

Mobile Computing and Wireless Communications

**Applications, Networks, Platforms,
Architectures, and Security**

Amjad Umar, Ph.D.

*Publisher: NGE Solutions, Inc.
(www.ngesolutions.com)*

Publication Date: July 2004

Umar, Amjad

Mobile Computing and Wireless Communications, ISBN: 0-9759182-0-6

Publisher: NGE Solutions, Inc. (www.ngesolutions.com)

Copyright: 2004 by the Author

All Rights Reserved

No parts of this book may be reproduced without written permission of the author

Author Website (www.amjadumar.com)

Book at a Glance

Preface

Suggested Usage in Courses

Acronyms and Glossary of Terms

Part I: Mobile Computing Applications and Platforms

Chapter 1: Overview and the Big Picture

Chapter 2: Mobile Computing Applications: Supporting M-Business and M-Government

Chapter 3: Wireless Internet, Mobile IP, and Wireless Web

Chapter 4: Mobile Computing Platforms, Middleware, and Servers

Part II: Wireless Networks

Chapter 5: Wireless Network Principles

Chapter 6: Wireless LANs -- 802.11 and Mobile Ad Hoc Networks

Chapter 7: Wireless Personal Area Networks: Bluetooth, UWB, and Sensor Networks

Chapter 8: Cellular Networks -- From 1G to 5G

Chapter 9: Wireless Local Loops and Satellite Communications

Chapter 10: Emerging Wireless Networks: UWB, FSO, MANET, and Flash OFDM

Part III: Architectures, Security and Management

Chapter 11: Integrated Architectures for Wireless

Chapter 12: Wireless Security

Chapter 13: Management and Support Issues

Part IV: Appendices

Appendix A: Tutorial on Network Basics

Appendix B: Closer Look at Physical Wireless Communications

Index

OTHER RECENT BOOKS BY THE SAME AUTHOR

Information Security and Auditing in the Digital Age

A Managerial and Practical Perspective

This book integrates people, processes, and technologies to solve the current and future security problems in highly distributed and mobile enterprises. The focus is on recent issues such as Web Services security (e.g., SAML), wireless security, and integrated systems security. Additional topics include security management, policies and requirements, risk assessment and mitigation, cryptographic techniques, security packages (PKI and security auditing tools), a systematic methodology, network security, host security, web security, middleware, security, application security, and auditing in modern environments.

e-Business and Distributed Systems Handbook

From Strategies to Working Solutions

This is an extensive handbook that covers management as well as technical issues. The handbook consisting of the following modules, available individually:

e-Business and Distributed Systems Handbook: Overview Module ISBN: 0-9727414-1-0

e-Business and Distributed Systems Handbook: Applications Module ISBN: 0-9727414-2-9

e-Business and Distributed Systems Handbook: Architecture Module ISBN: 0-9727414-3-7

e-Business and Distributed Systems Handbook: Integration Module ISBN: 0-9727414-4-5

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

e-Business and Distributed Systems Handbook: Middleware Module ISBN: 0-9727414-8-8

e-Business and Distributed Systems Handbook: Platforms Module ISBN: 0-9727414-9-6

All books available through Amazon.com and other book sellers.

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

Dedicated to my best friend, Dolores, 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
- Frequently asked questions
- Feedback and suggestions
- Contacting the author
- Author background

Trademark Acknowledgements

The following list recognizes the commercial and intellectual property of the trademark holders whose products are mentioned in this book. Omission from this list is inadvertant:

AIX is a trademark of IBM Corporation

CORBA is a trademark of Object Management Group

DB2 is a trademark of IBM Corporation

DCE is a trademark of Open Software Foundation

DSOM is a trademark of IBM Corporation

EDA/SQL is a trademark of Information Builders, Inc.

Encina is a trademark of IBM Corporation

Flowmark is a trademark of IBM Corporation

HotJava is a trademark of Sun Microsystems

i-mode is a trademark of DoComo

IPX/SPX is a trademark of Novell Corporation

J2EE, J2SE and J2ME are trademarks of Sun Microsystems

Java is a trademark of Sun Microsystems

JSP and JDBC are trademarks of Sun Microsystems

Lotus Notes is a trademark of IBM Corporation

NetBIOS is a trademark of IBM Corporation

NetWare is a trademark of Novell Corporation

.Net is a trademark of Microsoft Corporation

ODBC is a trademark of Microsoft Corporation

OLE is a trademark of Microsoft Corporation

OpenMail is a trademark of Hewlett Packard

Orbix is a trademark of Iona Technologies

UNIX is a registered trademark licensed exclusively through X/Open Company, Ltd.

