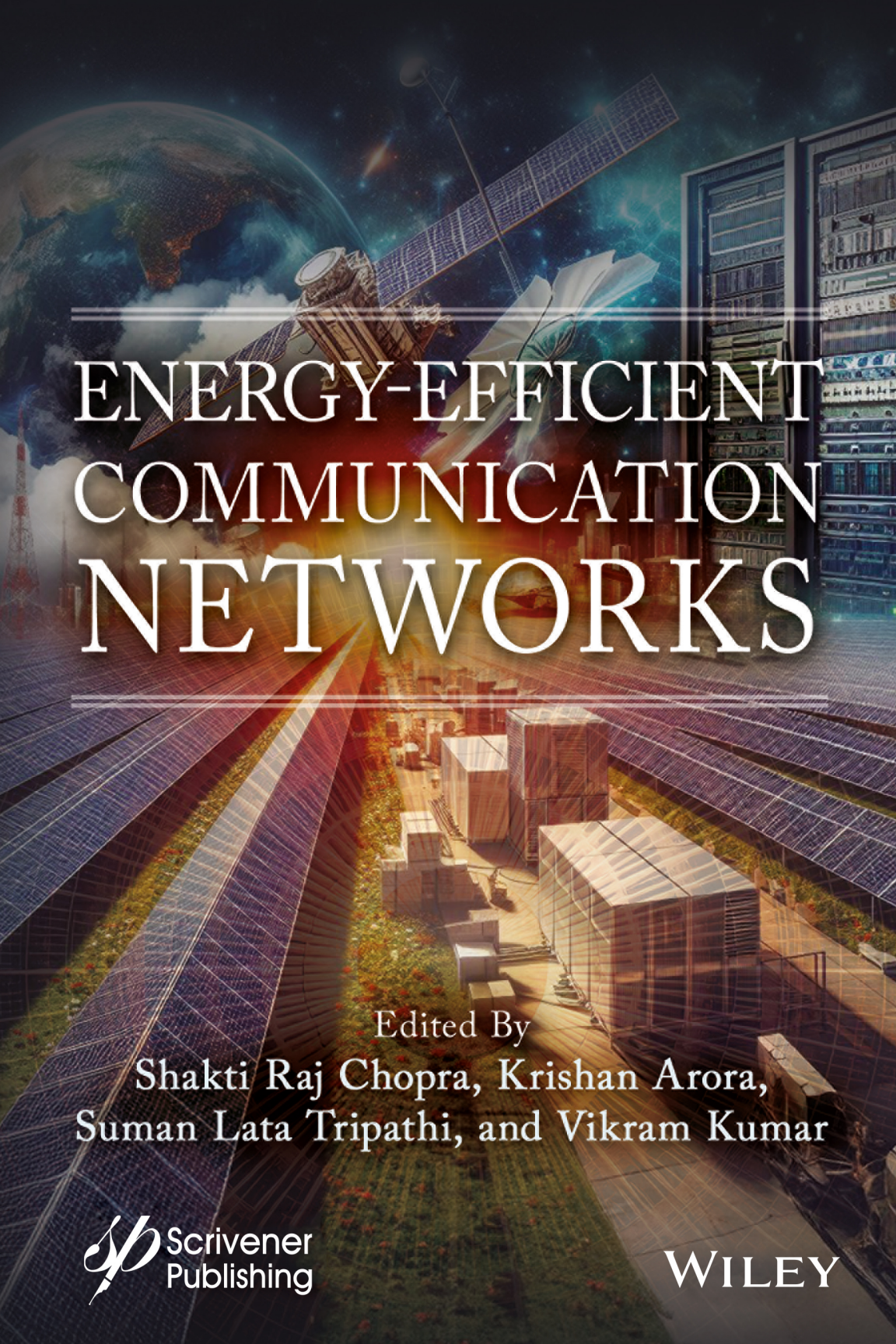


The background of the cover is a composite digital image. In the upper left, a satellite with large solar panels is in space, with a view of Earth's horizon. In the upper right, there are server racks with glowing blue lights. The lower half of the image shows a vast field of solar panels stretching towards a horizon, with a small, modern building in the center. The overall color palette is dominated by blues, purples, and oranges, creating a high-tech, sustainable energy theme.

