and channel state information assisted). It is demonstrated that due to possible asymmetry in co-channel interference, power allocation is very important to attain good performance. In addition, performance with some of the suggested power allocation schemes is characterized.

User scheduling is another approach to mitigate interference, and can ensure fairness amongst users. In this thesis, performance of a multiuser relay system is characterized in the presence of co-channel interference. Performance of user scheduling that takes signal-to-interference-plus-noise ratio (SINR) is characterized, and shown to be superior to approaches based solely on signal-to-interference ratio (SIR) or on signal-to-noise ratio (SNR). Since the average interference levels might be different for various users in the system, the issue of fairness arises. In this thesis, two fair scheduling algorithms are evolved for a multiuser system with co-channel interference, and their performance with these scheduling schemes is characterized.

सारांश

वायरलेस सेवाओं के प्रकार तथा संख्या में तेजी से वृद्धि ने स्पेक्ट्रम की तीव्र कमी की है। स्पेक्ट्रम उपयोग की दक्षता को बढ़ाने के लिए काफी प्रयास किए गए हैं, और दो दृष्टिकोण सबसे अधिक आशाजनक माने जाते हैं। पहला दृष्टिकोण है स्पेक्ट्रली कुशल सिग्नलिंग तकनीकों का उपयोग करें, और दूसरा दृष्टिकोण फ्रिकवेनसी उपयोग को बढ़ाना। पहले दृष्टिकोण में दो-तरफा रिले (टीडबल्युआर) का उपयोग शामिल हो सकता है। उनकी उच्च स्पेक्ट्रली दक्षता के कारण, सेलुलर सिस्टम में उपयोग के लिए उनका तेजी से अध्ययन किया जा रहा है। आम तौर पर रिले को नए सेलुलर मानकों में शामिल किया गया है। इसके लाभ में उन्नत कवरेज, विश्वसनीयता और थ्रूपुट शामिल हैं। अन्य लाभों में शामिल हैं बिजली दक्षता और समग्र हस्तक्षेप के स्तर का कम होना। दूसरा दृष्टिकोण है फ्रिकवेनसी पुन: उपयोग कारक की वृद्धि जिसकी वजह से सह-चैनल हस्तक्षेप में वृद्धि होती है। परिष्कृत हस्तक्षेप प्रबंधन तकनीक (बिजली आवंटन और उपयोगकर्ता शेड्यूलिंग उदाहरण के लिए) सेवा की वांछित गुणवत्ता (क्यूओएस) सुनिश्चित करने के लिए आवश्यक हैं। यह स्पष्ट है कि टीडबल्युआर अध्ययन और अन्य रिलेइंग सिस्टम जिनमे सह-चैनल हस्तक्षेप होता है व्यावहारिक दृष्टिकोण से अच्छी तरह प्रेरित हैं ।

इस थीसिस में, विभिन्न टीडब्लयुआर सिग्नलिंग तकनीकों का आउटेज प्रदर्शन सह-चैनल हस्तक्षेप की उपस्थिति में अध्ययन किया गया है। इस तरह का अध्ययन सिस्टम डिजाइनर को प्रदर्शन का यथार्थवादी अनुमान प्रदान करता है। इसके अलावा, सह-चैनल हस्तक्षेप की उपस्थिति में प्रदर्शन को अधिकतम करने के लिए परिष्कृत शक्ति आवंटन एल्गोरिदम के विकास के लिए मदद करता है। इस थीसिस में, रिले के आधार पर दो चरण और तीन चरण टीडब्लयुआर बिजली आवंटन योजनाएं विकसित की गई हैं। यह दिखाया गया है कि सह-चैनल हस्तक्षेप में संभावित असमानता के लिए, बिजली आवंटन बहुत महत्वपूर्ण है अच्छा प्रदर्शन प्राप्त करने के लिए। इसके अलावा, कुछ सुझाए गए शक्ति के आवंटन योजनाओं प्रदर्शन केरेक्टराईज़ किया गया है ।

उपयोगकर्ता शेड्यूलिंग, हस्तक्षेप को कम करने के लिए एक और तरीका है, और उपयोगकर्ताओं के बीच में निष्पक्षता सुनिश्चित कर सकता है । इस थीसिस में, सह-चैनल हस्तक्षेप की उपस्थिति में एक बहुउद्देशीय रिले सिस्टम का प्रदर्शन केरेक्टराईज़ किया गया है । सिग्नल-टू-हस्तक्षेप-प्लस-शोर अनुपात एसआईएनआर) शेड्यूलिंग का प्रदर्शन सिग्नल-टू-हस्तक्षेप अनुपात (एसआईआर) बेहतर दिखाया गया है। चूंकि इस प्रणाली में विभिन्न उपयोगकर्ताओं के लिए औसत हस्तक्षेप स्तर अलग-अलग हो सकते हैं, निष्पक्षता का मुद्दा उठता है। इस थीसिस में, दो निष्पक्ष शेड्यूलिंग एल्गोरिदम का प्रदर्शन सह-चैनल हस्तक्षेप के साथ विकसित किया गया है।

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2P-TWR	Two phase two way relaying
2P-OTWR	Two phase outage-optimal two way relaying
3P-TWR	Three phase two way relaying
3P-OTWR	Three phase outage-optimal two way relaying
AF	Amplify-and-forward
AWGN	Additive white Gaussian noise
bpcu	bits per channel use
BER	Bit error rate
BS	Base station
CAR	Channel access ratio
CCI	Co-channel Interference
CDF	Cumulative distribution function
CSI	Channel state information
CS-SINR	Cumulative distribution of second hop signal-to-interference-plus-noise ratio
DF	Decode-and-forward
DMT	Diversity multiplexing tradeoff
e2e	end-to-end
EPA	Equal power allocation
FA-SINR	Fair access second hop signal-to-interference-plus-noise ratio
FDMA	Frequency division multiple access
HPA	Hybrid power allocation
i.i.d	Independent and identically distributed
i.ni.d	Independent and non-identically distributed
IPA	Instantaneous power allocation
MU	Multi-user
MU-OWR	Multi-user one way relaying

OWR	One way relaying
PDF	Probability density function
RF	Radio frequency
SPA	Statistical power allocation
SNR	Signal-to-noise ratio
SINR	Signal-to-interference-plus-noise ratio
SH-SNR	Second hop signal-to-noise ratio
SH-SIR	Second hop signal-to-interference ratio
SH-SINR	Second hop signal-to-interference-plus-noise ratio
TDMA	Time division multiple access
TWR	Two way relaying