COOPERATIVE NETWORKING
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Editors

Mohammad S. Obaidat
Monmouth University, USA

Sudip Misra
Indian Institute of Technology, West Bengal, India
This book is dedicated to our parents and families

Mohammad S. Obaidat and Sudip Misra
Contents

About the Editors xiii
List of Contributors xvii

1 Introduction 1
Mohammad S. Obaidat and Sudip Misra
1.1 Major Features of the Book 4
1.2 Target Audience 4
1.3 Supplementary Resources 5
1.4 Acknowledgements 5

2 Fundamentals and Issues with Cooperation in Networking 7
Mohammad S. Obaidat and Tarik Guelzim
2.1 Introduction 7
2.2 Fundamentals of Cooperating Networks 7
2.2.1 Cooperative Adhoc Network Services 8
2.2.2 Cooperative Relaying Network Service 13
2.3 Issues and Security Flaws with Cooperating Networks: Wireless Sensor Networks Case Study 15
2.3.1 Limitations in Mobile Ad hoc Networks 16
2.4 Conclusions 19
References 19

3 To Cooperate or Not to Cooperate? That is the Question! 21
Mohamed H. Ahmed and Salama S. Ikki
3.1 Introduction 21
3.2 Overview of Cooperative-Diversity Systems 22
3.2.1 Relaying Techniques 22
3.2.2 Combining Techniques 23
3.2.3 Other Cooperating Techniques 24
3.3 Benefits of Cooperative-Diversity Systems 25
3.3.1 Signal-Quality Improvement 25
3.3.2 Reduced Power 28
3.3.3 Better Coverage 28
3.3.4 Capacity Gain 28
3.4 Major Challenges of Cooperative-Diversity Systems 28
  3.4.1 Resources Over-Utilization 28
  3.4.2 Additional Delay 29
  3.4.3 Complexity 30
  3.4.4 Unavailability of Cooperating Nodes 32
  3.4.5 Security Threats 32
3.5 Discussion and Conclusion 32
References 33

4 Cooperation in Wireless Ad Hoc and Sensor Networks 35
  J. Barbancho, D. Cascado, J. L. Sevillano, C. León, A. Linares and F. J. Molina
4.1 Introduction 35
4.2 Why Could Cooperation in WAdSN be Useful? 36
  4.2.1 Time Synchronization, Localization and Calibration 36
  4.2.2 Routing 41
  4.2.3 Data Aggregation and Fusion 43
4.3 Research Directions for Cooperation in WAdSN 45
  4.3.1 Middleware for WAdSN 46
  4.3.2 Multi-Agent Systems in WAdSN 48
  4.3.3 Artificial Neural Networks in WAdSN 50
4.4 Final Remarks 53
4.5 Acknowledgements 53
References 53

5 Cooperation in Autonomous Vehicular Networks 57
  Sidi Mohammed Senouci, Abderrahim Benslimane and Hassnaa Moustafa
5.1 Introduction 57
5.2 Overview on Vehicular Networks 58
5.3 Cooperation at Different OSI Layers 59
  5.3.1 Cooperation at Lower Layers 59
  5.3.2 Cooperation at Network Layer 60
  5.3.3 Security and Authentication versus Cooperation 67
  5.3.4 Cooperation at Upper Layers 69
5.4 Conclusion 73
References 73

6 Cooperative Overlay Networking for Streaming Media Content 77
  F. Wang, J. Liu and K. Wu
6.1 Introduction 77
6.2 Architectural Choices for Streaming Media Content over the Internet 78
  6.2.1 Router-Based Architectures: IP Multicast 79
  6.2.2 Architectures with Proxy Caching 80
  6.2.3 Peer-to-Peer Architectures 81
6.3 Peer-to-Peer Media Streaming 82
  6.3.1 Comparisons with Other Peer-to-Peer Applications 82
  6.3.2 Design Issues 83
  6.3.3 Approaches for Overlay Construction 83
6.4 Overview of mTreebone
  6.4.1 Treebone: A Stable Tree-Based Backbone
  6.4.2 Mesh: An Adaptive Auxiliary Overlay
6.5 Treebone Construction and Optimization
  6.5.1 Optimal Stable Node Identification
  6.5.2 Treebone Bootstrapping and Evolution
  6.5.3 Treebone Optimization
6.6 Collaborative Mesh-Tree Data Delivery
  6.6.1 Seamless Push/Pull Switching
  6.6.2 Handling Host Dynamics
6.7 Performance Evaluation
  6.7.1 Large-Scale Simulations
  6.7.2 PlanetLab-Based Experiments
6.8 Conclusion and Future Work
References