ENERGY-EFFICIENT COMMUNICATION NETWORKS

Edited By

Shakti Raj Chopra, Krishan Arora,
Suman Lata Tripathi, and Vikram Kumar

 Scrivener
Publishing

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Energy-Efficient Communication Networks

Scrivener Publishing

100 Cummings Center, Suite 541J
Beverly, MA 01915-6106

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WILEY

This edition first published 2025 by John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA and Scrivener Publishing LLC, 100 Cummings Center, Suite 541J, Beverly, MA 01915, USA

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Library of Congress Cataloging-in-Publication Data

ISBN 9781394271658

Front cover images supplied by Adobe Firefly

Cover design by Russell Richardson

Set in size of 11pt and Minion Pro by Manila Typesetting Company, Makati, Philippines

Printed in the USA

10 9 8 7 6 5 4 3 2 1

Contents

Preface	xv
List of Contributors	xvii
1 Efficient Energy Management in Hyperledger Fabric Blockchain Networks: A Proposed Optimized Solution	1
<i>Kamurthi Ravi Teja and Shakti Raj Chopra</i>	
1.1 Introduction	2
1.2 Methodology	3
1.3 Experimental Analysis	4
1.3.1 Existing Problem in the Network	4
1.3.2 Proposed Hyperledger Fabric Network Approach	5
1.4 Results and Discussion	5
1.5 Conclusion	7
References	7
2 Framework for UAV-Based Wireless Power Harvesting	9
<i>Tanishk Singhal and Harpreet Singh Bedi</i>	
2.1 Introduction	9
2.2 Literature Review	10
2.2.1 Proposed Framework	11
2.2.2 Integration with UAV Systems	12
2.2.3 Methodology	13
2.3 Results and Discussion	15
2.4 Conclusion	19
References	19
3 Future Generation Technology and Feasibility Assessment	23
<i>Pradeep Singh, Krishan Arora and Umesh C. Rathore</i>	
3.1 Introduction	24
3.1.1 Technological Breakthroughs	25
3.1.2 Economic Viability and Feasibility	25

3.1.3	Regulatory Environments	25
3.1.4	Atmospheric Reliability	26
3.1.5	Customer Requirements	26
3.1.6	Societal Acceptability	26
3.2	Next-Generation Electrical Technologies	26
3.2.1	Smart Grids	26
3.2.1.1	Components and Features	27
3.2.1.2	Advantages	28
3.2.1.3	Challenges	28
3.2.2	Renewable Energy Integration	28
3.2.2.1	Grid Integration	29
3.2.2.2	Power Electronics and Control System	29
3.2.2.3	Energy Storage	30
3.2.2.4	Transmission and Distribution	30
3.2.2.5	Challenges	30
3.2.3	Energy Storage	31
3.2.3.1	Types of Energy Storage	31
3.2.3.2	Applications of Energy Storage	31
3.2.3.3	Advancements and Challenges	32
3.2.4	Electric Vehicles	32
3.2.4.1	Types of Electric Vehicles	32
3.2.4.2	Key Components and Systems	33
3.2.4.3	Challenges	33
3.2.5	Power Electronics	34
3.2.5.1	Components and Systems	34
3.2.5.2	Applications	34
3.2.5.3	Challenges and Future Trends	35
3.2.6	Internet of Things (IoT) and Connectivity	35
3.2.6.1	Internet of Things (IoT)	35
3.2.6.2	Connectivity in Electrical Engineering	36
3.2.6.3	Advantages and Challenges	37
3.3	Artificial Intelligence	37
3.3.1	Types of Artificial Intelligence	38
3.3.1.1	Type I	38
3.3.1.2	Type II (Based on Functionalities)	38
3.3.2	Applications of AI in Electrical Engineering	40
3.3.2.1	Design and Development	40
3.3.2.2	Predictive Maintenance	40
3.3.2.3	Power System and Grid Management	40
3.3.2.4	Automation and Control Systems	40
3.3.2.5	Energy Efficiency	41

