Mobile Computing and Wireless Communications

Applications, Networks, Platforms, Architectures, and Security

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Book at a Glance

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e-Business and Distributed Systems Handbook: Management Module ISBN: 0-9727414-5-3
e-Business and Distributed Systems Handbook: Networks Module ISBN: 0-9727414-6-1
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e-Business and Distributed Systems Handbook: Platforms Module ISBN: 0-9727414-9-6

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Visit the author website (www.amjadumar.com) for additional details and instructor materials.

Dedicated to my best friend, Dolorese, who also happens to be my wife,
fond memories of my parents and the rest of the gang.

Visit the Author Website (www.amjadumar.com) for:

- Additional information about this book and updates
- Purchasing options and instructions
- Instructor corner for course outlines, powerpoint slides, and sample assignments
- Free slides (PDF format) of all chapters of the book that summarize the chapter topics and can be used as lecture notes
- Information about other books by the same author
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PREFACE

This book is a result of several years of practical experience in the telecommunications industry and numerous university and industry teaching assignments on different aspects of mobile computing and wireless communications. As a practitioner and a teacher in this growing field, I looked for a book that provided a broad and balanced view of applications, networks, platforms, architectures, security, and management issues. In particular, as a teacher of a popular course on wireless communications that attracted students from electrical engineering, computer science, and IS/IT departments, I was quite unhappy with the available books in the field. The popular books in the marketplace covered either deeply technical views (e.g., Stallings[1] and Rappaport[2]) or highly business views (e.g., Kalakota[3] and Evans[4]), but not both. In addition, many books take a very network centric view – with deep details of physical wireless communications – but almost no discussion of applications, platforms, architectures, security, and management issues that are increasingly important in developing wireless solutions. After trying for several years, I found it difficult to teach a balanced course in this area from the available texts – hence this text.

This book provides a recent and relevant coverage of the subject matter based on a systematic approach. It is written to present a broad as well as comprehensive analysis. Especially suitable for practitioners and managers, the book has also been classroom tested in CS/IS/IT courses on mobile computing and wireless communications. The salient features of this book are:

1. A practical approach based on a systematic framework that covers the basic building blocks of mobile computing and wireless systems and their interrelationships to each other. This facilitates a balanced coverage of applications, networks, platforms, architectures, security, and management issues instead of one narrow topic.

2. Comprehensive analysis of recent and relevant topics such as the following:
   - Mobile computing applications and their role in supporting the M-Business, M-Government, and Mobile Life initiatives. Two chapters[5] are devoted to discussion of applications such as mobile messaging systems (e.g., SMS, MMS), mobile commerce, location-based services, mobile portals, mobile customer relationship management, mobile supply chain management systems, wireless sensor applications, and mobile agent applications.
   - Mobile computing platforms and how they enable the mobile computing applications. Two chapters are devoted to extensive discussion of topics such as the wireless Internet, Mobile IP, wireless middleware, wireless gateways, mobile application servers, WAP, i-mode, J2ME, BREW, Mobile Internet Toolkit, and Mobile Web Services.
   - Wireless networks that support and enable the mobile computing applications. The discussion starts with a chapter that covers wireless communication principles such as wireless transmissions, smart antennas, frequency allocations, error detection and correction, location-based technologies, spread spectrum, and CDMA/TDMA. Five

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[1] Stallings, W. *Wireless Communications and Network*. Prentice Hall, 2002.

[2] Rappaport, T. *Wireless Communications: Principles and Practice*. 2nd ed. Prentice Hall, 2001.

[3] Kalakota, R. and Robinson, M. *M-Business: The Race to Mobility*. McGraw Hill, 2002.

[4] Evans, N. *Business Agility: Strategies For Gaining Competitive Advantage Through Mobile Business Solutions*. Prentice Hall, 2001.

[5] Most chapters in this book are about 50 pages.

additional chapters are devoted to detailed discussion of wireless LANs with emphasis on 802.11, Bluetooth, wireless sensor networks, UWB (Ultra Wideband), cellular networks ranging from 1G to 5G, mobile ad hoc networks (MANETs), wireless local loops, FSO (Free Space Optics), satellites communications, and deep space networks.

- The architectural, security, and management/support issues and their role in building, deploying and managing wireless systems in modern settings. Three chapters examine how integrated architectures can be built to provide seamless services to the end-users on top of hybrid wireless/wired systems; how effective wireless security solutions can be developed on top of weakly secure wireless components; and how a wireless project can be planned, organized, developed, deployed, and monitored for success.
- The relevant regulatory and standards bodies and their role in this dynamic field is also examined. Discussions also include the different types of wireless businesses such as network element providers, wireless telephone network operators, wireless software/hardware developers, wireless application service providers, and wireless engineering/consulting firms.