7 Cooperation in DTN-Based Network Architectures
  Vasco N. G. J. Soares and Joel J. P. C. Rodrigues
    7.1 Introduction
    7.2 Delay-Tolerant Networks
      7.2.1 DTN Application Domains
      7.2.2 Cooperation in Delay-Tolerant Networks
    7.3 Vehicular Delay-Tolerant Networks
      7.3.1 Cooperation in Vehicular-Delay Tolerant Networks
      7.3.2 Performance Assessment of Node Cooperation
    7.4 Conclusions
    7.5 Acknowledgements
References

8 Access Selection and Cooperation in Ambient Networks
  Ramón Agüero
    8.1 Leveraging the Cooperation in Heterogeneous Wireless Networks
    8.2 The Ambient Networks Philosophy
      8.2.1 Generic Link Layer
      8.2.2 Management of Heterogeneous Wireless Resources
      8.2.3 Additional Functional Entities
      8.2.4 Multi-Access Functions and Procedures
    8.3 Related Work
    8.4 Outlook
      8.4.1 Cognition
      8.4.2 Mesh Topologies
    8.5 Conclusions
References

9 Cooperation in Intrusion Detection Networks
  Carol Fung and Raouf Boutaba
    9.1 Overview of Network Intrusions
      9.1.1 Single-Host Intrusion and Malware
9.1.2 Distributed Attacks and Botnets 134
9.1.3 Cooperative Attacks and Phishing 134

9.2 Intrusion Detection Systems 135
9.2.1 Signature-Based and Anomaly-Based IDSs 135
9.2.2 Host-Based and Network-Based IDSs 135

9.3 Cooperation in Intrusion Detection Networks 136
9.3.1 Cooperation Topology 136
9.3.2 Cooperation Scope 137
9.3.3 Specialization 137
9.3.4 Cooperation Technologies and Algorithms 137
9.3.5 Taxonomy 138

9.4 Selected Intrusion Detection Networks 139
9.4.1 Indra 139
9.4.2 DOMINO 139
9.4.3 DShield 140
9.4.4 NetShield 140
9.4.5 Gossip 141
9.4.6 Worminator 142
9.4.7 ABDIAS 142
9.4.8 CRIM 142
9.4.9 HBCIDS 143
9.4.10 ALPACAS 143
9.4.11 CDDHT 143
9.4.12 SmartScreen Filter 143
9.4.13 FFCIDN 144

9.5 Open Challenges and Future Directions 144

9.6 Conclusion 144
References 144

10 Cooperation Link Level Retransmission in Wireless Networks 147
Mehrdad Dianati, Xuemin (Sherman) Shen and Kshirasagar Naik

10.1 Introduction 147

10.2 Background 149
10.2.1 Modeling of Fading Channels 149
10.2.2 Automatic Repeat Request 152

10.3 System Model 154

10.4 Protocol Model 155

10.5 Node Cooperative SW Scheme 156

10.6 Performance Analysis 157

10.7 Delay Analysis 164

10.8 Verification of Analytical Models 168
10.8.1 Throughput 169
10.8.2 Average Delay and Delay Jitter 171

10.9 Discussion of the Related Works 172

10.10 Summary 174

10.11 Acknowledgement 174
References 175
11 Cooperative Inter-Node and Inter-Layer Optimization of Network Protocols

D. Kliazovich, F. Granelli and N. L. S. da Fonseca

11.1 Introduction 177

11.2 A Framework for Cooperative Configuration and Optimization

11.2.1 Tuning TCP/IP Parameters 177

11.2.2 Cooperative Optimization Architecture 179

11.3 Cooperative Optimization Design

11.3.1 Inter-Layer Cooperative Optimization 181

11.3.2 Inter-Node Cooperative Optimization 183

11.4 A Test Case: TCP Optimization Using a Cooperative Framework

11.4.1 Implementation 184

11.4.2 Inter-Layer Cognitive Optimization 186

11.4.3 Inter-Node Cognitive Optimization 187

11.5 Conclusions 189

References 189

12 Cooperative Network Coding

H. Rashvand, C. Khirallah, V. Stankovic and L. Stankovic

12.1 Introduction 191

12.2 Network Coding Concept

12.2.1 Example 192

12.3 Cooperative Relay 195

12.4 Cooperation Strategies

12.4.1 Performance Measures 197

12.5 Cooperative Network Coding 206

12.6 Conclusions 214

References 214

13 Cooperative Caching for Chip Multiprocessors

J. Chang, E. Herrero, R. Canal and G. Sohi

13.1 Caching and Chip Multiprocessors

13.1.1 Caching Background 217

13.1.2 CMP (Chip Multiprocessor) 218

13.1.3 CMP Caching Challenges 218

13.2 Cooperative Caching and CMP Caching

13.2.1 Motivation for Cooperative Caching 220

13.2.2 The Unique Aspects of Cooperative Caching 220

13.2.3 CMP Cache Partitioning Schemes 225

13.2.4 A Taxonomy of CMP Caching Techniques 226

13.3 CMP Cooperative Caching Framework

13.3.1 CMP Cooperative Caching Framework 227

13.3.2 CC Mechanisms 229

13.3.3 CC Implementations 234

13.3.4 CC for Large Scale CMPs 241

13.3.5 Distributed Cooperative Caching 243

13.3.6 Summary 249
13.4 CMP Cooperative Caching Applications 251
  13.4.1 CMP Cooperative Caching for Latency Reduction 252
  13.4.2 CMP Cooperative Caching for Adaptive Repartitioning 259
  13.4.3 CMP Cooperative Caching for Performance Isolation 262
13.5 Summary 269
References 270