3.4	Machine Learning	41
3.4.1	Types of Machine Learning	42
3.4.1.1	Supervised Machine Learning	42
3.4.1.2	Unsupervised Machine Learning	43
3.4.1.3	Semi-Supervised Learning	44
3.4.1.4	Reinforcement Learning	44
3.4.2	Applications of Machine Learning in Electrical Engineering	45
3.4.2.1	Predictive Maintenance	45
3.4.2.2	Power System Optimization	45
3.4.2.3	Control Systems and Optimization	46
3.4.2.4	Energy Efficiency	46
3.4.2.5	Design and Development	46
3.5	Conclusion	46
	References	47
4	IoT-Enabled Weather Forecasting Systems in Future Networks: Constraints and Solutions	51
	<i>Yogesh Kumar Verma, Archana Kanwar and Manoj Kumar Shukla</i>	
4.1	Introduction	52
4.2	Need of IoT-Based Weather Forecasting System	53
4.3	Methodology and Results	58
4.4	Conclusion	61
	References	62
5	Cognitive Radio-Based NOMA Communication Networks	65
	<i>Indu Bala</i>	
5.1	Introduction to Cognitive Radio and NOMA Networks	66
5.1.1	Motivation for Integrating Cognitive Radio with NOMA	66
5.2	Fundamentals of Cognitive Radio Technology	67
5.2.1	Spectrum Sensing Techniques in Cognitive Radio	67
5.2.2	Dynamic Spectrum Access (DSA)	68
5.2.3	Spectrum Management	69
5.2.4	Cognitive Radio Architectures and Protocols	70
5.3	Principles of Non-Orthogonal Multiple Access (NOMA)	70
5.3.1	Orthogonal Multiple Access versus NOMA	71
5.3.2	NOMA Techniques and Variants	71
5.3.3	Advantages and Challenges of NOMA Networks	72
5.4	Integration of Cognitive Radio with NOMA	73

5.4.1	Cognitive Radio Capabilities and Spectrum Sensing in NOMA Networks	73
5.4.2	Spectrum-Sharing Techniques in Cognitive Radio-NOMA Systems	74
5.4.3	Cognitive Radio-NOMA Architecture and Protocol Stack	74
5.4.4	Resource Allocation and Management in Cognitive Radio-NOMA Networks	75
5.4.4.1	Power Allocation and Control Strategies	75
5.4.4.2	Spectrum Sensing and Dynamic Spectrum Access in NOMA-CR Networks	76
5.4.4.3	QoS Provisioning and Optimization Techniques	76
5.5	Performance Evaluation and Analysis	77
5.5.1	Metrics for Assessing Cognitive Radio-NOMA Networks	77
5.5.2	Simulation and Modeling Approaches	78
5.6	Applications and Use Cases	78
5.6.1	Cognitive Radio-NOMA in Next-Generation Wireless Systems	78
5.6.2	Internet of Things (IoT) and Machine-to-Machine (M2M) Communications	79
5.6.3	Vertical Industry Applications	79
5.7	Challenges and Future Directions	80
5.7.1	Interference Management and Coexistence Issues	80
5.7.2	Security and Privacy Concerns in Cognitive Radio-NOMA Systems	81
5.7.3	Emerging Trends and Future Research Directions	81
5.8	Conclusion	82
	References	83
6	Cognitive Radio (CR) Based Non-Orthogonal Multiple Access (NOMA) Network	87
	<i>Raja Gunasekaran, Ragavi Boopathi, Gobinath Velu Kaliyannan, Dinesh Dhanabalan and Kesavan Duraisamy</i>	
6.1	Introduction	88
6.2	Fundamentals of CR	90
6.2.1	Spectrum Hole Approach	91
6.2.2	Physical Layout of CR	92
6.2.3	Characteristics of CR	92
6.2.3.1	Cognitive Capability	93

