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Cloud Computing's Transformative Power in Computing Environments

Aisha Hassan Abdalla Hashim, Zeinab E. Ahmed,
Othman O. Khalifa, and Rashid A. Saeed



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Cloud Computing's Transformative Power in Computing Environments

Aisha Hassan Abdalla Hashim
International Islamic University, Malaysia

Zeinab E. Ahmed
University of Gezira, Sudan

Othman O. Khalifa
International Islamic University, Malaysia

Rashid A. Saeed
Taif University, Saudi Arabia

Vice President of Editorial
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Cover Design

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Published in the United States of America by
IGI Global Scientific Publishing
701 East Chocolate Avenue
Hershey, PA, 17033, USA
Tel: 717-533-8845
Fax: 717-533-7115
Website: <https://www.igi-global.com> E-mail: cust@igi-global.com

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Library of Congress Cataloging-in-Publication Data

Names: Hashim, Aisha A., 1965- editor

<http://id.loc.gov/rwo/agents/n2024040016> | Ahmed, Zeinab E., 1984-
editor <http://id.loc.gov/rwo/agents/n2024040015> | Khalifa, Othman, 1962-
editor <http://id.loc.gov/rwo/agents/n2025011745> | Saeed, Rashid A.,
1974- editor <http://id.loc.gov/rwo/agents/n2011072667>

Title: Cloud computing's transformative power in computing environments /
edited by Aisha Hashim, Zeinab Ahmed, Othman Khalifa, Rashid Saeed.

Description: Hershey, PA : IGI Global Scientific Publishing, [2026] |
Includes bibliographical references and index. | Summary: "This book
provides a deep understanding of the transforming ability of cloud
computing technologies in computing environments. It focuses on
understanding the principles, practical implementations, and future
trends in cloud computing. It covers the fundamental concepts, service
models, and deployment architectures of cloud computing"-- Provided by
publisher.

Identifiers: LCCN 2025000179 (print) | LCCN 2025000180 (ebook) | ISBN
9798369399842 h/c | ISBN 9798369399859 s/c | ISBN 9798369399866 ebook

Subjects: LCSH: Cloud computing--Industrial applications | Computer
networks--Industrial applications | Computer networks--Technological
innovations

Classification: LCC QA76.585 .C58455 2025 (print) | LCC QA76.585 (ebook)
| DDC 004.67/82--dc23/eng/20250317

LC record available at <https://lcn.loc.gov/2025000179>

LC ebook record available at <https://lcn.loc.gov/2025000180>

British Cataloguing in Publication Data

A Cataloguing in Publication record for this book is available from the British Library.

All work contributed to this book is new, previously-unpublished material.

The views expressed in this book are those of the authors, but not necessarily of the publisher.

This book contains information sourced from authentic and highly regarded references, with reasonable efforts made to ensure the reliability of the data and information presented. The authors, editors, and publisher believe the information in this book to be accurate and true as of the date of publication. Every effort has been made to trace and credit the copyright holders of all materials included. However, the authors, editors, and publisher cannot assume responsibility for the validity of all materials or the consequences of their use. Should any copyright material be found unacknowledged, please inform the publisher so that corrections may be made in future reprints.

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S. Lakshmi Sridevi, Chennai Institute of Technology, India

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Aayushma Gautam, School of Computer Engineering, Kalinga Institute of Industrial Technology, Bhubaneswar, India
Hitesh Mohapatra, School of Computer Engineering, Kalinga Institute of Industrial Technology, Bhubaneswar, India

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Lukumon Oyedele, University of the West of England, UK
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Essential Concepts in Cloud Computing 1

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Malaysia*

Noor Asiah Rashid, University Geomatika Malaysia, Malaysia

This chapter offers an in-depth review of the revolutionary development of cloud computing, from its theoretical underpinnings to its current position as a vital component of modern infrastructure for information technology. The historical trends, significant turning points, and technological advancements in the discipline are reviewed in this chapter. It explores the beginnings of cloud computing, how service models have changed over time, the effects of virtualization, and how new technologies are being incorporated. Readers will gain a profound appreciation for how cloud computing has transformed the operations and innovation of organizations by comprehending the historical background and recent developments.