14 Market-Oriented Resource Management and Scheduling: A Taxonomy and Survey 277
Saurabh Kumar Garg and Rajkumar Buyya
14.1 Introduction 277
14.2 Overview of Utility Grids and Preliminaries 277
14.3 Requirements 279
  14.3.1 Consumer Side Requirements 279
  14.3.2 Resource Provider Side Requirements 280
  14.3.3 Market Exchange Requirements 280
14.4 Utility Grid Infrastructural Components 282
14.5 Taxonomy of Market-Oriented Scheduling 283
  14.5.1 Market Model 284
  14.5.2 Allocation Decision 288
  14.5.3 Participant Focus 288
  14.5.4 Application Type 288
  14.5.5 Allocation Objective 289
14.6 Survey of Grid Resource Management Systems 289
  14.6.1 Survey of Market-Oriented Systems 289
  14.6.2 System-Oriented Schedulers 296
14.7 Discussion and Gap Analysis 300
  14.7.1 Scheduling Mechanisms 300
  14.7.2 Market Based Systems 301
14.8 Summary 302
References 303

Glossary 307

Index 319
About the Editors

Professor Mohammad S. Obaidat (Fellow of IEEE and Fellow of SCS) is an internationally well known academic/researcher/scientist. He received his PhD and MSc degrees in Computer Engineering with a minor in Computer Science from The Ohio State University, Columbus, Ohio, USA. Dr Obaidat is currently a full Professor of Computer Science at Monmouth University, NJ, USA. Among his previous positions are Advisor of the President of Philadelphia University (Jordan), Chair of the Department of Computer Science and Director of the Graduate Program at Monmouth University and a faculty member at the City University of New York. He has received extensive research funding and has published numerous books and numerous refereed technical articles (500 articles as of date of publication of this book) in scholarly international journals and proceedings of international conferences, (about 500 refereed papers as of today), and is currently working on three more books. Professor Obaidat has served as a consultant for several corporations and organizations worldwide. He is the Editor-in-Chief of the Wiley International Journal of Communication Systems, the FTRA Journal of Convergence and the KSIP Journal of Information Processing. He served as an Editor of IEEE Wireless Communications from 2007–2010. Between 1991–2006, he served as a Technical Editor and an Area Editor of Simulation: Transactions of the Society for Modeling and Simulations (SCS) International, TSCS. He also served on the Editorial Advisory Board of Simulation. He is now an editor of the Wiley Security and Communication Networks Journal, Journal of Networks, International Journal of Information Technology, Communications and Convergence, IJITCC, Inderscience. He served on the International Advisory Board of the International Journal of Wireless Networks and Broadband Technologies. Professor Obaidat is an associate editor/editorial board member of seven other refereed scholarly journals including two IEEE Transactions, Elsevier Computer Communications Journal, Springer Journal of Supercomputing, SCS Journal of Defense Modeling and Simulation, Elsevier Journal of Computers and EE, International Journal of Communication Networks and Distributed Systems, The Academy Journal of Communications, International Journal of BioSciences and Technology and International Journal of Information Technology. He has guest edited numerous special issues of scholarly journals such as IEEE Transactions on Systems, Man and Cybernetics, SMC, IEEE Wireless Communications, IEEE Systems Journal, SIMULATION: Transactions of SCS, Elsevier Computer Communications Journal, Journal of C & EE, Wiley Security and Communication Networks, Journal of Networks, and International Journal of Communication Systems, among others. Obaidat has served as the general chair, steering committee chair, advisory Committee Chair and program chair of numerous international conferences. He is the founder of the International Symposium on Performance Evaluation of Computer and Telecommunication Systems, SPECTS.
and has served as the General Chair of SPECTS since its inception. He is also the founder of the International Conference on Computer, Information and Telecommunication Systems, CITS. Obaidat has received a recognition certificate from IEEE. Between 1994–1997, Obaidat has served as distinguished speaker/visitor of IEEE Computer Society. Since 1995 he has been serving as an ACM distinguished Lecturer. He is also an SCS distinguished Lecturer. Between 1996–1999, Dr. Obaidat served as an IEEE/ACM program evaluator of the Computing Sciences Accreditation Board/Commission, CSAB/CSAC. He has served as the Scientific Advisor for the World Bank/UN Digital Inclusion Workshop- The Role of Information and Communication Technology in Development. Between 1995–2002, he has served as a member of the board of directors of the Society for Computer Simulation International. Between 2002–2004, he has served as Vice President of Conferences of the Society for Modeling and Simulation International (SCS). Between 2004–2006, Professor Obaidat has served as Vice President of Membership of the Society for Modeling and Simulation International SCS. Between 2006–2009, he has served as the Senior Vice President of SCS. Currently, he is the President of the Society for Modeling and Simulation International (SCS). One of his recent co-authored papers has received the best paper award in the IEEE AICCSA 2009 international conference. He also received the best paper award for one of his papers accepted in IEEE GLOBECOM 2009 conference. Dr. Obaidat received very recently the Society for Modeling and Simulation International (SCS) prestigious McLeod Founder’s Award in recognition of his outstanding technical and professional contributions to modeling and simulation. He received in Dec 2010, the IEEE ComSoc- GLOBECOM 2010 Outstanding Leadership Award for his outstanding leadership of Communication Software Services and Multimedia Applications Symposium, CSSMA 2010.