6.2.3.2	Reconfigurability	94
6.2.4	CR Paradigms	94
6.2.5	Multiple Access Scheme	94
6.3	Spectrum Management System	96
6.3.1	Spectrum Sensing	96
6.3.2	Spectrum Decision	97
6.3.3	Spectrum Sharing	97
6.3.4	Spectrum Mobility	97
6.4	Noma Networks	98
6.4.1	NOMA Classification	99
6.4.1.1	PD-NOMA	99
6.4.1.2	CD-NOMA	99
6.4.2	OMA vs. NOMA	100
6.4.3	Downlink NOMA	101
6.4.4	Uplink NOMA	102
6.4.5	CR-Based NOMA Network	103
6.5	Enabling Technologies	104
6.5.1	Millimeter Wave (mmWave)	104
6.5.2	Intelligent Reflecting Surfaces (IRS)	105
6.5.3	Simultaneous Wireless Information and Power Transfer (SWIPT)	106
6.5.4	Cooperative CR-Based NOMA Systems	106
6.5.5	Satellite Communication (SatCom) CR-Based NOMA Systems	107
6.6	Conclusion	107
	References	108
7	Artificial Intelligence and Machine Learning-Based Network Power Optimization Schemes	115
	<i>Jyoti, Aarti Shar, Ramandeep Sandhu, Manish Kumar Sharma and Deepika Ghai</i>	
7.1	Introduction	116
7.2	Network	117
7.2.1	Working of Network	117
7.2.1.1	Client-Server Architecture	118
7.2.1.2	Network Protocols	118
7.2.1.3	Network Addresses	118
7.2.2	Network Methods	119
7.2.2.1	Wireless vs. Wired	119
7.2.2.2	Network Range	119
7.3	Decentralized Connection	120

7.4	Communication Network	121
7.4.1	Types of Communication Networks	121
7.4.2	Components of Communication Networks	121
7.4.3	Communication Protocols	122
7.4.4	Communication Medium	123
7.5	Internet of Things (IoT)	123
7.6	5G and Future Technologies	123
7.7	Network Power and Unstable Power Supply of Computer Networks	123
7.8	Adaption of Optimization Schemes to Enhance Network Power	124
7.9	Related Work	127
7.10	Traditional Evaluation AI and ML-Based Network Energy Optimization Techniques	129
7.11	AI- and ML-Based Systems for Network Energy Optimization Techniques	132
7.11.1	Problem Definition and Objectives	132
7.12	Conclusion	135
	References	135
8	Integration of PV Solar Rooftop Technology for Enhanced Performance and Sustainability of Electric Vehicles: A Techno-Analytical Approach	139
	<i>Vinay Anand and Himanshu Sharma</i>	
8.1	Introduction	140
8.1.1	Electric Vehicle	140
8.2	Literature Review	142
8.2.1	Numerous Challenges Faced by Electric Vehicles	143
8.3	Methods and Methodology	144
8.3.1	Structure of an Electric Vehicle Driven by Induction Motor	144
8.3.1.1	Solar Panel	144
8.3.1.2	Battery System	144
8.3.1.3	Motor Controller	145
8.3.1.4	Induction Motor	146
8.3.1.5	Power Electronics	146
8.3.1.6	Charging System	146
8.3.1.7	Energy Management System	146
8.3.1.8	Regenerative Braking System	147
8.3.1.9	Vehicle Control Unit	147
8.3.1.10	Mechanical Design	147