3. Case study orientation with numerous real-life examples and case studies throughout the book to clarify and illustrate key points. Each chapter starts with a short case study/example and concludes with 3 to 4 additional examples.

4.. Complete instructor materials (PowerPoint slides, course outlines, project assignments) to support an academic or industrial course are provided.

5. An appendix containing a short tutorial on network concepts for novices in the field and another appendix for more detailed coverage of wireless physical communications for people with more technical interests.

The book takes a big picture view, shown in Figure 1, that encompasses networks, applications, platforms, architectures, security, and management perspectives. Different parts of this book cover the building blocks shown in Figure 1 (see "Book at a Glance" on a previous page and "Detailed Table of Contents" in the following pages for additional details).

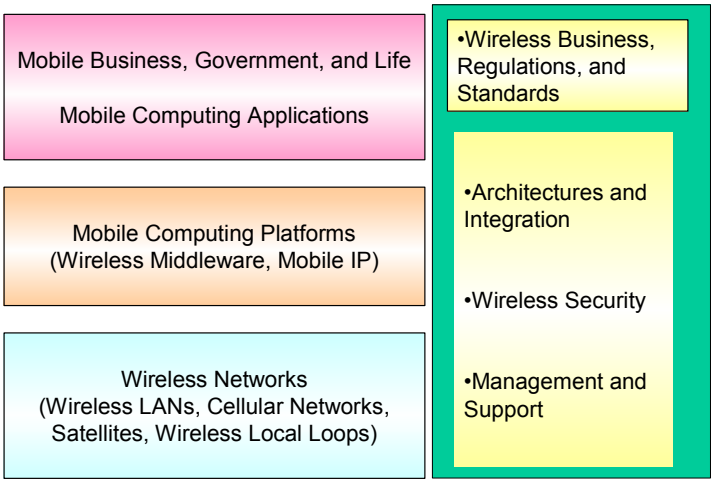

Figure 1 : Mobile Computing and Wireless Communications -- The Big Picture

The book is subdivided into the following parts:

- Part I (four chapters) presents the big picture and discusses mobile business, mobile computing applications and mobile computing platforms.

- Part II (six chapters) concentrates on different aspects of wireless networks that span wireless LANs, WANs, and MANs.
- Part III (three chapters) examines the issues that span all layers. Examples of these issues include architectures, security, and management/support considerations.
- Part IV (Appendices) gives background tutorials for the novice and a more detailed discussion of wireless communication principles.

Intended audience and recommended usage

The book was developed due to the knowledge gained in several industrial, research management, and university teaching assignments. The book can thus be used in academic courses, corporate training seminars, and as a self learning tool/reference guide. The intended audience is:

- IT executives and CIOs who need to develop a good understanding of the big picture with various building blocks and their interrelationships.
- IT and network managers who need to manage the mobile computing and wireless communications initiatives.
- IT and network technical staff who need to analyze, develop, deploy, and/or live with the mobile computing and wireless communications systems in modern digital environments.
- IT, computer science, and EE students who want to get through a wireless course with minimal damage to their body and soul and also understand the big picture.
- All others who just want to read good books written by good people.

Conventions Used

We will use the following conventions in this book. ***Highlighted italics*** are used to indicate definitions of new terms, *italics* are used for emphasis and **bold letters** are used for subject headings.

Acknowledgements

I am greatly indebted to my wife, Dolorese, who keeps supporting me through this endless writing process. This work could never have been finished without her help and understanding. Many thanks to my students at the University of Pennsylvania, Fordham University, and Rutgers University for "soldiering through" this material in various forms of readiness. Some interesting short case studies from some of these students appear in the book. I am also indebted to my colleagues and friends at Bellcore, now known as Telcordia Technologies, for exposing me to various mobile computing problems over the past several years and for working with me through several projects in distributed systems, e-business, wireless systems, and security.

Suggested Usage in Courses

This book has been classroom tested in different university and industrial courses in the past five years. These courses were intended to provide a broad understanding of the subject matter that exposed the students to different aspects of wireless communications. The university courses have been attended by CS/IT/EE students, many of them practitioners in the IT industry. The current book format has been largely influenced by the feedback received from the students over the years.

The following course description outlines the main course. I have taught variations of this course in the industry, mostly as a three-day intensive training seminar. The course can be easily modified for a more technical audience by adding one or two sessions on physical wireless communications and by reducing/eliminating the management and support topics. The course can also be modified to fit a management and MBA audience by reducing the technical content and emphasizing the business and management issues. There is enough material in this book to allow this customization.

