ENERGY-EFFICIENT COMMUNICATION NETWORKS

Edited By

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

Scrivener Publishing

WILEY

Energy-Efficient Communication Networks

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

Publishers at Scrivener
Martin Scrivener (martin@scrivenerpublishing.com)
Phillip Carmical (pcarmical@scrivenerpublishing.com)

Energy-Efficient Communication Networks

Edited by

Shakti Raj Chopra

Krishan Arora

Suman Lata Tripathi

and

Vikram Kumar

Scrivener Publishing

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

For more information about Scrivener publications please visit www.scrivenerpublishing.com.

Wiley Global Headquarters
111 River Street, Hoboken, NJ 07030, USA

For details of our global editorial offices, customer services, and more information about Wiley products visit us at www.wiley.com.

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

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.

Shakti Raj Chopra
Krishan Arora
Suman Lata Tripathi
Vikram Kumar
19th March 2025

List of Contributors

Kamurthi Ravi Teja
Dept. of Computer Science and Information Engineering, National Taipei University of Technology, Taipei, Taiwan

Shakti Raj Chopra
School of Electronics and Electrical Engineering, Lovely Professional University, Punjab, India

Tanishk Singhal
School of Electronics and Electrical Engineering, Lovely Professional University, Punjab, India

Harpreet Singh Bedi
School of Electronics and Electrical Engineering, Lovely Professional University, Punjab, India

Pradeep Singh
ABVGIET-Pragatinagar, Shimla, Himachal Pradesh, India

Krishan Arora
School of Electronics and Electrical Engineering, Lovely Professional University, Punjab, India

Umesh C. Rathore
Director-cum-Principal, ABVGIET-Pragtinagar, Shimla, Himachal Pradesh, India

Yogesh Kumar Verma
School of Electronics and Electrical Engineering, Lovely Professional University, Punjab, India

Archana Kanwar
School of Electronics and Electrical Engineering, Lovely Professional University, Punjab, India

Manoj Kumar Shukla
Department of Robotics and Automation, Symbiosis Institute of Technology, Pune, India

Indu Bala
School of Electronics and Electrical Engineering, Lovely Professional University, Punjab, India

Raja Gunasekaran
Department of Mechanical Engineering, Velalar College of Engineering and Technology, Erode, Tamil Nadu, India

Ragavi Boopathi
Department of Biomedical Engineering, Dr. N.G.P Institute of Technology, Coimbatore, Tamil Nadu, India

Gobinath Velu Kaliyannan
Department of Mechatronics Engineering, Kongu Engineering College, Erode, Tamil Nadu, India

Dinesh Dhanabalan
Department of Mechanical Engineering, Bannari Amman Institute of Technology, Sathyamangalam, Erode, Tamil Nadu, India

Kesavan Duraisamy
Department of Mechanical Engineering, Velalar College of Engineering and Technology, Erode, Tamil Nadu, India

Jyoti
School of Computer Science & Engineering, Lovely Professional University, India

Aarti Shar
School of Computer Science & Engineering, Lovely Professional University, India

Ramandeep Sandhu
School of Computer Science & Engineering, Lovely Professional University, India

Manish Kumar Sharma
School of Computer Science & Engineering, Lovely Professional University, India

Deepika Ghai
School of Electronics and Electrical Engineering, Lovely Professional University, Jalandhar, India

Vinay Anand
School of Electronics and Electrical Engineering, Lovely Professional University, Phagwara, (India)

Himanshu Sharma
School of Electronics and Electrical Engineering, Lovely Professional University, Phagwara, (India)

Manjushree Nayak
Department of Computer Science and Engineering, NIST Institute of Science and Technology (Autonomous), Berhampur Odisha

Ashutosh Pattnaik
Department of Computer Science and Engineering, NIST Institute of Science and Technology (Autonomous), Berhampur Odisha

Harpreet Kaur Channi
Department of Electrical Engineering, Chandigarh University, Gharuan, Mohali, Punjab, India

Pulkit Kumar
Department of Electrical Engineering, Chandigarh University, Gharuan, Mohali, Punjab, India

Ramandeep Sandhu
School of Computer Science and Engineering, Lovely Professional University, Jalandhar, Punjab, India

Manoj Singh Adhikari
School of Electronics and Electrical Engineering, Lovely Professional University, Phagwara, Punjab, India

Raju Patel
School of Electronics Engineering, Vellore Institute of Technology, Chennai, India

Manoj Sindhwani
School of Electronics and Electrical Engineering, Lovely Professional University, Phagwara, Punjab, India

Shippu Sachdeva
School of Electronics and Electrical Engineering, Lovely Professional University, Phagwara, Punjab, India

Suman Lata Tripathi
Department of Electronics and Communication Engineering, Symbiosis Institute of Technology (SIT), Symbiosis International Deemed University (SIU), Pune, India

Shahid Hamid
Physics Wallah Private Limited, Noida (UP), Uttar Pradesh, India

Shakti Raj Chopra
School of Electronics and Electrical Engineering, Lovely Professional University, Punjab, India

1

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

Kamurthi Ravi Teja[1] and Shakti Raj Chopra[2*]

[1]Dept. of Computer Science and Information Engineering, National Taipei University of Technology, Taipei, Taiwan
[2]School of Electronics and Electrical Engineering, Lovely Professional University, Punjab, India

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

**Corresponding author*: shakti.chopra@lpu.co.in

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].

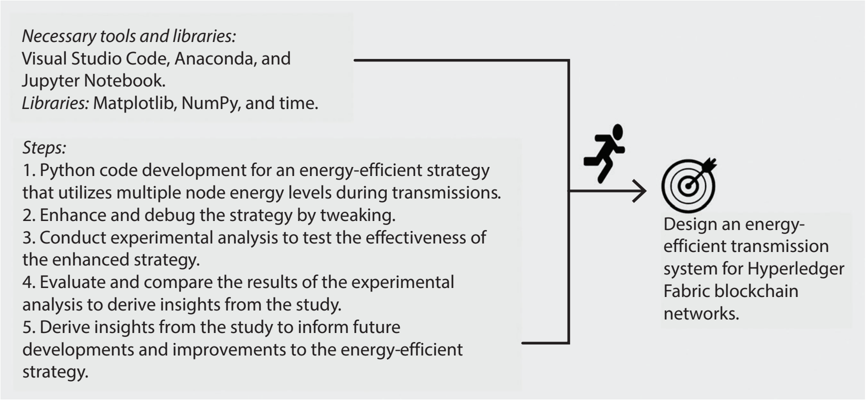

Figure 1.1 The design process for energy-efficient Hyperledger Fabric blockchain transmission networks.

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

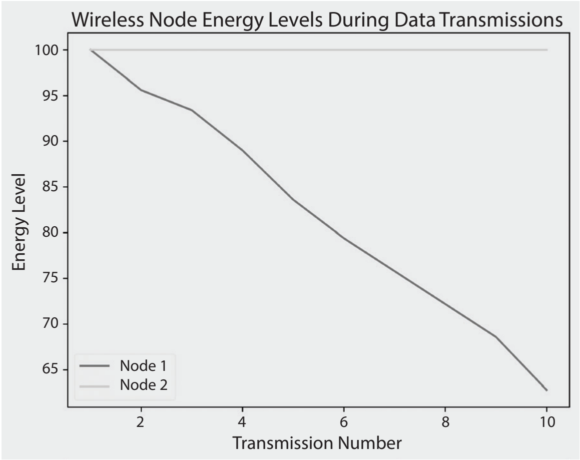

Figure 1.2 Old energy strategy – wireless node energy levels during transmissions.