8.3.2	Contribution	147
8.4	Result and Discussion	147
8.4.1	Modeling and Simulation of Induction Motor Used in Electric Vehicles	148
8.4.1.1	Dynamic Equations	148
8.4.1.2	Electric Dynamics	148
8.4.1.3	Magnetic Dynamic	149
8.4.1.4	Mechanical Dynamics	149
8.4.1.5	Equation of Motion	149
8.4.1.6	Electromagnetic Torque Equation	150
8.4.1.7	Synchronous Speed	150
8.4.1.8	Rotor Speed	150
8.4.1.9	Torque-Speed Characteristics	150
8.4.1.10	Load Torque	151
8.4.2	Outcomes and a Comparative Analysis of Our Proposed Photovoltaic (PV)-Based Electric Vehicle (EV) System	151
8.4.2.1	Simulation of an Induction Motor with Inverter	152
8.5	Conclusion	153
	References	154
9	The Viability of Advanced Technology for Future Generations <i>Manjushree Nayak and Ashutosh Pattnaik</i>	157
9.1	Introduction	158
9.2	Communication Systems	159
9.2.1	5G	159
9.2.2	6G	161
9.2.3	Quantum Communications	163
9.2.4	Satellite Communication	164
9.2.5	Holography	166
9.2.6	Brain Computer Interface (BCI)	167
9.2.7	Artificial Intelligence (AI)	168
9.2.8	Internet of Things (IOT)	169
9.3	Conclusion	171
	References	171
10	Power Optimization and Scheduling for Multi-Layer, Multi-Dimensional 6G Communication Networks <i>Harpreet Kaur Channi, Pulkit Kumar and Ramandeep Sandhu</i>	175
10.1	Introduction	176

10.1.1	Background	176
10.1.2	Motivation	177
10.2	Literature Review	177
10.2.1	Evolution of Communication Networks	179
10.2.2	Key Features and Requirements of 6G	179
10.2.3	Previous Approaches to Power Optimization and Scheduling	180
10.3	Multi-Layer, Multi-Dimensional 6G Communication Networks	180
10.3.1	Architecture Overview	180
10.3.2	Integration of Multiple Layers	181
10.3.3	Consideration of Various Dimensions	182
10.4	Power Optimization in MLMD 6G Networks	183
10.4.1	Challenges in Power Consumption	183
10.4.2	Machine Learning Approaches	183
10.4.3	Adaptive Power Management	184
10.5	Scheduling Strategies for MLMD 6G Networks	184
10.5.1	Dimensions Considered in Scheduling	185
10.5.2	Resource Allocation Algorithms	186
10.5.3	Interference Mitigation Techniques	186
10.6	Proposed Framework	187
10.6.1	Integration of Power Optimization and Scheduling	187
10.6.2	Machine Learning in Dynamic Adaptation	188
10.6.3	Intelligent Resource Allocation	189
10.7	Challenges and Future Directions	190
10.7.1	Challenges and Limitations	190
10.7.2	Potential Enhancements	191
10.7.3	Future Trends in 6G Communication Networks	192
10.8	Conclusion	193
	References	193
11	Industry 4.0: Future Opportunities and Challenges	199
	<i>Manoj Singh Adhikari, Raju Patel, Manoj Sindhwani, Shippu Sachdeva and Suman Lata Tripathi</i>	
11.1	Introduction	200
11.2	Future Opportunities of Industrial 4.0	201
11.3	Increased Productivity and Efficiency	202
11.4	Innovation	203
11.5	Data-Driven Decision-Making	205
11.6	Supply Chain Optimization	205
11.7	Future Challenges of Industrial 4.0	206

11.8	Data Security and Privacy	207
11.9	Skills Gap and Workforce Training	208
11.10	Interoperability and Standardization	210
11.11	Ethical and Social Implications	211
11.12	Infrastructure Investment	211
11.13	Regulatory and Legal Challenges	212
11.14	Dependency on Technology	213
11.15	Conclusion	213
	References	214
12	MIMO and Its Significance	217
	<i>Shahid Hamid and Shakti Raj Chopra</i>	
12.1	Introduction	218
12.2	MIMO	219
12.3	Signal Model for MIMO	221
12.4	Standard MIMO Configurations	223
12.5	Why MIMO	224
12.6	Results	225
	References	227
	Index	231

Preface

The rapid expansion of communications networks has transformed how we interact, work, and share information. Expansion, though, has also greatly increased energy usage, with sustainability, operating expense, and environmental factors. With more and more demand for higher speeds, more reliability, and more pervasive connectivity, the need for energy-efficient communication networks has never been greater.