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Cloud Computing Architecture: Investigating the Complex Details of Cloud Computing Architecture..... 33

*Fatima Ahmed Mohamed Abdalla, University Geomatika Malaysia,
Malaysia*

Noor Asiah Rashid, University Geomatika Malaysia, Malaysia

The cloud computing era is currently in the IT industry. With its Internet-based foundation, cloud computing boasts the most potent processing architecture. Hardware, software, and internet infrastructure are all interconnected and integrated to form this system. It offers several advantages over grid computing and other computing systems. Cloud computing architecture is a fundamental framework that enables the delivery of various computing services over the Internet. This architecture comprises a front-end platform, back-end platforms, a cloud-based delivery model, and the network infrastructure that connects these components. The architecture is designed to provide scalable, flexible, and cost-effective solutions for a wide range of applications, from data storage and processing to software development and deployment. This chapter investigates the intricate details of cloud computing architecture, exploring its components

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Wan Muhd Hazwan Azamuddin, Institut Latihan Perindustrian, Tangkak, Malaysia

Maznifah Salam, Faculty of Information Science and Technology, Bangi, Malaysia

Zainab S. Attarbashi, Kulliyyah of Information and Communication Technology, Malaysia

This chapter provides a comprehensive overview of cloud deployment models, including public, private, hybrid, and community clouds, and their profound impact on modern IT infrastructure and the development of inclusive IoT smart systems. The selection of an appropriate cloud model significantly influences critical aspects such as data sovereignty, scalability, resource utilization, and crucially, the accessibility features for individuals with disabilities. We examine the distinct characteristics, advantages, and disadvantages of each model, highlighting how they cater to diverse organizational needs, from cost optimization and rapid provisioning in public clouds to enhanced security and control in private environments. The discussion also addresses the complexities and benefits of hybrid and community cloud approaches, emphasizing their role in enabling flexible, compliant, and collaborative computing solutions. Understanding these models is essential for making informed strategic decisions that foster innovation and ensure equitable access to technology.

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Maznifah Salam, Faculty of Information Science and Technology, Bangi, Malaysia

Zainab S. Attarbashi, Kulliyyah of Information and Communication Technology, Malaysia

Cloud computing has revolutionized the way businesses access and utilize computational resources, providing unparalleled cost efficiency, scalability, and flexibility. Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) comprise the three primary cloud service models; this chapter offers a thorough examination of each. We explore the characteristics, use cases, advantages, and disadvantages of each model, emphasizing the varying degrees of control and responsibility that cloud providers and consumers share.

In addition, the chapter delves into significant future trends, such as the increased integration of Artificial Intelligence functionalities, the paramount importance of robust cloud security measures, the convergence of edge and cloud computing, advancements in resource optimization, and the increasing adoption of cloud-native and serverless architectures. It is imperative for organizations to comprehend these models and emergent trends in order to effectively leverage the transformative power of the evolving cloud landscape.

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Technology, Sudan*

Cloud computing is a primary driver for digital transformation, driving agility, scalability, and efficiency enhancements across industries. This chapter introduces cloud computing benefits such as flexibility, cost reduction, and accelerated innovation. Cloud strategies such as Hybrid, Multi-Cloud, and a Cloud-Native approach to fit the business needs will be explored. Some industry-specific impacts concerning healthcare, finance, and manufacturing processes will be vividly brought forth. While cloud adoption is a beneficial decision, it can also pose threats such as security, compliance, and integration challenges that will be addressed through mitigation strategies. The future trends in cloud computing that will be discussed include AI-driven cloud services, Edge computing, and Serverless architectures. Real-world case studies will fortify the argument on successful practical applications as effective references for businesses to leverage cloud computing.

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India*
*Sunita Rani, Bhagat Phool Singh Mahila Vishwavidyalaya, Sonipat,
India*
*Vinod Kr. Saroha, Bhagat Phool Singh Mahila Vishwavidyalaya,
Sonipat, India*

This chapter explores the key security threats and vulnerabilities at different levels, such as SaaS, PaaS and IaaS in cloud computing and provides their solutions. It will comprehensively analyze common security risks such as data breaches, unauthorized access and compliance issues. Discuss all security issues such as application security, data security, network security issues, authentication and authorization issues. It explains various data security techniques such as Cryptography, Steganography, Homomorphic cryptography, Quantum cryptography, DNA cryptography, Machine learning and Deep learning, Multi-factor authentication, and Blockchain to describe

which technique is suitable at which stage of data. It explains regulatory bodies such as GDPR (European Union), HIPAA (United States), CCPA (United States), DSL (China), CSL(China), IT Act, and PDPB (India) and case studies related to regulatory role in data privacy. It describes the role of AI and machine learning, zero-trust architecture in threat detection, and the future of cloud computing.