He has been invited to lecture and give keynote speeches worldwide. His research interests are: wireless communications and networks, cooperative networking, telecommunications and Networking systems, security of network, information and computer systems, security of e-based systems, performance evaluation of computer systems, algorithms and networks, high performance and parallel computing/computers, applied neural networks and pattern recognition, adaptive learning and speech processing. Recently, Prof. Obaidat has been awarded a Nokia Research Fellowship and the distinguished Fulbright Scholar Award. During the 2004/2005, he was on sabbatical leave as Fulbright Distinguished Professor and Advisor to the President of Philadelphia University in Jordan, Dr. Adnan Badran. The latter became the Prime Minister of Jordan in April 2005 and served earlier as Vice President of UNESCO. Prof. Obaidat is a Fellow of the Society for Modeling and Simulation International SCS, and a Fellow of the Institute of Electrical and Electronics Engineers (IEEE). For more information, see http://bluehawk.monmouth.edu/mobaidat/.
Dr Sudip Misra is an Assistant Professor in the School of Information Technology at the Indian Institute of Technology Kharagpur. Prior to this he was associated with Cornell University (USA), Yale University (USA), Nortel Networks (Canada) and the Government of Ontario (Canada) in different capacities. He received his PhD degree in Computer Science from Carleton University, in Ottawa, Canada, and the masters and bachelor’s degrees respectively from the University of New Brunswick, Fredericton, Canada, and the Indian Institute of Technology, Kharagpur, India. Dr Misra has several years of experience working in the academia, government and the private sectors in research, teaching, consulting, project management, architecture, software design and product engineering roles.

His current research interests include algorithm design for emerging communication networks. Dr Misra is the author of over 120 scholarly research papers and book chapters. He has won six research paper awards in different conferences. He was also the recipient of several academic awards and fellowships such as the Young Scientist Award (National Academy of Sciences, India), Young Systems Scientist Award (Systems Society of India), Young Engineers Award (Institution of Engineers, India), (Canadian) Governor General’s Academic Gold Medal at Carleton University, the University Outstanding Graduate Student Award in doctoral level at Carleton University and the National Academy of Sciences, India – Swarna Jayanti Puraskar (Golden Jubilee Award).

He was also awarded the Canadian Government’s prestigious NSERC Post Doctoral Fellowship and the Humboldt Research Fellowship in Germany. Dr Misra is the Editor-in-Chief of two journals – the International Journal of Communication Networks and Distributed Systems (IJCNDS) and the International Journal of Information and Coding Theory (IJICoT), UK. He has also been serving as the Associate Editor of the Telecommunication Systems Journal (Springer SBM), Security and Communication Networks Journal (Wiley), International Journal of Communication Systems (Wiley), and the EURASIP Journal of Wireless Communications and Networking. He is also an Editor/Editorial Board Member/Editorial Review Board Member of the IET Communications Journal, Computers and Electrical Engineering Journal (Elsevier), the International Journal of Internet Protocol Technology, the International Journal of Theoretical and Applied Computer Science, the International Journal of Ad Hoc and Ubiquitous Computing, Journal of Internet Technology, and the Applied Intelligence Journal (Springer).

Dr Misra has edited around six books in the areas of wireless ad hoc networks, wireless sensor networks, wireless mesh networks, communication networks and distributed systems, network reliability and fault tolerance, and information and coding theory, published by reputed publishers such as Springer and World Scientific.

