*Cooperative Communications and Networking* by K.J. Ray Liu, Ahmed K. Sadek, Weifeng Su, and Andres Kwasinski, Cambridge University Press, ISBN-13: 9780521895132. *Reviewed by Ruoheng Liu (rliu@princeton.edu), Princeton University, USA .*

**R**apid advances in wireless technology are quickly moving us towards a pervasively connected world in which a vast array of wireless devices, from iPhones to biosensors, seamlessly communicate with one another. Fostered by the rapid proliferation of wireless communication devices, technologies, and applications, the need for reliable and efficient data communications over wireless networks is more important than ever before. A new wireless communication technique, user-cooperation, enhances the reliability and throughput performance of traditional communication systems. Inspired by the activity, progress, and success in this research field, several new books are being published in the area of cooperative communications. An example is *Cooperative Communications and Networking* by K.J. Ray Liu, Ahmed K. Sadek, Weifeng Su, and Andres Kwasinski.

This book presents the fundamentals of cooperative communications and networking. The authors treat the concept of space-time-frequency diversity, multi-input, multi-output (MIMO), and user-cooperation with a comprehensive and systematic approach to principal topics and, hence, make the book more than an introductory text. The intended audience consists of senior undergraduate and graduate students as well as engineers and other professionals. In this reviewer's opinion, this book is particularly well suited for a one-semester advanced graduate course in electrical engineering, depending on the background of the students, and how the topic of cooperative communications fits into the flow of an institute's communications curricula. To make the best use of this book, students should have a solid background in communication theory, digital communications, and wireless networking. Moreover, the fact that the book provides 82 examples, 117 exercises, 250 figures, a thorough list of references, and clear and lucid explanations of the basic concepts behind cooperative communications will help ensure that the book successfully meets the needs of its academic audience. Potential instructors interested in using the book for a course will be happy to know that the authors have PDF slides and solutions to exercises available from the publisher upon request.

*Cooperative Communications and Networking* can also be valuable outside the classroom. In particular, the authors provide discussion about the information-theoretic limits and tradeoffs of cooperative coding for multimedia communications as well as answer practical questions related to what and how system performance can be improved by using cooperative communications. These make the book useful for system engineers in the field and researchers attempting to get a first view of particular aspects of this area and whether cooperative communications will meet their needs.

In terms of book structure, the first three chapters build the foundation of communication systems that are highly related to user-cooperation. In particular, the authors provide an overview of the characteristics of wireless channels and their capacities, followed by orthogonal frequency division multiplexing (OFDM) for frequency selective fading channels, space-time coding in MIMO systems, and other diversity techniques to combat deep fading. The early chapters are tied to the rest of the book as these chapters describe several techniques that will be used extensively in subsequent chapters.

The second part (from Chapter 4 to Chapter 10) considers mostly physical layer issues behind cooperative communications. Chapter 4 introduces a relay channel and presents various relay (cooperation) protocols, including amplify-and-forward, decode-and-forward, compress-and-forward, distributed coded, and adaptive cooperation strategies. The authors discuss performance evaluation for these protocols and identify what aspects can be improved by incorporating user-cooperation. Next, the authors take a deep look at the symbol error rate performance analyses of single-relay and multi-relay cooperative communication scenarios in Chapter 5 and Chapter 6, respectively. Distributed space-time and space-frequency coding is presented in Chapter 7. Some important issues in physical layer cooperation, such as relay selection, differential cooperative schemes, and practical cooperative gains

and tradeoff, are discussed in Chapters 8, 9, and 10.

Finally, the third part (Chapter 11 to Chapter 18) of this book explores the applications of cooperation beyond the physical layer, including content-aware cooperative multiple access protocols at the link layer, distributed cooperative routing at the network layer, cross-layer design based on source-channel coding with cooperation, and coverage expansion and the network lifetime maximization via cooperation.

One topic that this reviewer believes could have been better addressed in this book was hierarchical cooperation. In Chapter 4, the authors describe the linear capacity scaling achieved by hierarchical cooperation in a wireless ad hoc network. In this reviewer's opinion, this topic would have benefited from its own targeted background section. For example, defining capacity scaling and explaining its importance in wireless networks would have been beneficial for an audience of nonexperts. Further, in this chapter, the authors do not discuss the underlying propagation model and other assumptions involved in the network modeling when they review Gupta and Kumar's result for aggregate throughput scaling limitations. Generally, this reviewer believed that this material was not connected well with the previous sections of this chapter that focus on the outage capacity

performance for the small-scale fading channel, and that the exposition could have been improved by connecting it to better to the rest of the chapter.

This book has many distinctive features that make it attractive both as a textbook and as a reference. The depth of the discussions varies throughout the book. At the beginning of the text, the authors have made a significant effort to introduce the basic concepts behind radio propagation, the capacity of wireless channels, the various diversity techniques to combat fading, as well as the state-of-the-art OFDM and MIMO techniques. This allows a beginner to build up the requisite foundation easily. The material related to cooperative communications is presented in a coherent and integrated fashion. The authors describe different schemes to implement cooperation, analyze these algorithms through evaluating the outage capacity and characterizing diversity gains, and summarize the tradeoff between system performance and operation complexity. This helps readers develop a broad understanding of the topic and obtain a comprehensive knowledge of the principles behind various methods. There are also sufficient references, concise chapter summaries, and bibliographical notes for readers seeking more details.

In terms of aesthetics and functionality, the book is very well designed. The formatting, font, and figures are all well

laid out and organized, making the book easy to read. The figures in the book are quite attractive. Key examples are set out from the rest of the text by lined boxes.

*Cooperative Communications and Networking* is likely to be positioned between the book *Cooperative Communications* by Gerhard Kramer, Ivana Maric, and Roy D. Yates and the book *Wireless Communications* by Andrea Goldsmith. The former book has a narrower focus and can be viewed as a tutorial for the reader who is familiar with information theoretic concepts. The latter book provides a general discussion on current wireless systems, such as equalization, coding for wireless systems, diversity, multiple antennas communications, and spread spectrum. Compared with these two books, *Cooperative Communications and Networking* fills a slightly different market need. In particular, Liu, Sadek, Su and Kwasinski's book provides a more thorough treatment of material that is at the cutting edge of cooperative communication over wireless network, and its treatment of cooperative communication is more advanced. Overall, *Cooperative Communications and Networking* is an excellent, reader-friendly book. This reviewer believes that this book will have a lasting impact upon those involved in cooperative communications research. **SP**

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