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Blockchain-Based Security for Cloud Data Storage 221

Mamoon M. Saeed, University of Modern Sciences, Yemen
Zeinab E. Ahmed, University of Gezira, Sudan
Rania A. Mokhtar, Sudan University of Science and Technology, Sudan
Rashid A. Saeed, Sudan University of Science and Technology, Sudan

Blockchain technology has shown promise to improve security across several industries, including cloud data storage. The integration of blockchain technology with safe cloud data storage solutions is examined in this chapter. Data integrity, secrecy, and authentication in cloud storage systems can be greatly enhanced by utilizing the decentralized and immutable nature of blockchain. Important ideas about cloud data security are covered, including distributed consensus, smart contracts, and cryptographic hashing. The chapter also explores the difficulties, advantages, and potential avenues for future research in applying blockchain technology to improve cloud data storage security.

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Smart Clouds: Integrating AI, Machine Learning, and Blockchain for Next-Gen Analytics..... 255

C. V. Suresh Babu, Hindustan Institute of Technology and Science, India
K. Sakthivel, Hindustan Institute of Technology and Science, India

This study explores the transformative integration of AI, Machine Learning (ML), and Blockchain within cloud computing to address the growing demand for secure, scalable, and real-time data-driven solutions across industries. The primary objective is to present a comprehensive framework for smart cloud platforms by combining AI and ML-driven analytics with Blockchain-as-a-Service (BaaS) for enhanced data security, transparency, and decision-making. The research targets professionals in IT, academia, and enterprises seeking innovative cloud solutions. Methodologically, the study leverages architectural models, real-world case studies, and a detailed analysis of current industry trends to propose best practices for implementation. Key findings reveal significant improvements in organizational insights, secure transactions, and operational efficiency through integrated cloud ecosystems. The study concludes by highlighting future trends such as quantum computing and AI-driven blockchain models, emphasizing their implications for business innovation and policy development.

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Sheraz Maki Mohd Ahmed, International Islamic University Malaysia, Malaysia

Aisha Hassan Abdalla Hashim, International Islamic University Malaysia, Malaysia

Zainab Senan Attar, Kulliyya of Engineering, Malaysia

Othman Omran Khalifa, International Islamic University Malaysia, Malaysia

Blockchain is a decentralized and distributed digital ledger that records transactions across multiple computers. It consists of a continuously growing list of blocks, where each block contains a set of transactions and a reference to the previous block. The blockchain ensures the immutability and integrity of the recorded transactions by using cryptographic hashes and consensus mechanisms. Cloud computing is a service available over the network. Users can access and store data and applications remotely rather than on local servers or personal computers. Cloud computing offers resource pooling by letting users share the same physical resources dynamically according to their demands, often through virtualization. Cloud computing offers flexible, scalable resources, it can address blockchain's limitations in scalability and transaction speeds by act as a backup for blockchain data, enabling faster recovery and reduced latency. Synergy between cloud computing and blockchain offers significant potential for innovation across numerous sectors

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K. Murali Krishna, Rajalakshmi Engineering College, India

S. Lakshmi Sridevi, Chennai Institute of Technology, India

Sarala Patchala, KKR and KSR Institute of Technology and Sciences, India

S. Gopinath, Karpagam Institute of Technology, India

Harishchander Anandaram, Amrita Vishwa Vidyapeetham, India

The main idea of cloud computing is being widely promoted as the solution to current ongoing IT problems. In recent years the approach towards IT investment and management is constantly changing. At the same time, cloud computing has developed as a foundation of the contemporary technologies which enables the users

to receive the necessary amount of such resources and services without any delays. The research paper delves into the transformative landscape of 5G networks, focusing on the fusion of edge and cloud computing. This fusion represents a paradigm shift in network architecture, promising enhanced performance, scalability, and innovation. Edge computing, characterized by real-time processing and low-latency applications, complements cloud computing's scalable resources for data storage and processing. Despite these challenges, the fusion of edge and cloud computing enables improved performance, scalability, and innovation, driving digital transformation and competitive advantage in the digital economy.

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Salaheldin Mohamed Ibrahim Edam, Sudan University of Science and Technology, Sudan
Loay Ahmed Hassan Bushara, Sudan University of Science and Technology, Sudan
Abuagla Babiker Mohammed, Sudan University of Science and Technology, Sudan

In this chapter, the convergence of IoT and Cloud Computing are discussed with an emphasis on scalability, elasticity, real-time processing, cost-effectiveness, resource optimization, and security. Giant amounts of data are generated by IoT networks; hence the role cloud computing can play in efficient data storage and management becomes critical. In addition, it discusses the importance of disaster recovery, fault tolerance, global access, and management in the cloud-enabled IoT ecosystem. Finally, the authors present the future trends highlighting the advancements that will drive the IoT and cloud computing integration. The research gives insight on how cloud computing support IoT applications to help companies build strong, scalable, secure systems-all with resource efficiency and operational costs in check.