He was invited to chair several international conference/workshop programs and sessions. He has been serving in the program committees of over a dozen international conferences. Dr Misra was also invited to deliver keynote lectures in over a dozen international conferences held in USA, Canada, Europe, Asia and Africa.
List of Contributors

Mohamed H. Ahmed
Memorial University of Newfoundland,
St. John’s, Newfoundland,
A1B 3X5, Canada
mahmed@mun.ca

J. Barbancho
University of Seville,
EPS. Virgen de África, 7
41011 – Seville, Spain
jbarbancho@us.es

Abderrahim Benslimane
LIA/CERI University of Avignon,
339 Chemin des Meinajaries BP 1228,
84911 Avignon cedex 9, France
abderrahim.benslimane@univ-avignon.fr

Raouf Boutaba
University of Waterloo,
200 University west,
Waterloo, ON, Canada
rboutaba@uwaterloo.ca

Rajkumar Buyya
University of Melbourne,
Parkville, Victoria, 3010,
Australia
raj@csse.unimelb.edu.au

Ramón Agüero
University of Cantabria,
Plaza de la Ciencia s/n,
39005 Santander, Spain
ramon@tlmat.unican.es
R. Canal
Universitat Politècnica de Catalunya,
C/Jordi Girona 1-3, C6-107
08034 Barcelona, Spain
rcanal@ac.upc.edu

D. Cascado
University of Seville,
ETSII. Av. Reina Mercedes s/n
41012 – Seville, Spain
danic@atc.us.es

J. Chang
HP Labs
1501 Page Mill Road,
MS 1183, Palo Alto,
CA 94304, USA
jichuan.chang@hp.com

Mehrdad Dianati
University of Surrey,
Guildford, GU2 7XH, UK
m.dianati@surrey.ac.uk

N. L. S. da Fonseca
State University of Campinas,
Av Albert Einstein 1251,
13083-852 Campinas SP, Brazil
nfonseca@ic.unicamp.br

Carol Fung
University of Waterloo,
200 University west,
Waterloo, ON, Canada
j22fung@uwaterloo.ca

Saurabh Kumar Garg
University of Melbourne,
111 Barry St. Carlton, Victoria, 3053, Australia
sgarg@csse.unimelb.edu.au

F. Granelli
University of Trento,
Via Sommarive 14, I-38123,
Trento, Italy
granelli@disi.unitn.it
Tarik Guelzim
Res El Hayat B1 BD Emile Zola APT#6,
Belvedere, Casablanca, 20300, Morocco
Tarik.guelzim@gmail.com

E. Herrero
Universitat Politècnica de Catalunya,
C/Jordi Girona 1-3, C6-E208
08034 Barcelona, Spain
eherrero@ac.upc.edu

Salama S. Ikki
University of Waterloo,
Waterloo, Ontario, N2M2C5, Canada
sikki@uwaterloo.ca

C. Khirallah
The University of Edinburgh,
Faraday Building, Mayfield Road,
Edinburgh, EH9 3JL, UK
C.Khirallah@ed.ac.uk

D. Kliazovich
University of Luxembourg,
6 rue Coudenhove Kalergi,
L-1359, Luxembourg
dzmitry.kliazovich@uni.lu

C. León
University of Seville,
EPS. Virgen de África, 7
41011 – Seville, Spain
cleon@us.es

A. Linares
University of Seville,
ETSII. Av. Reina Mercedes s/n
41012 – Seville, Spain
alinares@atc.us.es

J. Liu
Simon Fraser University,
8888 University Drive,
Burnaby, BC, V5A 1S6, Canada
jcliu@cs.sfu.ca
Sudip Misra
Indian Institute of Technology
Kharagpur – 721302,
West Bengal, India
smisra@sit.iitkgp.ernet.in

F.J. Molina
University of Seville,
EPS. Virgen de África, 7
41011 – Seville, Spain
fjmolina@us.es

Hassnaa Moustafa
France Telecom – Orange Labs Networks and Carriers,
38-40 rue General Leclerc,
92794 Issy le Moulineaux Cedex 9, France
hassnaa.moustafa@orange-ftgroup.com

Kshirasagar Naik
University of Waterloo,
Waterloo Ontario, N2L 3G1, Canada
S.Naik@ece.uwaterloo.ca

Mohammad S. Obaidat
Monmouth University,
W. Long Branch, NJ 07764, USA
obaidat@monmouth.edu

H. Rashvand
Advanced Communication Systems Ltd,
University of Warwick,
Coventry, CV4 7AL, UK
h.rashvand@warwick.ac.uk
rashvand.editor@gmail.com

Joel J. P. C. Rodrigues
Instituto de Telecomunicações,
University of Beira Interior,
Rua Marquês D’Ávila e Bolama,
6201-001 Covilhã, Portugal
joeljr@ieee.org

Sidi Mohammed Senouci
University of Bourgogne, 49 rue Mademoiselle Bourgeois,
58000 Nevers, France
Sidi-Mohammed.Senouci@u-bourgogne.fr
**J. L. Sevillano**  
University of Seville,  
ETSII. Av. Reina Mercedes s/n  
41012 – Seville, Spain  
jlsevillano@us.es