This book, *Energy-Efficient Communication Networks*, explores the basics, issues, and future directions toward reducing the energy requirements of modern networking infrastructure. The book offers a comprehensive view of energy-conserving approaches in network layers of architecture, ranging from the physical hardware to the transmission protocols and cloud infrastructure. The book further illustrates new technologies such as green networking, energy-efficient routing, software-defined networks (SDN), and artificial intelligence-based optimizations that enable communication infrastructure sustainability.

Intended for researchers, engineers, and students in the fields of networking and telecommunications, this book is an extremely helpful one on which to gain knowledge of new innovations in energy-efficient communication. Based on theoretical frameworks, actual case studies, and research agendas, the book equips readers with the knowledge and tools to design and roll out greener and more sustainable networks.

We would like to inspire further innovation in energy efficiency, towards a time when high-performance communication networks and environmental responsibility may coexist.

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Krishan Arora
Suman Lata Tripathi
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19th March 2025

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Efficient Energy Management in Hyperledger Fabric Blockchain Networks: A Proposed Optimized Solution

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Abstract

This study aims to address the energy-efficiency challenge in Hyperledger Fabric networks, focusing on the energy consumption of network nodes during communication. A simulation model was developed to evaluate energy consumption patterns among nodes during simulated data transmissions. The simulation considers data transmissions, random data sizes, and energy consumption associated with these interactions. The results of this study provide insights into optimizing energy transmission and reception among multiple nodes, leading to a reduction in energy waste and an improvement in energy utilization. The study evaluates energy efficiency by calculating average and total energy consumption metrics for each node and visualizing energy consumption patterns. The experimental analysis involves adjusting parameters, including transmission times, data sizes, and communication protocols, to provide a comprehensive understanding of energy-efficient communication in blockchain networks, with a focus on Hyperledger Fabric. The proposed Hyperledger Fabric network strategy targets reducing energy consumption in wireless communication involving multiple nodes by refining the transmit data function and associated methods to incorporate energy-saving measures, sleep modes, or communication protocol optimizations.

Keywords: Blockchain, networks, energy, hyperledger, communication

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Shakti Raj Chopra, Krishan Arora, Suman Lata Tripathi and Vikram Kumar (eds.) Energy-Efficient Communication Networks, (1–8) © 2025 Scrivener Publishing LLC

1.1 Introduction

Blockchain technology, particularly Hyperledger Fabric networks, has enabled decentralized and secure data management. Hyperledger Fabric, a key player in enterprise-grade blockchain solutions, is widely used in finance and supply chain. However, concerns about energy efficiency arise with the growing reliance on these distributed networks [1–3].

This study aims to address the critical challenge of elevated energy consumption during communication within Hyperledger Fabric networks by examining the energy efficiency of network nodes, which is essential for sustainability and operational costs. Employing a simulation model, this research delves into the intricacies of wireless communication within a Hyperledger Fabric network, specifically focusing on node 1 to node 5 transmission network. The primary objectives of this research include evaluating energy consumption patterns among nodes during simulated data transmissions and also to develop a model for wireless communication between network nodes while simultaneously highlighting the energy consumption associated with this process. By analyzing the dynamics of energy consumption, the study aims to uncover variations in efficiency levels among nodes, which can inform subsequent optimization strategies [4–6]. The findings from this study contribute to the ongoing discourse on enhancing the sustainability of Hyperledger Fabric networks, and advancing our understanding of energy-efficient blockchain communication [4–10].

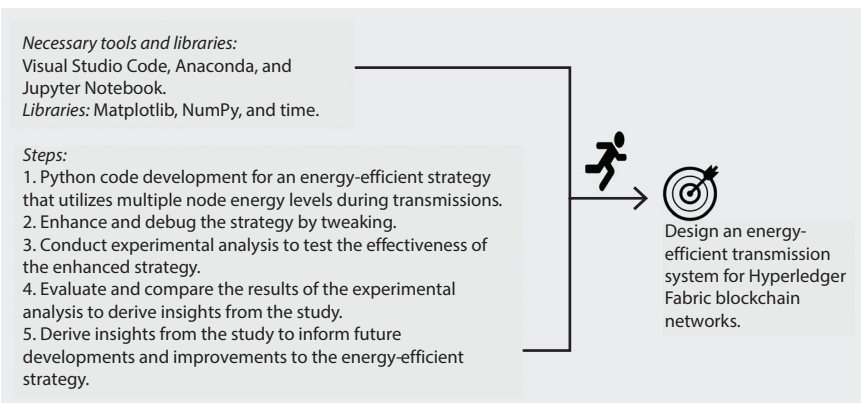


Figure 1.1 The design process for energy-efficient Hyperledger Fabric blockchain transmission networks.