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Managing Cloud Services on Sensor Nodes for Efficient Wireless Energy Harvesting 385

Muhammed Zaharadeen Ahmed, International Islamic University Malaysia, Malaysia & University of Technology of Arts of Byumba, Rwanda
Aisha Hassan Abdalla Hashim, International Islamic University Malaysia, Malaysia
Othman Omran Khalifa, International Islamic University Malaysia, Malaysia

Wireless Sensor Networks are integral to a wide array of smart applications, including environmental supervision, healthcare, and manufacturing automation. However, the

operation of sensor nodes is often constrained by limited energy resources. Efficient wireless energy harvesting (WEH) is a promising solution that can extend the operational lifetime of these nodes. Managing cloud services on sensor nodes plays a critical role in optimizing energy consumption and ensuring effective integration of WEH technologies.

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Revolutionizing Load Balancing in Cloud Computing With Genetic Algorithms 411

Abhipsha Das, School of Computer Engineering, Kalinga Institute of Industrial Technology, Bhubaneswar, India

Swayam Yadav, School of Computer Engineering, Kalinga Institute of Industrial Technology, Bhubaneswar, India

Neetu Dey, School of Computer Engineering, Kalinga Institute of Industrial Technology, Bhubaneswar, India

Aayushma Gautam, School of Computer Engineering, Kalinga Institute of Industrial Technology, Bhubaneswar, India

Hitesh Mohapatra, School of Computer Engineering, Kalinga Institute of Industrial Technology, Bhubaneswar, India

Load balancing is vital in cloud computing for efficiently distributing workloads and preventing resource bottlenecks. This review explores using Genetic Algorithms (GAs), known for their optimization strength, to improve load balancing by minimizing task execution times and boosting resource utilization. The GA-based approach adapts to changing tasks and conditions, evolving solutions through iterative natural selection processes. This paper examines the key principles and real-world applications of this method, showing its potential to transform traditional load balancing and enhance cloud system performance and scalability.

Chapter 14

Enhancing Supply Chain Efficiency and Decision-Making With Cloud-Based Predictive Analytics 433

Rehab Ibrahim Ahmed Omer, International Islamic University Malaysia, Malaysia

This chapter explores how cloud-based predictive analytics is transforming supply chain management by improving efficiency, accuracy in demand forecasting, and strategic decision-making. It discusses the benefits of integrating cloud computing with advanced analytics to enhance real-time data visibility, streamline operations, and enable proactive decision-making across the supply chain. Through detailed use cases, the chapter explains the practical applications of predictive and prescriptive analytics for optimizing inventory levels, forecasting demand fluctuations, and

mitigating risks. The chapter highlighting the increasing significance of artificial intelligence, IoT integration, and edge computing

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Unbundling Cloud Computing and Emergent Technologies: Construction Industry in Perspective..... 467

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Lukumon Oyedele, University of the West of England, UK
Khadeejah Adebisi Abdulsalam, University of Lagos, Nigeria
Akinropo Musiliu Olajumoke, Obafemi Awolowo University, Nigeria

The construction industry, an important sector of the global economy, with large data generation and huge employment opportunities, requires automation for enhanced productivity and contribution to the Gross Domestic Products (GDP). The integration of Cloud Computing (CC) with Building Information Modelling (BIM), however cannot deliver the future construction, hence, the need to explore the other specialised Emergent Technologies (ET). In this chapter, critical appraisal of existing literature to identify the application domain, problem areas and intersections between CC and ET were carried out. Case studies were cited to demonstrate the benefits of the adoption of CC and ET such as, BIM, Internet of Things (IoT) and Intelligent Analytics. The reluctance of this industry was also identified and some suggestions were proffered to mitigate the potential risks. However, the adoption is believed to have the potential to open up issues. Hence, the adoption is conjectured to be viewed as an asset.

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Preface

In the past decade, cloud computing has transitioned from a disruptive technology to a foundational infrastructure that underpins nearly every sector of our digital society. As organizations increasingly seek flexible, scalable, and efficient computing solutions, cloud computing has emerged as the driving force behind innovation, operational agility, and digital transformation. This edited volume, *Cloud Computing's Transformative Power in Computing Environments*, is a comprehensive collection of research contributions that explore the evolving architecture, deployment strategies, and applications of cloud technologies while addressing the ethical, security, and integration challenges posed by emerging technologies such as AI, blockchain, IoT, and edge computing.

The goal of this book is twofold: first, to present readers with foundational and technical insights into cloud computing; and second, to explore its strategic application across industries and disciplines. Each chapter delves into specific aspects of cloud computing, from architectural frameworks to AI-integrated solutions, providing a multidisciplinary perspective that bridges theory and practice. The book brings together researchers, technologists, and academics from diverse regions and disciplines to provide a truly global and contextualized exploration of cloud computing's transformative power.