---

**Xuemin (Sherman) Shen**  
University of Waterloo,  
Waterloo Ontario, N2L 3G1, Canada  
xshen@bcr.uwaterloo.ca

---

**Vasco N. G. J. Soares**  
Instituto de Telecomunicações,  
University of Beira Interior,  
Rua Marquês D’Ávila e Bolama,  
6201-001 Covilhã, Portugal  
Polytechnic Institute of Castelo Branco,  
Av. do Empresário,  
6000-767 Castelo Branco, Portugal  
vasco.g.soares@ieee.org

---

**G. Sohi**  
University of Wisconsin-Madison,  
1210 West Dayton Street,  
Madison, WI 53706-1685 USA  
sohi@cs.wisc.edu

---

**V. Stankovic**  
University of Strathclyde,  
Royal College Building,  
204 George Street, Glasgow G1 1XW, UK  
vладimir.stankovic@eee.strath.ac.uk

---

**L. Stankovic**  
University of Strathclyde,  
Royal College Building,  
204 George Street, Glasgow G1 1XW, UK  
lina.stankovic@eee.strath.ac.uk

---

**F. Wang**  
Simon Fraser University,  
8888 University Drive,  
Burnaby, BC, V5A 1S6, Canada  
fwal@cs.sfu.ca
K. Wu
University of Victoria,
P.O. Box 3055, Station CSc,
Victoria, BC, V8W 3P6, Canada
wkui@cs.uvic.ca
Introduction

Mohammad S. Obaidat\textsuperscript{1} and Sudip Misra\textsuperscript{2}
\textsuperscript{1}Department of Computer Science and Software Engineering, Monmouth University, NJ, USA
\textsuperscript{2}School of Information Technology, Indian Institute of Technology, West Bengal, India

Cooperative Networking is an important topic in emerging network technologies characterized by relatively high degrees of autonomy and self-dependent behaviour. Cooperative networking deals with how the different hosts in a resource-constrained communication network cooperate with each other to improve the overall network performance. Different issues are involved in cooperative networking – identifying the bottleneck resource, identifying the peers that when selected would improve the resource utilization, identifying the servers that are loaded and that should be avoided for downloading content at a certain time instant, security issues and so on. The topics that this book covers span these issues.

The issue of cooperation is not new. Successful instances of cooperation exist in biological, chemical, economic, social and telecommunication networks. Instances of cooperation in nature have motivated development of models of cooperation in telecommunication networks. In any telecommunication network, cooperation is important in different degrees to improve the network performance. However, there has been an increased interest in cooperation in the recent years with the growing attention to peer-to-peer networks, and ad-hoc and sensor networks, in which the network throughput largely depends on the degree of cooperation amongst the different nodes. As these technologies are viewed to be very promising for the future, it is expected that cooperative networking will remain an essential subject of interest. Short summaries of the rest of the chapters in this book are provided below. We should emphasize that these summaries provide simplified abstraction of concepts that are described in detail in the later chapters of this book. The summaries in some instances have text, terms, expressions or ideas that are borrowed from the respective chapters.

In Chapter 2, the fundamental issues with cooperation in communication networking are investigated. Today’s cooperative networking is one of the leading topics of research around the world. It has huge contributions not only in academic areas such as biology, sociology and economy, but it also has direct applications in communications, robotics and military science. The chapter elaborately discusses the interaction of this field with distributed processing where heterogeneous nodes promise significant enhancement in the capability of the system as well as performance and potentiality. Cooperative communication gives an alternative method to make an advantage of existing network infrastructure by means of spatial diversity. The conviction of user operation...
Cooperative Networking

consists of the concept of relay channel. The two issues of cooperative quality-of-service (CQoS) and cooperative data caching play a vital role in enhancing the network output, ability and utility.

Chapter 3 discusses the issue of cooperative diversity. Cooperative diversity has revealed an aspiring technique in modern wireless communication systems. According to the authors, the prime concept behind cooperative diversity is that the existing nodes between the pairs of ingress-egress nodes can transmit the signal from the ingress nodes to obtain multiple copies of the same signal at the egress node. This leads to excellent signal quality and amend coverage and acute capacity. Moreover, the authors have represented the main aspects of cooperative diversity including relaying techniques, combining methods and other cooperation schemes (other than cooperative diversity). Efficient algorithms and protocols are necessary to make it easier to accomplish cooperative diversity in order to be able to yield the advantage of cooperative diversity in resource constrained networks.

