

INTERCONNECTED  
WORLDS OF  
**PERVASIVE  
COMPUTING**  
IoT and Networking



INTERCONNECTED  
WORLDS OF  
**PERVASIVE  
COMPUTING**  
IoT and Networking

Edited by  
**MARINA MD ARSHAD**  
**SYED HAMID HUSSAIN MADNI**



[www.penerbit.utm.my](http://www.penerbit.utm.my)

2024

First Edition 2024

© **MARINA MD ARSHAD & SYED HAMID HUSSAIN MADNI** 2024

Hak cipta terpelihara. Tiada dibenarkan mengeluarkan ulang mana-mana bahagian artikel, ilustrasi, dan isi kandungan buku ini dalam apa jua bentuk dan cara apa jua sama ada dengan cara elektronik, fotokopi, mekanikal, atau cara lain sebelum mendapat izin bertulis daripada Timbalan Naib Canselor (Penyelidikan & Inovasi), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor Darul Ta'zim, Malaysia. Perundingan tertakluk kepada perkiraan royalti atau honorarium.

*All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical including photocopying, recording, or any information storage and retrieval system, without permission in writing from Deputy Vice-Chancellor (Research & Innovation), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor Darul Ta'zim, Malaysia. Negotiation is subject to royalty or honorarium estimation.*

Editor : **MARINA MD ARSHAD & SYED HAMID HUSSAIN MADNI**

Editor Penyelaras / *Acquisition Editor*: **MAZLAN SAID & AMYSHA AZIZA ABD AZID**

Pereka Kulit / *Cover Designer*: **NORIZAN YAACOB**

Diatur huruf oleh / *Typeset by*:

**MARINA MD ARSHAD & SYED HAMID HUSSAIN MADNI**

Faculty of Computing

UNIVERSITI TEKNOLOGI MALAYSIA

81310 UTM Johor Bahru

Johor Darul Ta'zim, MALAYSIA

Diterbitkan di Malaysia oleh:

**PENERBIT UTM PRESS**

UNIVERSITI TEKNOLOGI MALAYSIA

81310 UTM Johor Bahru

Johor Darul Ta'zim, MALAYSIA

(PENERBIT UTM ahli MAJLIS PENERBITAN

ILMIAH MALAYSIA–MAPIM dan MABOPA

dengan no. keahlian 9101)

Dicetak di Malaysia oleh:

**JASAMAX ENTERPRISE**

No. 16, Jalan Kebudayaan 2,

Taman Universiti

81300 Skudai, Johor, MALAYSIA



Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the  
National Library of Malaysia

ISBN 978-983-52-2003-6

# Contents

<i>Contributors</i>		<i>vii</i>
<i>Preface</i>		<i>ix</i>
<b>Chapter 1</b>	<b>Introduction to Pervasive and Ubiquitous Computing</b>	<b>1</b>
	<i>Marina Md-Arshad and Syed Hamid Hussain Madni</i>	
<b>Chapter 2</b>	<b>Bibliometric Analysis of Pervasive and Ubiquitous Computing Research</b>	<b>11</b>
	<i>Marina Md-Arshad, Firoz Yusuf Patel Dawoodi, and Muhalim Mohamed Amin</i>	
<b>Chapter 3</b>	<b>Pervasive Computing in Smart Cities</b>	<b>25</b>
	<i>Zhan JingChun, Goh Eg Su, and Mohd Shahrizal Sunar</i>	
<b>Chapter 4</b>	<b>Probabilistic Ontology Model for Human Activity Recognition</b>	<b>39</b>
	<i>Pouya Foudeh and Naomie Salim</i>	
<b>Chapter 5</b>	<b>Machine and Deep Learning Approaches for IoT Networks</b>	<b>85</b>
	<i>Hina Kim, Ayesha Altaf, Muhammad Anwar, and Marina Md-Arshad</i>	