CHAPTER OVERVIEW

Chapter 1: Essential Concepts in Cloud Computing

Fatima Ahmed Abdalla and Noor Asiah Rashid present a historical and conceptual overview of cloud computing, tracing its roots, technological evolution, and foundational models. This chapter serves as a springboard for understanding subsequent discussions.

Chapter 2: Cloud Computing Architecture

This chapter, also authored by Fatima Ahmed Abdalla and Noor Asiah Rashid, dives into the structural design of cloud computing, detailing its front-end and back-end components and the internet infrastructure that links them, while discussing advantages over legacy systems.

Chapter 3: Cloud Deployment Models

Azana Hafizah Mohd Aman and her co-authors explore public, private, hybrid, and community clouds. The chapter focuses on strategic decision-making, particularly regarding accessibility, scalability, and compliance in enterprise and IoT contexts.

Chapter 4: Cloud Service Models

This chapter outlines the core service models - SaaS, PaaS, and IaaS- while forecasting emerging trends like AI integration and serverless architecture. It equips organizations to choose appropriate service models for their evolving needs.

Chapter 5: Cloud Computing's Role in Digital Transformation

Salaheldin Edam illustrates how cloud adoption accelerates innovation across industries, including healthcare and manufacturing. He presents real-world cases and forecasts trends such as edge computing and AI-enabled services.

Chapter 6: Cloud Security and Privacy

Rubi Kadyan and her co-authors address the pressing issues of data protection, regulatory compliance, and multi-layered security using modern techniques like quantum cryptography, machine learning, and blockchain.

Chapter 7: Blockchain-Based Security for Cloud Data Storage

Mamoon Saeed and colleagues examine how blockchain can be harnessed to secure cloud data, using mechanisms like smart contracts and distributed consensus to strengthen integrity, confidentiality, and transparency.

Chapter 8: Smart Clouds: Integrating AI, ML, and Blockchain

C.V. Suresh Babu and Sakthivel K. present an integrated framework for intelligent cloud platforms that combine analytics, blockchain, and automation to meet the growing demand for secure and data-driven cloud services.

Chapter 9: Synergizing Cloud and Blockchain Architectures

Sheraz Maki Mohd Ahmed and collaborators explore the complementarity of cloud scalability and blockchain immutability. The chapter provides insights into how this synergy can transform sectors like healthcare, finance, and governance.

Chapter 10: Integrated 5G and Edge Computing Framework

Ashok P. and a multidisciplinary team discuss how the convergence of 5G, edge computing, and cloud can address latency-sensitive IoT applications. This chapter highlights innovations that redefine network performance and resource management.

Chapter 11: Enhancing IoT through Cloud Computing

Salaheldin Edam and co-authors examine how cloud computing enhances IoT through efficient data handling, global scalability, and real-time analytics, paving the way for resilient and intelligent ecosystems.

Chapter 12: Managing Cloud Services on Sensor Nodes for Wireless Energy Harvesting

Muhammed Zaharadeen Ahmed and colleagues highlight the importance of energy-aware cloud service management on sensor nodes. The chapter focuses on integrating wireless energy harvesting to extend the lifespan of smart applications.

Chapter 13: Load Balancing in Cloud Computing with Genetic Algorithms

Abhipsha Das and her co-authors delve into optimization techniques, especially Genetic Algorithms, for efficient load balancing. This chapter proposes an adaptive and scalable approach for handling dynamic cloud workloads.

Chapter 14: Cloud-Based Predictive Analytics in Supply Chains

Rehab Ibrahim Ahmed Omer presents the transformative role of predictive analytics in supply chain optimization. Through cloud integration, companies gain real-time visibility and improved decision-making capabilities.

Chapter 15: Unbundling Cloud Computing in the Construction Industry

Sururah Bello and co-authors analyze the interplay of cloud computing and emergent technologies such as BIM and IoT in the construction sector. This chapter provides a roadmap for digital transformation within one of the world's largest and most traditional industries.

As we navigate an era defined by digitization and rapid technological evolution, this book offers a timely, essential resource for students, professionals, and decision-makers. We invite readers to explore the nuanced intersections of cloud computing with emerging technologies, security challenges, and real-world applications—and to envision the future of computing shaped by the cloud.

