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Zaigham Mahmood
Editor

Guide to Ambient Intelligence in the IoT Environment

Principles, Technologies and Applications

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*To Imran, Zoya, Arif, Hanya and Ozair
For their Love and Support*

Preface

Overview

Ambient Intelligence (AmI) is an element of pervasive computing that brings smartness to living and business environments to make them more sensitive, adaptive, autonomous, and personalized to human needs. It refers to intelligent interfaces that recognize human presence and preferences and adjust smart environments to suite their immediate needs and requirements. The key factor is the presence of intelligence and decision-making capabilities in the IoT environments. The underlying technologies include pervasive computing, ubiquitous communication, seamless connectivity of smart devices, sensor networks, artificial intelligence (AI), machine learning (ML), and context-aware human–computer interaction (HCI). AmI applications and scenarios include smart homes, autonomous self-drive vehicles, healthcare systems, smart roads, industry sector, smart facilities management, education sector, emergency services, and many more.

The AmI process comprises three main stages: Sensing, Reasoning, and Acting. Sensing relies on real-world data collected by interconnected smart sensors present in the IoT environment. During the Reasoning process, the data is processed by intelligent algorithms embedded within the networked devices that perceive the environment and apply reasoned approaches based on AI and ML. This, in turn, provides responsiveness and adaptability, for the Acting stage of the process, to react to the ambient conditions and modify the environment as per the human requirements that are already built within the ambient systems.

Core benefits of AmI include customisation and automation of IoT-based living and industrial environments to meet user needs, however, because of automation, often control is taken away from the users when environments perform incorrect actions. This is generally due to the newness of the approaches that embed intelligence in smart devices, and the diversity, and sometimes unreliability, of such devices. There are therefore real issues of operability, reliability, consistency, connectivity, security, and trust. Other challenges refer to device communication protocols, sensor battery life, sensor robustness, self-testing and self-repairing of

smart devices, as well as the heterogeneity of devices from diverse vendors. It is also important that relevant devices' costs are low, network bandwidth is high, device connectivity is seamless, and software systems are platform independent. Besides, much work still needs to be done at all levels on topics such as infrastructure, unobtrusive hardware, semantic web, algorithms, network capabilities, machine-to-machine (M2M) interactions, and device communication standards to effectively support the cyber-physical interconnections. All this is necessarily required for reliable, autonomic, and self-governing systems and networks.

As mentioned above, the advantages of AmI in the IoT environment are obviously huge, however, like any new technological paradigm, issues, and limitations are also many. This is the context within which the present book has been developed.

The focus of the book is on the AmI element of the IoT, in particular the relevant principles, frameworks, and technologies, as well as on benefits and inherent limitations. With this background, the present volume, *Guide to Ambient Intelligence in the IoT Environment: Principles, Technologies and Applications*, aims to capture the state of the art on current developments of smart spaces and AmI-based IoT environments. Majority of the contributions in the book focus on device connectivity, pervasive computing, and context modeling including communication, security, interoperability, scalability, and adaptability. Forty-Four researchers and practitioners of international repute have presented latest research, current trends, and case studies, as well as suggestions for further understanding, development, and enhancement of the AmI-IoT vision.

Objectives

The aim of this volume is to present and discuss AmI-based IoT in terms of frameworks and methodologies for connected smart environments. The objectives include

- Capturing the state-of-the-art research and practice with respect to the principles, frameworks, and methodologies of AmI-based IoT environments
- Presenting case studies illustrating challenges of AmI-enabled IoT, best practices, and practical solutions
- Developing a complete reference for students, researchers, and practitioners of pervasive computing and smart context-aware environments
- Identifying further research directions and technologies with respect to AmI-based IoT and distributed computing vision.

Organization

There are 12 chapters in *Guide to Ambient Intelligence in the IoT Environment: Principles, Technologies and Applications*. These are organized in three parts, as follows:

Part I: Principles and Technologies

This part has a focus on concepts, principles, and underlying technologies. There are four chapters. The first contribution explores the AmI research linked to the realization of smart city environments from the topology and architecture point of view. The second chapter extends the Internet of Things (IoT) vision to Industrial IoT to present the state of the art and the future of AmI in such environments. The next chapter discusses AmI implementation suitable for applications in business settings and suggests guidelines and strategies for IT business managers. The final contribution of this part has a focus on adaptability of Ambient Intelligence mechanism based on the well-known component-based approach and presents a relevant AmI system.

Part II: Frameworks and Methodologies

This part of the book comprises four chapters that focus on frameworks and latest approaches. The first chapter presents a WLAN-based intelligent positioning system for the presence detection and conducts performance analysis through simulation. The second contribution looks into the need for AmI for connected autonomous vehicles in a VANET and smart city scenario. A use-case involving augmented reality is also presented. The third contribution in this part aims to develop a mathematical model for embedded intelligent controllers for the detection of carbon monoxide in smart living environments. The last chapter provides an assessment of the AmI microcontrollers and proposes the design and architecture of a low-powered high-performance microcontroller.

Part III: Applications and Use Scenarios

There are four chapters in this part that focus on AmI-embedded applications and use cases. The first chapter examines the tax services provision of revenue administration in the IoT environment and discusses the changing role of tax providers. The next contribution suggests mechanisms to support vehicle drivers and proposes a low-cost IoT-enabled wearable device to improve the wellbeing of drivers in the context of Bangladesh. The third chapter proposes a vision-based posture monitoring system for the elderly using intelligent fall detection technique. The results of the study are also presented. The fourth chapter and the last in the book discusses new approaches to modern smart facilities management that employs AmI for developing smart office and living spaces.