COURSE TITLE: Mobile Computing and Wireless Communications

Suggested Course Description

This course presents a broad overview of the technical as well as business aspects of mobile computing and wireless communications. Instead of one narrow topic, this course covers the major building blocks (mobile applications, mobile computing platforms, wireless networks, architectures, security, and management) of mobile computing and wireless communications. The course starts with a discussion of m-business and m-government initiatives and examines mobile computing applications such as mobile messaging, m-commerce, M-CRM, M-portals, M-SCM, mobile agents, and sensor applications. The role of wireless Internet and Mobile IP is reviewed and the mobile computing platforms are examined with a discussion of wireless middleware, wireless gateways, mobile application servers, WAP, i-mode, J2ME, BREW, Mobile Internet Toolkit, and Mobile Web Services. The wireless networks are discussed next with a review of wireless communication principles, wireless LANs with emphasis on 802.11 LANs, Bluetooth, wireless sensor networks, UWB (Ultra Wideband), cellular networks ranging from 1G to 5G, wireless local loops, FSO (Free Space Optics), satellite communications, and deep space networks. The course concludes with a review of the architectural, security, and management/support issues and their role in building, deploying and managing wireless systems in modern settings.

Prerequisite: Basic course in Computing Networks or Data Communications and a basic course on IS/IT principles.

Main Text:

Umar, A., "Mobile Computing and Wireless Communications: Applications, Networks, Platforms, Architectures, and Security", NGE Solutions, July 2004.

Course Grade:

- Two projects (200 Points)
- One Examination - in class, open book, open notes (100 Points)
- Total: 300 points

Course Outline

Note: Each session represents a 3 hour lecture/discussion session.

Session	Major Topic	Required Reading`	Comments and Additional Details
1	Introduction and the Big Picture	(Ch.1)	Establish framework for discussion and explain the main building blocks.
2	Mobile Computing Applications to Support M-Business and M-Government	(Ch. 2)	Highlight the main applications (wireless messaging, M-Commerce, M-CRM, M-Portals, sensor applications, location-based services, and mobile agent applications).
3	Wireless Internet, Mobile IP, and the Wireless Web	(Ch.3)	May ask the students to review (U -Appendix A) for basic Networking Concepts, if needed.
4	Mobile Computing Platforms, Wireless Middleware, WAP, i-mode, VoiceXML	(Ch.4)	Examine the principles of the platforms with a practical analysis of the various platforms and wireless middleware services.
5	Wireless Communication Fundamentals	(Ch. 5)	Principles of wireless communications with a review of frequency allocations, location management, transmission impairments, error detection and correction, and multiple access strategies (CDMA versus TDMA).
6	Wireless LANs and IEEE 802.11 LANs	(Ch. 6)	Principles of wireless LANs, key characteristics of IEEE 802.11 LANs, Wi-Fi LANs, and Mobile Ad Hoc Networks.
7	Midterm exam or project (student presentations)		Student project may be building a WAP application, survey and analysis of mobile computing applications and platforms (depending on background).
8	WPANs, Bluetooth, UWB, Sensor Networks	(Ch. 7)	Principles of wireless personal area networks with emphasis on Bluetooth. The concepts of UWB and wireless sensor networks are briefly reviewed.
9	Cellular Networks	(Ch. 8)	Principles of cellular networks ranging from 1G to 5G with emphasis on 2G, 2.5G, and 3G. Design of cellular networks is briefly reviewed.
10	Fixed Wireless Networks, Wireless Local Loops (WLLs), Satellite Communications	(Ch. 9)	Principles of WLLs, LMDS/MMDS, and their role in the last mile. A discussion of satellites and GEOs/MEOs/LEOs with a brief review of deep space communications.
11	Special Topics in Wireless Networks: Adhoc Networks, FSO, Flash OFDM, sensor networks	(Ch.10)	This session may be conducted by students reporting on details of emerging wireless networks and their strengths/weaknesses.
12	Wireless Architectures and Traffic Engineering	(Ch. 11)	Review of how the different components of a wireless system (networks, platforms, and applications can be packaged together to build integrated architectures.
13	Wireless Security	(Ch. 12)	Principles of security, special issues in wireless security, and approaches to secure a complete wireless system from networks to applications.
14	Wireless Management and Support	(Ch. 13)	Planning, organization, staffing, deployment and support issues in wireless systems. Special discussion of management platforms for wireless systems.
15	Final exam or project (student presentations)		The students may make presentations on topics of their choice or may give demos of small prototypes they build.