Aisha Hassan Abdalla Hashim

International Islamic University, Malaysia

Zeinab E. Ahmed

University of Gezira, Sudan

Othman O. Khalifa

International Islamic University, Malaysia

Rashid A. Saeed

Taif University, Saudi Arabia

About the Contributors

Aisha A. Hashim received her Ph.D in Computer Engineering (2007), M.Sc. in Computer Science (1996) and B.Sc. in Electronics Engineering (1990). She won the Best Graduating Ph.D Student Award during the IIUM Convocation ceremony in 2007. She joined IIUM in 1997 and is currently a Professor at the Department of Electrical and Computer Engineering. Professor Aisha has taught several courses related to Communication and Computer Engineering and is actively involved in curriculum development and programme accreditation. She has been a member of the Department Board of Studies for several years. She received the Best Teacher Award during IIUM Quality Day in 2007. Prof. Aisha has been appointed as external examiner/visiting professor/adjunct professor at different universities. Professor Aisha who is actively involved in research and postgraduate programmes, has published more than 200 journal/conference papers, and supervised/co-supervised more than 40 Ph.D/Master's students. She received the Promising Researcher Award in 2009 during IIUM Quality Day. She has also received many medals/awards in different national/international research exhibitions. One of her research exhibitions won the Promising Commercial Value Award (Second Runner Up) in IRIIE 2014. As a researcher, she has secured research grants from IIUM, Ministry of Higher Education (MOHE) and Ministry of Science, Technology and Innovation (MOSTI). She has actively contributed as a reviewer /technical committee member in many journals/conferences. Professor Aisha has established several teaching/research networks between IIUM and overseas universities. She has been appointed as IIUM's Internationalisation Ambassador to Sudan (October 2014) and has participated in initiating several MoUs as well as encouraging the PhD Student Mobility programme between IIUM and Sudanese Universities. Professor Aisha also participates in community services. She was appointed as a Board of Studies member at the International Islamic School, Malaysia. She also served as Parent/Teacher Committee member at the school for more than 10 years.

Zeinab E. Ahmed received her Ph.D. in Computer Engineering and Networks from the University of Gezira, Sudan. Dr. Zeinab has been working as an assistant professor in the Department of Computer Engineering at the University of Gezira, Sudan since June 2020. Currently, she is working as a postdoc fellow at the Department of Electrical and Computer Engineering, International Islamic University Malaysia, Malaysia. Dr. Zeinab has served as Head of the Department of Computer Engineering, Faculty of Engineering Technology, and the University of Gezira, Sudan. I've been engaged in some projects related to the field of computer engineering and networks. She has published more than eight research papers and book chapters on networking in peer-reviewed academic venues. Her areas of research interest are wireless communication networks. An experienced lecturer with a demonstrated history of working in the higher education industry. She is skilled in research, e-learning, programming, and lecturing.

Othman Omran Khalifa received his bachelor's degree in electrical and Electronic Engineering from Garyounis University, Libya in 1986. He obtained his Master's degree and PhD from Newcastle University, UK in 1996 and 2000 respectively. He worked in industries for eight years and he is currently a professor at the department of Electrical and Computer Engineering, International Islamic University Malaysia. Prof. Khalifa served as the head of department of Electrical and computer Engineering, IIUM from July 2005 until December 2014. He is a Charter Engineer (CEng) UK, a Senior member of IEEE USA, and a member IET UK. Prof. Khalifa was the chairman of the International Conference on Computer and Communication Engineering (ICCCE), 2006, 2010, 2012, 2014. Prof. Khalifa supervised more than 60 Masters and PhD students. He has extensively contributed through his writings in international journals, conferences and books. He published more than 500 publications including 14 books. In 2013, he received the highest citation in Citation Indexed Journal Award, in 2019 he got the TOKOH academic "Best Academician" award and last year in 2020, he Won the Murabbi "Best Teacher" award. In 2021, he got the publication (book publication) award. In 2022 won the National Best Book in Science and technology 2022.

Rashid A. Saeed received his Ph.D. in Communications Network Engineering, at UPM, Malaysia. Currently, he is a professor, Computer Engineering Dept, Taif University. He is also working in the Electronics Dept, Engineering Faculty, SUST, Sudan. He was a senior researcher in Telekom Malaysia™ R&D and MIMOS bhd sdn. He was Deputy director of the Scientific Research and Innovation Directorate at the MOHE, Sudan from 2015 to 2019 and Deputy dean for Scientific Research, SUST from 2012 to 2015. Rashid published more than 300 research papers, books, and book chapters in peer-reviewed academic venues. He is successfully awarded

13 WO, EP, CN, and MY patents in these areas. He supervised more than 50 MSc/Ph.D. students. Rashid is a Senior Member of IEEE, and a Member of IEM (I.E.M), Professional Accreditation as Consultant from SEC and SCE. Rashid is co-founder and Technical Committee Chair (TPC) of the International Conference on Computing, Electrical and Electronics Engineering (ICCEEE) in Sudan from 2013 to 2018, and General Chair for EAI AFRICOMM 2022 to 2024. He is an editorial board member Scientific African (SCIAF) journal. He is a guest editor in many journals.