Chapter 4 reviews the issue of cooperation in Wireless Ad-Hoc Sensor Networks (WAdSN). Commonly, WAdSN are characterized by very small sized nodes having limited radio frequency range, low resources and autonomy. They communicate with one another by transmitting data over multi-hop pathways. However, in this case, collaboration is limited to a certain barter of information. The chapter introduces the new approach taking the network as a whole. It represents cooperation in WAdSN as a collaborative action where network nodes are implicated. Time synchronization, calibration and localization have been emphasized as issues requiring efficient mechanisms of cooperation. Time synchronization is required in wireless sensor networks for the sake of saving of limited energy resident in the nodes. Another issue where cooperation is important is localization, because location information is not only required for monitoring a given area, but can also be exploited to trace a mobile vehicle and animal, or to monitor elderly and disabled people in residencies. In this approach, while a node provides a measure with location information, data fusion techniques can reduce traffic and energy consumption.

Chapter 5 studies cooperation in autonomous vehicular networks. Since chronological advancement of wireless technologies are taking place regularly in all respects, autonomous vehicular networks have become like a new network technology comprising of vehicle-to-infrastructure and vehicle-to-vehicle communication. Cooperation in vehicular networks is categorized into two types: implicit and explicit. Implicit cooperation solicitudes the proficiency of MAC layer protocols for multi-hop communication and for adroit mechanism allowing trusted communication between different vehicles. The behaviours of the drivers focus on explicit communication, and allow the vehicles without having a specific need for a service access to participate in the communication to assist other vehicles that need relay nodes to allow them to access services. It is believed that cooperative techniques can be helpful to amend the enforcement of vehicular networks. Their application ranges from road safety to amusement and commercial.

Chapter 6 investigates the issue of cooperative overlay networking for streaming media content. Currently, media streaming has been recognized as having widespread applications in the networked world. Recently, peer-to-peer content delivery has emanated as one of the inspiring techniques to enable its large-scale deployment. The authors investigate various solutions pronounced for peer-to-peer media streaming. The chapter divides the solutions into two categories: tree-based and mesh-based approaches. It states that these two may endure inefficiencies either due to the vulnerability caused by dynamic end-hosts or the efficiency-latency tradeoff. The chapter puts forward a cooperative mesh-tree design, named as mTreebone, which clouts both tree and mesh structures. Using simulation analysis and PlanetLab experiments, the authors show that cooperative hybrid solution exhibits superior performance.

Chapter 7 studies the issues of cooperation in Delay Tolerant Network (DTN) based architectures. The DTN architecture consolidates a store-carry-and-forward paradigm by overlaying a protocol layer, called bundle layer, that provides internetworking on heterogeneous networks (regions) operating on different transmission media. DTN is usually exploited in an environment
categorized by sparse connectivity, frequent network partitioning, intermittent connectivity, long propagation delays, asymmetric data rates, and high error rates. DTN can be deployed in different kinds of challenged and resource constrained network environments including interplanetary networks, underwater networks, wildlife tracking networks, remote area networks, social networks, military networks, vehicular networks, among others. In this chapter, the authors present a recapitulation of the delay-tolerant networking epitome, including innovative network architecture for vehicular communications, called vehicular delay-tolerant network (VDTN). The chapter also sketches the recent advances related to cooperation on delay tolerant networks. The chapter also highlighted the importance of the nodes’ cooperation to revive the delivery ratio, thereby improving the performance of VDTN networks.

The rapid increase in wireless technologies has led to the opening of fast technological areas that have a great impact on our lives. One of the important requirements in wireless technology is cooperation; it improves the network connectivity and also enhances the quality of service of the network. The ambient network architecture includes both scalability and flexibility and it has also the capability of firming up the connection between two networks. Chapter 8 presents the key aspects followed by ambient networks needed to interact with the heterogeneous access networks based upon the cooperation between two functionalities having relevance to ‘Generic Link Layer (GLL)’ and ‘Multi Radio Resource Management (MRMM).’ GLL is essential, as it can make comparison among different radio access technologies. On the contrary, MRMM is based on a decision-based scheme. After having gathered information from different sources, the most suitable path for communication is chosen. Additionally, the chapter introduces two ideas that would function in the ensuing wireless communication technologies.

Chapter 9 presents the issue of cooperation in intrusion detection networks. In today’s era of advanced technology, we are mostly dependent on Internet-based applications such as email, web-browsing, social networks, remote connections, and online messaging. Concurrently, network intrusions and consequent loss of privacy and security are becoming serious issues for the Internet community. The intrusions are unwanted traffic or computer activities that are generally vicious and troublesome. As stated by the authors, this leads to Denial of Service (DoS), ID theft, spam and phishing. Malicious pieces of code are used to succeed in attack goals. This chapter surveyed the cooperation schemes in Intrusion Detection Network. The authors have first classified network intrusions and IDSs according to their behaviour and the techniques they use. Some of the open challenges and future directions in cooperative intrusion detection networks are also discussed.