This chapter examines the use of blockchain technology in wireless networks to enhance energy efficiency in communication systems. Through simulations and experiments, the proposed method is shown to improve energy efficiency in wireless networks. The design process for energy-efficient Hyperledger Fabric blockchain transmission networks is illustrated in Figure 1.1.

1.2 Methodology

A simulation model was developed to capture the complex dynamics of wireless communication within a Hyperledger Fabric network by instantiating nodes (node 1 to node 5) to mimic the communication process. The simulation takes into account data transmissions, random data sizes, and the energy consumption associated with these interactions. This study seeks to address the energy-efficiency concerns that arise from the widespread use of blockchain technologies, particularly in Hyperledger Fabric networks. By simulating data transmissions and calculating the resulting energy consumption, the study evaluates the energy-efficiency levels of the nodes. The findings of this research suggest that there is potential for optimizing energy transmission and reception among multiple nodes, which could lead to a reduction in energy waste and an improvement in energy utilization. The implications and insights derived from this study are discussed in detail in the chapter. These results have significant implications for the development of effective strategies aimed at enhancing the sustainability and efficiency of blockchain technologies in enterprise environments. The simulation collects data on node energy levels during multiple transmissions using randomized data sizes and target node selections. Recorded energy levels provide a comprehensive dataset for subsequent analysis.

The study evaluates energy efficiency by calculating average and total energy consumption metrics for each node and visualizing energy consumption patterns. The experimental analysis involves adjusting parameters including transmission times, data sizes, and communication protocols to provide a comprehensive understanding of energy-efficient communication in blockchain networks, with a focus on Hyperledger Fabric.

1.3 Experimental Analysis

1.3.1 Existing Problem in the Network

The old system's network simulation considers wireless data transmission's time and energy, incorporating a basic model of communication overhead that introduces delay. It also includes a simplified energy consumption model for nodes during transmission. In a two-node example, consider these key points.

- In this simulation, node 1 sends data to node 2 using the *transmit_data* method. Before sending, node 1 checks its energy level and updates it after transmission. Node 2 receives the data using the *receive_data* method.
- The energy levels of both nodes are continuously monitored and recorded as they engage in simulated data transmissions. This information is then used to visualize the changes in their energy levels over time.

The impact of data transmissions on energy levels can be observed in Figure 1.2, which displays the fluctuating energy levels of node 1 and node 2 after each transmission. While node 2's energy consumption remained constant at 100%, the energy levels of node 1 decreased as the number of transmissions increased. Moreover, node 2 consumed more energy with

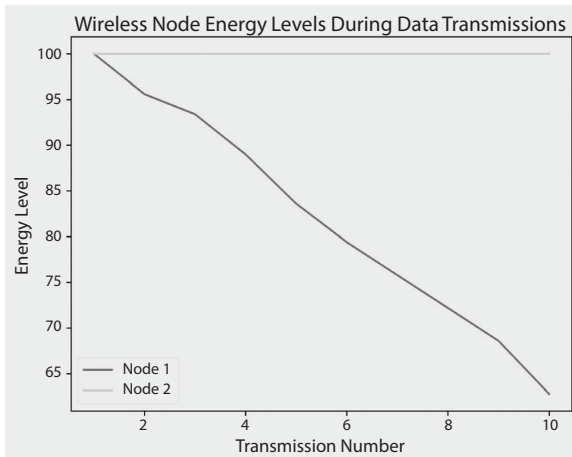


Figure 1.2 Old energy strategy – wireless node energy levels during transmissions.