Muhammed Zaharadeen Ahmed is a Post-Doctoral Fellow at the International Islamic University Malaysia, where he also earned his PhD in Engineering in 2022 and MSc in Computer and Information Engineering in 2017. He holds a BSc in Computer Engineering from the University of Maiduguri, Nigeria, obtained in 2014. His research interests include Networking, particularly Network Mobility (NEMO), Blockchain, and the Internet of Things (IoT). Dr. Ahmed currently serves as a Volunteer Senior Lecturer at the University of Technology and Arts of Byumba (UTAB), Rwanda, since February 2025. He has also held several notable academic leadership positions, including Head of the Computer Engineering Department at the University of Maiduguri, Nigeria (2023–2024), Head of the Cyber Security Department at Al-Ansar University, Nigeria (2022–2024), and Senate Member at Al-Ansar University in 2022. His professional journey also includes his role as a Research Engineer at the International Islamic University Malaysia and as a Computer Engineer at Zenith International Academy, Nigeria. Dr. Ahmed is an active member of several professional bodies, including the Nigerian Society of Engineers (NSE), the Council for Regulation of Engineering in Nigeria (COREN), the Board of Engineers Malaysia (BEM), and the Nigeria Computer Society (NCS). He is proficient in English and Hausa and has an intermediate command of Arabic.

Harishchander Anandaram completed a PhD in bioengineering, an M.Tech., and a B.Tech. in bioinformatics from the Sathyabama Institute of Science and Technology, Chennai, in 2020, 2011, and 2009. In his bachelor's and master's theses, he worked on analysing resistance in HIV protease inhibitors based on molecular mechanics and machine learning studies, a collaborative project with IIT Madras. In his PhD thesis, he worked on pharmacogenomics and miRNA-regulated networks in psoriasis, a collaborative project with Georgetown University, USA; JIPMER, India; CIBA, India; and ILS, India. His thesis illustrated a multi-disciplinary approach by combining computational biophysics and molecular biology machine learning. While doing a PhD, he had the opportunity to collaborate with international

researchers and have publications in reputed international journals in bioinformatics and systems biology. He has received the prestigious “Young Scientist Award” from “The Melinda Gates Foundation” for his research abstract on “The Implications of miRNA Dynamics in Infectious Diseases.”. To date, he has reviewed more than 200 manuscripts in systems biology.

Zainab Senan Attarbashi is an assistant professor at the Faculty of Information and Communication Technology, International Islamic University Malaysia (IIUM). She received her BSc (in Electronic and Computer Engineering), MSc, and Ph.D. (in Information and Computer Engineering) degrees from the International Islamic University in Malaysia. She Worked at School of Computing, Universiti Utara Malaysia (UUM). Her current research interests are Cyber Security, Info-Centric Networks, Network Mobility, blockchain and IoT Connectivity.

Wan Muhd Hazwan Azamuddin received his Ph.D from the National University of Malaysia (UKM), Malaysia in 2024. He obtained an MSc in Computer Science from the Technical University of Malaysia (UTeM) in 2016. Currently working as the head of the electrical department at Tangkak Industrial Institute. He has published several papers in peer-reviewed international journals. His research area includes networking, future internet technology, & mobility NDN

Salaheldin Mohamed Ibrahim Edam is an accomplished academic and researcher in the field of electronics and communications, currently serving as an Assistant Professor at the Sudan University of Science and Technology since July 2014. He has extensive teaching experience, having previously held positions as a Lecturer and Teaching Assistant in the School of Electronics Engineering. Edam earned his PhD in Engineering (Communications and Information Systems) from Beijing University of Posts & Telecommunications in China (2010-2014) and holds a Master’s degree in Information Technology from Sudan University of Science and Technology (2008). His educational background also includes a Post Graduate Diploma in Advanced Information Technology from the International Institute of Information Technology in India and a Bachelor's degree in Electronics Engineering with honors. His areas of expertise encompass a wide range of topics, including MIMO systems, 5G and 6G technologies, machine learning applications in wireless communications, and the Internet of Things (IoT). Edam has supervised numerous graduate students and has held administrative roles, such as Head of the Communication Engineering Department and Coordinator of Graduate Studies for Electronics Engineering. Edam has contributed significantly to the academic community, with over 27 peer-reviewed publications focusing on wireless sensor networks, machine learning, and telecommunications. His work has been presented at

various international journal and conferences, showcasing his commitment to advancing research in his field.