Chapter 10 reviews the issue of utilizing cooperative diversity in link layer over wireless fading channels. In this chapter, the authors discuss a link level retransmission scheme, named as Node Cooperative Stop and Wait (NCSW). The scheme exploits the inherent cooperative diversity belonging to a multi-user communication system, thereby improving upon the traditional stop-and-wait retransmission. The chapter explains how in conventional retransmission schemes the neighbour nodes remain virtually non-existent to the ongoing transmission between a sender and receiver nodes, whereas in the NCSW scheme, some of the neighbour nodes which may have enough resources may want to cooperate and assist the sender node in retransmission.

Chapter 11 presents a novel concept of cooperative network optimization that is based on inter-layer and inter-node communication. With this concept, protocols from the TCP/IP can be extended to fine tune their configuration parameter values continuously based on the past performance. As stated by the authors, compared to non-cooperative approaches, the results manifest that cooperation between layers of a protocol stack can bring major improvements in data transfer performance. The authors present an analysis of cooperative inter-node and inter-layer networking issues and their respective solutions.

Chapter 12 presents the topic of cooperative network coding (CNC). CNC is a fairly recent methodology which came into existence as a combination of concepts from both network coding
and cooperative communications. It has become popular in the last decade or so with the popularity of the future Internet and wireless communications. The authors discuss how the issue of cooperation helps in increasing capacity and minimizing the effect of blackout and how network coding enables more efficient use of the network resources. In addition, this chapter discusses the fundamental issues and definitions underlying the concept of network coding. A summary of currently used cooperative relaying strategies, and different issues of performance is also given.

Chapter 13 reviews the different issues surrounding cooperative caching for chip multiprocessors. In data access patterns, caches are deliberately used to help minimize network activities and storage access latencies. The chapter explores the concept and effectuation of cooperative caching for modern CMPs (i.e., today’s multi-core and tomorrow’s many-core processors). Cooperative caching helps in supporting various cache sharing behaviours using different techniques relating to cooperative capacity sharing and throttling capabilities.

Finally, Chapter 14 presents a taxonomy and survey of market-oriented resource management and scheduling. Market-oriented computing is currently inevitable for both industry and academia. Grid computing is one of the most important concepts which supports market-oriented computing. Since the last decade, many researchers have investigated issues related to resource management and scheduling in utility grids, but still a lot of work needs to be done. Moreover, the chapter provides a comprehensive taxonomy summarizing the important works on this aspect. A survey of market-oriented resource management systems has been presented as well.

1.1 Major Features of the Book

Below are some important features of this book, which, we believe, would make it a valuable resource for our readers:

- This book is designed, in structure and content, with the aim of making it useful at all learning levels.
- The chapters of this book are authored by prominent academicians/researchers, and practitioners, with solid experience in the subject matter.
- The chapters’ authors of the book are distributed across a large number of countries and institutions of worldwide reputation. This gives this book an international flavour.
- The chapter authors have attempted to provide a comprehensive bibliography, which should greatly help the readers interested in exploring the topics in greater detail.
- Throughout the chapters of this book, most of the groundwork research topics of cooperative networking have been covered from both theoretical and practical viewpoints. This makes the book particularly useful for industry practitioners working directly with the practical aspects behind enabling the technologies in the field.
- To make the book useful for pedagogical purpose, all chapters of the book are accompanied by a corresponding set of presentation viewgraphs. The viewgraphs can be obtained as a supplementary resource by contacting the publisher, John Wiley & Sons Ltd, UK.

1.2 Target Audience

The book is written by primarily targeting the student community. This includes the students of both undergraduate and graduate levels – as well as students having an intermediate level of knowledge of the topics, and those having extensive knowledge about many of the topics. To keep up this goal, we have tried to design the overall structure and content of the book in such a manner that makes it useful at all learning levels. The secondary audience for this book is the research community, in academia or in the industry. Finally, we have also taken
Introduction

into consideration the needs of those readers, typically from the industry, who wish to gain an insight into the practical significance of the topics, expecting to discover how the spectrum of knowledge and the ideas are relevant for real-life applications of cooperative networking.

1.3 Supplementary Resources
As previously mentioned, this book comes with sets of viewgraphs for each chapter, which can be used for classroom instruction by instructors who adopt the book as a textbook. Instructors are requested to contact the publisher for access to these supplementary resources.

1.4 Acknowledgements
We are extremely thankful to the authors of the chapters of this book, who have worked very hard to bring this unique resource forward to help students, researchers and community practitioners. We feel it is in context to mention that as the individual chapters of this book are written by different authors, the responsibility of the contents of each of the chapters lies with the concerned authors of each chapter.

We are also very thankful to the John Wiley & Sons publishing and marketing staffs, for taking special interest in publishing this book, considering the current worldwide market needs for such a book. In particular, we would like to thank Sarah Tilley, Anna Smart, Susan Barclay, Jasmine Chang and Gayatri Shanker who efficiently worked with us in the publication process. Special thanks go to our institutions, students and research colleagues who in one way or the other contributed to this book. Finally, we would also like to thank our families, for their patience and for the continuous support and encouragement they have offered during the course of this book project.