This outline can be modified as follows (visit the instructor corner for this book on the website www.amjadumar.com for instructor materials, sample projects and more details):

- A technology focused course intended for students in EE and CS departments by compressing sessions 1 and 2 into one session, expanding session 5 into two sessions, and eliminating session 14.
- A business focused course for students in IS/IT programs in the business schools by expanding the first two sessions into three sessions, compressing network sessions (5 to 11) into four sessions, and expanding session 14 into two sessions.

Acronyms and Glossary of Terms

ACL	Authorized Control List
ACM	Association of Computing Machinery
ACSE	Association Control Service Elements
AI	Artificial Intelligence
AIA	Application Integration Architecture
AM	Amplitude Modulation
AMPS	Advanced Mobile Phone System
ANSI	American National Standards Institute
ASK	Amplitude Shift Keying
ASN.1	Abstract Syntax Notation One
API	Application Programming Interface
APPC	Advanced Program to Program Communications
ASP	Application Service Provider
ASP	Active Server Pages – A Microsoft technology for building server side code
ATM	Asynchronous Transfer Mode – a packet switching Technology used typically in high data rate networks
ATM	Automatic Teller Machine – used in banking
ATMF	Asynchronous Transfer Mode Forum
B2B	Business to Business
B2C	Business to Consumer
B2E	Business to Employee
B2G	Business to Government
BFSK	Binary Frequency Shift Keying
BISDN	Broadband Integrated Services Digital Network
BPSK	Binary Phase Shift Keying
BREW	Binary Runtime Environment for Wireless
BSP	Business System Planning
CAD	Computer Aided Design
CAM	Computer Aided Manufacture
CBX	Computerized Branch Exchange
CCITT	Comité Consultatif Internationale de Télégraphique et Téléphonique (The International Telegraph and Telephone Consultative Committee)
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CGI	Common Gateway Interface - A Web gateway technology
CICS	Customer Information Control System - an IBM mainframe transaction manager
CIM	Computer Integrated Manufacturing
CIO	Chief Information Officer
CLNP	Connectionless Mode Network Protocol
CLNS	Connectionless Mode Network Service
CMIP	Common Management Information Protocol
CMIS	Common Management Information Service
CMISE	Common Management Information Service Element
CMOT	Common Management Information Services and Protocol Over TCP/IP
CORBA	Common Object Request Broker Architecture
COTS	Commercial Off-The-Shelf
CPU	Central Processing Unit
CRM	Customer Relationship Management
CSF	Critical Success Factors

CSMA/CD	Carrier Sense Multiple Access/Collision Detect
DAF/ODP	Distributed Application Framework/Open Distributed Processing
DAS	Distributed Application System
DBMS	Database Management System
DCP	Distributed Computing Platform
DCOM	Distributed Component Object Model
DCRM	Distributed Computing Reference Model
DCS	Digital Communication System
DCS	Distributed Computing System
DDBM	Distributed Database Manager
DDBMS	Distributed Database Management System
DDL	Data Definition Language – used in database management
DDTMS	Distributed Data and Transaction Management System
DECT	Digital Enhanced Cordless Telecommunications
DFM	Distributed File Manager
DIS	Draft International Standard
DISOS	Distributed Operating System
DML	Data Manipulation Language
DNA	Digital Network Architecture
DOD	Department of Defense
DQDB	Distributed Queue Dual Bus
DQPSK	Differential Quadrature Phase Shift Keying
DRDA	Distributed Relational Database Architecture (from IBM)
DS	Directory Services
DSL	Digital Subscriber Loop
DTM	Distributed Transaction Manager
DTMS	Distributed Transaction Management System
EAI	Enterprise Application Integration
EB	Electronic Business
EC	Electronic Commerce
EDI	Electronic Data Interchange
EJB	Enterprise Java Beans
ERP	Enterprise Resource Planning
ES-IS	End System to Intermediate System
ETSI	European Telecommunication Standards Institute
FAP	File Allocation Program (Procedure)
FCC	Federal Communications Commission
FDD	Frequency Division Duplex
FDDI	Fiber Distributed Data Interface
FDM	Frequency Division Multiplexing
FDMA	Frequency Division Multiple Access
FEP	Front End Processor
FHSS	Frequency Hopping Spread Spectrum
FM	Frequency Modulation
FMS	Flexible Manufacturing System
FSK	Frequency Shift Keying
FSO	Free Space Optics
FTAM	File Transfer Access,and Management
FTP	File Transfer Protocol
GDMO	Guideline for Definition of Managed Objects
GFSK	Gaussian Frequency Shift Keying (with .5 Gaussian Filter)
GMSK	Gaussian Minimal Shift Keying (with either .3 or .5 Gaussian Filter)