Hitesh Mohapatra received the B.E. degree in Information Technology from Biju Patnaik University of Technology (BPUT), Odisha in 2006, and the MTech. Degree in CSE from Odisha University of Technology and Research (OUTR) University, Odisha in 2009. He received his Ph.D. in Computer Science & Engineering in 2021 from Veer Surendra Sai University of Technology (VSSUT), Burla, India. He has contributed 30 SCI and Scopus indexed research papers, 21 international/national conferences and books on Software Engineering and C Programming respectively. He has 15 years of teaching experience both in industry and academia. He has served the research community with various capacities like session chair, technical chair, keynote speaker etc. His research interests include wireless sensor network, smart city, smart grid and smart water. Currently he is working as Associate professor at School of Computer Engineering, KIIT DU, Bhubaneswar, and Odisha.

Azana Hafizah Mohd Aman is a Senior Lecturer at the Research Center for Cyber Security, Faculty of Information Science and Technology (FTSM), Universiti Kebangsaan Malaysia (UKM), Malaysia. She holds a B.Eng., M.Sc., and Ph.D. in computer and information engineering from International Islamic University Malaysia. Her research focuses on computer systems and networking, with a particular interest in information and network security, the Internet of Things (IoT), cloud computing, and big data.

Rania Abdelhameed (IEEE member since 2003) received the B.Sc. degree in Electronics Engineering (Computer Engineering) from the Sudan University of Science & Technology (SUST), Khartoum, Sudan, in 2001, & the Postgraduate Diploma in Information Technology (Advanced Networking & Telecommunications) from the International Institute of Information Technology (I2IT), Pune, India, in 2003, & the M.Sc. & PhD. degrees from the University Putra Malaysia (UPM), Kuala Lumpur, Malaysia, in 2005 & 2010, respectively. In May 2009, she earned the IEEE Wireless Communication Professional (IEEE WCP) certificate of the Wireless Communication Engineering Technology (WCET) Exam. Currently, she is an associate professor and Director, Electronics System Research Centre, Faculty of Engineering, Sudan University of Science and Technology, Khartoum, Sudan. She has been award Elsevier Foundation Award for women in Engineering in 2017. She published over 30 scientific papers and two books.

Mamoon Mohammed Ali Saeed is Deputy Dean of the College of Engineering and Information Technology, and Director of the University Branch, and a

Lecturer at the Department of Communication and Electronics Engineering, UMS University, Yemen. received his Bachelor's degree in Communication and Electronics Engineering from Sana'a University, Yemen 2005, and his M.S. degree from the Department of Computer Networks and Information Security in Yemen Academy for Graduate Studies Yemen 2013. Recently, a Ph.D. in Alzaiem Alazhari University, Faculty of Engineering, Electrical Engineering Department, Khartoum, Sudan 2021. His research areas include cyber security, communication security, and artificial intelligence.

Maznifah Salam is a Malaysian academic and cybersecurity researcher based at Universiti Teknologi MARA (UiTM), Shah Alam. She holds a Master's degree in Computer Science and is currently pursuing a PhD focused on ICT security governance. Actively involved in UiTM's infrastructure and ICT development, she has contributed to several scholarly publications on cybersecurity maturity models for higher education, emphasizing governance, risk, human factors, and compliance. Her work bridges academic research and institutional policy, helping to shape cybersecurity frameworks within Malaysian universities and supporting national standards such as ISO 9001:2015.

C.V. Suresh Babu is a pioneer in content development. A true entrepreneur, he founded Anniyappa Publications, a company that is highly active in publishing books related to Computer Science and Management. Dr. C.V. Suresh Babu has also ventured into SB Institute, a center for knowledge transfer. He holds a Ph.D. in Engineering Education from the National Institute of Technical Teachers Training & Research in Chennai, along with seven master's degrees in various disciplines such as Engineering, Computer Applications, Management, Commerce, Economics, Psychology, Law, and Education. Additionally, he has UGC-NET/SET qualifications in the fields of Computer Science, Management, Commerce, and Education. Currently, Dr. C.V. Suresh Babu is a Professor in the Department of Information Technology at the School of Computing Science, Hindustan Institute of Technology and Science (Hindustan University) in Padur, Chennai, Tamil Nadu, India.

Srikanth Velpula received Ph.D. degree from Vellore Institute of Technology, Vellore, Tamilnadu, India in 2020. He received B.Tech and M.Tech degrees both from Jawaharlal Nehru Technological University, Hyderabad, India, in 2009 and 2012, respectively. He worked as an Assistant Professor in the Department of Electrical and Electronics Engineering at various engineering colleges in India during 2011-2022. Currently, he is working as Assistant Professor at SR University, Warangal, Telangana, India. His research interests include Power system stability, Converter

controls, DFIG based systems, Electrical Vehicle Drives & Battery Management System, and the Integration of renewable energies into the power systems.

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