WebObjects is a trademark of NeXT Corporation

WebSphere is a trademark of IBM Corporation

Windows is a trademark of Microsoft Corporation

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., Stallings¹ and Rappaport²) or highly business views (e.g., Kalakota³ and Evans⁴), 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 chapters⁵ 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

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).

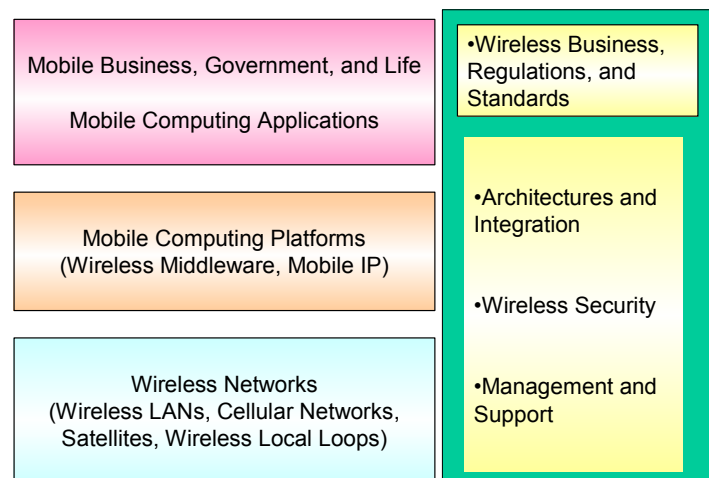


Figure 1 : Mobile Computing and Wireless Communications -- The Big Picture

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, Dolores, 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

PART I: Mobile Computing Applications and Platforms

1 OVERVIEW AND THE BIG PICTURE

- 1.1 INTRODUCTION
- 1.2 STRENGTHS AND WEAKNESSES OF WIRELESS
 - 1.2.1 *Strengths and Drivers*
 - 1.2.2 *Weaknesses and Issues*
- 1.3 A FRAMEWORK FOR DISCUSSION AND ANALYSIS
- 1.4 MOBILE BUSINESS, MOBILE GOVERNMENT AND MOBILE LIFE
 - 1.4.1 *m-Business: An Evolution*
 - 1.4.2 *Mobile Business as an Integral Part of Next Generation Enterprises (NGEs)*
 - 1.4.3 *Mobile Government (m-Government)*
 - 1.4.4 *Mobile Life*
- 1.5 MOBILE COMPUTING APPLICATIONS: SUPPORTING M-BUSINESS AND M-GOVERNMENT
 - 1.5.1 *Wireless Messaging*
 - 1.5.2 *Mobile Commerce and its Variants*
 - 1.5.3 *Mobile Enterprise Business Applications (M-Portals, M-CRMs, M-SCMs)*
 - 1.5.4 *Specialized Applications with Mobile Agents and Sensor Networks*
- 1.6 PLATFORMS TO SUPPORT MOBILE COMPUTING APPLICATIONS
 - 1.6.1 *Mobile Computing Application Development and Support Issues*
 - 1.6.2 *Wireless Internet, Mobile IP, and Wireless Web*
 - 1.6.3 *Wireless Middleware and Wireless Gateways (WAP, i-mode, J2ME, MMIT, BREW)*
- 1.7 OVERVIEW OF WIRELESS NETWORKS
 - 1.7.1 *A Classification of Wireless Networks*
 - 1.7.2 *Wireless LANs: IEEE802.11 and Bluetooth*
 - 1.7.3 *Wireless Metropolitan Area Networks (WMANs) – The Wireless Local Loop*
 - 1.7.4 *The Wireless Wide Area Networks – Cellular Networks*
 - 1.7.5 *Satellite Communication Systems*
 - 1.7.6 *Summary of Wireless Networks*
- 1.8 WIRELESS ARCHITECTURES, SECURITY AND MANAGEMENT
 - 1.8.1 *Integrated Architectures for Wireless Systems*
 - 1.8.2 *Wireless Security*
 - 1.8.3 *Management and Support Issues in Wireless*
- 1.9 REGULATORY AND STANDARDS BODIES
 - 1.9.1 *Significant Regulatory Bodies*
 - 1.9.2 *IEEE 802.11 Standards Body*
 - 1.9.3 *IETF (Internet Engineering Task Force)*
 - 1.9.4 *Open Mobility Alliance (OMA)*
 - 1.9.5 *Enhanced 911 (E911)*
 - 1.9.6 *Telecommunications Act of 1996*
- 1.10 THE WIRELESS BUSINESS – A QUICK SCAN
 - 1.10.1 *The Players in Wireless Business*
 - 1.10.2 *Example: Value Chain for Enterprise Wireless Services*
 - 1.10.3 *Wireless Network Element Providers*
 - 1.10.4 *Wireless Telephone Network Operators*
 - 1.10.5 *Wireless Internet Service Providers (WISPs)*