<b>Chapter 6</b>	<b>An Adaptive Interoperability Framework for IoT over 5G</b>	<b>99</b>
	<i>Saria Tasneem, Muhammad Kaleem, Ismail Fauzi Isnin, and Salman Rashid</i>	
<b>Chapter 7</b>	<b>Factor-based Authentications Techniques in Machine-to-Machine Communication</b>	<b>115</b>
	<i>Shafi Ullah, Raja Zahilah Raja Mohd Radzi, and Rashidah Kadir</i>	
<b>Chapter 8</b>	<b>Comparison of WEP, WPA, WPA2 and WPA3 in Wireless Security Protocols</b>	<b>125</b>
	<i>Muhammad Anwar, Ayaz Hussain, Abdul Qahar, and Farkhana Mughtar</i>	
<b>Chapter 9</b>	<b>Nature-Inspired Metaheuristic Approach to SD-WAN Controller Placement</b>	<b>139</b>
	<i>Cindy Ujan and Mohd Murtadha Mohammad</i>	
<b>Chapter 10</b>	<b>Energy Efficient Opportunistic Routing in Underwater Sensor Networks</b>	<b>149</b>
	<i>Nasarudin Ismail and Mohd Murtadha Mohammad</i>	
<b>Index</b>		<b>181</b>

# Contributors

**Abdul Qahar** *Department of Information Technology, University of Punjab, Jhelum Campus, Pakistan*

**Ayaz Hussain** *Department of Computer Science and IT, Lahore, Leads University, Pakistan*

**Ayesha Altaf** *University of Education, Lahore, Pakistan*

**Cindy Ujan** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Farkhana Muchtar** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Firoz Yusuf Patel Dawoodi** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Goh Eg Su** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Hina Kirn** *University of Education, Lahore, Pakistan*

**Ismail Fauzi Isnin** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Marina Md Arshad** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Mohd Murtadha Mohammad** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Mohd Shahrizal Sunar** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Muhaimin Mohamed Amin** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Muhammad Anwar** *Department of Information Sciences, University of Education, Lahore, Pakistan*

**Muhammad Kaleem** *Department of Computer Science and Information Technology, University of Sargodha, Pakistan*

**Naomie Salim** *UTM Big Data Centre, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Nasarudin Ismail** *Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor, Malaysia*

**Pouya Foudeh** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Raja Zahilah Raja Mohd Radzi** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Rashidah Kadir** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Salman Rashid** *Department of Computer Science and Information Technology, University of Sargodha, Pakistan*

**Saria Tasneem** *Department of Computer Science and Information Technology, University of Sargodha, Pakistan*

**Shafi Ullah** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*

**Syed Hamid Hussain Madni** *Computer Science Programme, University of Southampton, Iskandar Puteri, Johor, Malaysia,*

**Zhan JingChun** *Faculty of Computing, Universiti Teknologi Malaysia, Johor Bahru, Malaysia*



# Preface

Welcome to the world of *Interconnected Worlds of Pervasive Computing, IoT and Networking*. This edited book is a compelling exploration of the dynamic intersection between pervasive computing and ubiquitous computing, where technology seamlessly integrates into our lives.

From the foundations of pervasive computing to cutting-edge security protocols, this book unravels the transformative potential of interconnected systems. We begin with an introduction to the core principles, followed by a bibliometric study offering insights into the field's evolution. The journey then moves to the practical realm of smart cities, where technology elevates urban living.

As we venture deeper, the book examines knowledge models, machine learning in human activity recognition, IoT, adaptive interoperability frameworks, and security measures. The exploration of wireless security protocols and nature-inspired metaheuristics in SD-WAN placement paves the way for the final chapter on energy-efficient routing in underwater sensors.

We express our sincere gratitude to PM Dr Mohd Murtadha Mohammad for his consistent encouragement that is a driving force behind the creation of this book. Our sincere appreciation also goes to the contributors who have enriched this book with their expertise and knowledge. May this edited book provide insights and help deepen the reader's understanding of this ever-evolving landscape.

**Marina Md Arshad**  
**Syed Hamid Hussain Madni**  
Universiti Teknologi Malaysia  
**2024**