GUI	Graphical User Interface
I/O	Input/Output
IDL	Interface Definition Language – used in CORBA and other distributed object middleware services
IEEE	Institute for Electrical and Electronic Engineers
IMS	Information Management System - IBM DB/DC system on mainframes
IP	Internet Protocol
IPC	Interprocess Communication
IRM	Information Resource Management – a management methodology
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
ISP	Internet Service Provider
IT	Information Technology
ITU	International Telecommunications Union
ITU-T	International Telecommunications Union – Telecommunications Services Sector
J2EE	Java Version 2 Enterprise Edition
J2ME	Java Version 2 Mobile Edition
JDBC	Java Database Connectivity
LAN	Local Area Network
LDBMS	Local Database Management System
LLC	Logical Link Control
LMDS	Local Multipoint Distribution Service
LU	Logical Unit - an endpoint in the IBM SNA environment
MAC	Medium Access Control
MAN	Metropolitan Area Network
MAP	Manufacturing Automation Protocol
Mbps	Million bits per second
MHS	Message Handling Service
MIB	Management Information Base - used in network management
MIPS	Million Instructions Per Second
MMDS	Multichannel Multipoint Distribution Service
MMIT	Microsoft Mobile Internet Toolkit
MMS	Manufacturing Messaging Specification
MOM	Message Oriented Middleware
MVS	Multiple Virtual System - operating system on IBM's mainframes
MUX	Multiplexor
NAMPS	Narrowband Advanced Mobile Phone System
NAS	Network Application Support - DEC's open architecture
NBS	National Bureau of Standards
NCP	Network Control Program - a component of IBM's SNA
NFS	Network File Services - SUN Microsystem's File System for Networks
NIST	National Institute of Standards and Technology
NLM	Network Loadable Module (A Novell Netware feature)
NM	Network Management
NMF	Network Management Forum
NML	Network Management Layer
NMS	Network Management System
NOS	Network Operating Systems – typically indicates a LAN operating system (e.g., Novell Netware)
NSP	Network Service Provider (e.g., UUNET)
OAG	Open Application Group – a standards organization

ODBC	Open Database Connectivity – a de-facto standard for remote SQL
ODIF	Office Document Interchange Format
OEM	Original Equipment Manufacturer
OMA	Open Mobility Alliance
OMG	Object Management Group – the group that developed CORBA
OODBMS	Object-Oriented Database Management System
OOPL	Object-Oriented Programming Language
OQPSK	Offset Quadrature Phase Shift Keying
OS	Operating System
OSF	Open Software Foundation
OSF-DCE	OSF Distributed Computing Environment
OSF-DME	OSF Distributed Management Environment
OSI	Open System Interconnection
OSS	Operations Support Systems - for telecom network provisioning
PBX	Private Branch Exchange
PCM	Pulse Code Modulation
PCS	Personal Communication System
PGP	Pretty Good Privacy
PKI	Public Key Infrastructure
PSK	Phase Shift Keying
PU	Physical Unit - used in IBM's SNA
QMP	Queued Message Processing
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RDA	Remote Database Access
RFID	Radio Frequency Identification
RPC	Remote Procedure Call
RTS	Reliable Transfer Service
SAA	System Application Architecture - IBM's "Open" Environment
SCM	Supply Chain Management
SDLC	Synchronous Data Link Control - Layer 2 Protocol in IBM's SNA
SET	Secure Electronic Transaction – a security standard
SIF	Synchronous Optical Network (SONET) Interoperability Forum
SMDS	Switched Multi-megabit Data Service
SML	Service Management Layer - used in telecom network services
SNA	System Network Architecture - IBM's Network Architecture
SNMP	Simple Network Management Protocol - TCP/IP Network management Protocol
SOAP	Simple Object Access Protocol – part of Web Services
SONET	Synchronous Optical Network
SQL	Structured Query Language
SSL	Secure Socket Layer
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TMN	Telecommunications Managed Network

UDDI	Universal Description, Discovery and Integration - a registry for Web Services
UDP	User Datagram Protocol - a protocol that runs on IP
UMTS	Universal Mobile Telecommunication System (Mainly 3G Cellular Technology)
UWB	Ultra Wideband
VAN	Value-added Network
VPN	Virtual Private Network
VT	Virtual Terminal
VTAM	Virtual Telecommunications Access Method - a component of IBM's SNA
VXML	Voice eXtensible Markup Language
WAN	Wide Area Network
WAP	Wireless Application Protocol
WLL	Wireless Local Loop
WML	Wireless Markup Language
WS	Web Services
WSN	Wireless Sensor Network

Detailed Table of Contents

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