Target Audiences

The current volume is a reference text aimed at supporting a number of potential audiences, including the following:

- *Network Specialists, Hardware Engineers and Software Developers* who wish to adopt the newer approaches to develop smart living and working environments and smart intelligent software applications.
- *Students and Academics* who have an interest in further enhancing the knowledge of technologies, mechanisms, and frameworks relevant to AmI in the IoT environment from a distributed computing perspective.
- *Researchers and Practitioners* in this field who require up-to-date knowledge of the current methodologies and technologies relevant to the AmI-enabled IoT vision, to further enhance the connectivity of smart devices.

Derby, UK/Hebei, China

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Derby, UK/Hebei, China
November 2018

Zaigham Mahmood

Other Springer Books by Zaigham Mahmood

Fog Computing: Concepts, Frameworks and Technologies

This reference text describes the state of the art of Fog and Edge computing with a particular focus on development approaches, architectural mechanisms, related technologies, and measurement metrics for building smart adaptable environments. The coverage also includes topics such as device connectivity, security, interoperability, and communication methods. ISBN: 978-3-319-94889-8.

Smart Cities: Development and Governance Frameworks

This text/reference investigates the state of the art in approaches to building, monitoring, managing, and governing smart city environments. A particular focus is placed on the distributed computing environments within the infrastructure of smart cities and smarter living, including issues of device connectivity, communication, security, and interoperability. ISBN: 978-3-319-76668-3.

Data Science and Big Data Computing: Frameworks and Methodologies

This reference text has a focus on data science, and provides practical guidance on big data analytics. Expert perspectives are provided by an authoritative collection of 36 researchers and practitioners, discussing latest developments and emerging trends; presenting frameworks and innovative methodologies; and suggesting best practices for efficient and effective data analytics. ISBN: 978-3-319-31859-2.

Connected Environments for the Internet of Things: Challenges and Solutions

This comprehensive reference presents a broad-ranging overview of device connectivity in distributed computing environments, supporting the vision of IoT. Expert perspectives are provided, covering issues of communication, security, privacy, interoperability, networking, access control, and authentication. Corporate analysis is also offered via several case studies. ISBN: 978-3-319-70101-1.

Connectivity Frameworks for Smart Devices: The Internet of Things from a Distributed Computing Perspective

This is an authoritative reference that focuses on the latest developments on the Internet of Things. It presents state of the art on the current advances in the connectivity of diverse devices; and focuses on the communication, security, privacy, access control, and authentication aspects of the device connectivity in distributed environments. ISBN: 978-3-319-33122-5.

Cloud Computing: Methods and Practical Approaches

The benefits associated with cloud computing are enormous; yet the dynamic, virtualized, and multi-tenant nature of the cloud environment presents many challenges. To help tackle these, this volume provides illuminating viewpoints and case studies to present current research and best practices on approaches and technologies for the emerging cloud paradigm. ISBN: 978-1-4471-5106-7.

Cloud Computing: Challenges, Limitations and R&D Solutions

This reference text reviews the challenging issues that present barriers to greater implementation of the Cloud Computing paradigm, together with the latest research into developing potential solutions. This book presents case studies, and analysis of the implications of the cloud paradigm, from a diverse selection of researchers and practitioners of international repute. ISBN: 978-3-319-10529-1.

Continued Rise of the Cloud: Advances and Trends in Cloud Computing

This reference volume presents latest research and trends in cloud-related technologies, infrastructure, and architecture. Contributed by expert researchers and practitioners in the field, this book presents discussions on current advances and practical approaches including guidance and case studies on the provision of cloud-based services and frameworks. ISBN: 978-1-4471-6451-7.

Software Engineering Frameworks for the Cloud Computing Paradigm

This is an authoritative reference that presents the latest research on software development approaches suitable for distributed computing environments. Contributed by researchers and practitioners of international repute, the book offers practical guidance on enterprise-wide software deployment in the cloud environment. Case studies are also presented. ISBN: 978-1-4471-5030-5.

Cloud Computing for Enterprise Architectures

This reference text, aimed at system architects and business managers, examines the cloud paradigm from the perspective of enterprise architectures. It introduces fundamental concepts, discusses principles, and explores frameworks for the adoption of cloud computing. The book explores the inherent challenges and presents future directions for further research. ISBN: 978-1-4471-2235-7.

Software Project Management for Distributed Computing: Life-Cycle Methods for Developing Scalable and Reliable Tools

This unique volume explores cutting-edge management approaches to developing complex software that is efficient, scalable, sustainable, and suitable for distributed environments. Emphasis is on the use of the latest software technologies and frameworks for life-cycle methods, including design, implementation, and testing stages of software development. ISBN: 978-3-319-54324-6.

Requirements Engineering for Service and Cloud Computing

This text aims to present and discuss the state of the art in terms of methodologies, trends, and future directions for requirements engineering for the service and cloud computing paradigm. Majority of the contributions in the book focus on requirements elicitation; requirements specifications; requirements classification, and requirements validation and evaluation. ISBN: 978-3-319-51309-6.

User Centric E-Government: Challenges and Opportunities

This text presents a citizens-focused approach to the development and implementation of electronic government. The focus is twofold: discussion on challenges of service availability, e-service operability on diverse smart devices; as well as on opportunities for the provision of open, responsive, and transparent functioning of world governments. ISBN: 978-3-319-59441-5.

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