- 1.10.6 *Wireless Telephony Applications Providers*
- 1.10.7 *Wireless Application Service Providers (WASPs)*
- 1.10.8 *Software/Hardware Development*
- 1.10.9 *Wireless Consulting, Engineering and Management (CEM) Business*
- 1.10.10 *Frequency Auctioning and Bandwidth Trading Business*
- 1.11 SHORT EXAMPLES AND CASE STUDIES
 - 1.11.1 *UPS Uses Wireless Communications*
 - 1.11.2 *Sample m-Business and m-Government Initiatives*
 - 1.11.3 *Sample Wireless Internet Services*
- 1.12 CONCLUDING COMMENTS
- 1.13 SUGGESTED REVIEW QUESTIONS AND EXERCISES
- 1.14 ADDITIONAL SOURCES FOR INFORMATION

2 MOBILE COMPUTING APPLICATIONS – SUPPORTING M-BUSINESS AND M-GOVERNMENT

- 2.1 INTRODUCTION
- 2.2 KEY CHARACTERISTICS OF MOBILE COMPUTING APPLICATIONS
 - 2.2.1 *Highlights of Mobile Computing Applications*
 - 2.2.2 *Mobility of Users, Target Sources, and Networks*
 - 2.2.3 *Adding Other Capabilities (Positional, TV, and Voice) to Mobility*
 - 2.2.4 *High-Level Architecture of Mobile Computing Applications*
- 2.3 MESSAGING FOR MOBILE USERS
 - 2.3.1 *Overview and Examples*
 - 2.3.2 *Short Message Service (SMS) – Wireless Text Messaging*
 - 2.3.3 *Blackberry*
 - 2.3.4 *Multimedia Messaging Service (MMS) for Wireless*
 - 2.3.5 *Applications of Messaging in m-Business, m-Government, and Mobile Life*
- 2.4 MOBILE COMMERCE – BUYING/SELLING THROUGH MOBILE DEVICES
 - 2.4.1 *Overview and Examples*
 - 2.4.2 *Variants of Mobile Commerce – Positional and Voice Commerce*
- 2.5 MOBILE PORTALS
 - 2.5.1 *Overview and Examples*
 - 2.5.2 *What are Portals?*
 - 2.5.3 *What Are Mobile Portals? – A Closer Look*
 - 2.5.4 *Classes of Portals Accessible from Wireless Devices*
 - 2.5.5 *Mobile Portal Architectures and Software*
- 2.6 MOBILE CUSTOMER RELATIONSHIP MANAGEMENT (M-CRM)
 - 2.6.1 *Overview and Examples*
 - 2.6.2 *What is a CRM?*
 - 2.6.3 *What is a Mobile CRM – A Closer Look*
 - 2.6.4 *Technologies and Architectures*
- 2.7 MOBILE SUPPLY CHAIN MANAGEMENT
 - 2.7.1 *Overview and Examples*
 - 2.7.2 *What is a Supply Chain Management System?*
 - 2.7.3 *Supply Chain Decisions and Models*
 - 2.7.4 *What is Mobile SCM?*
 - 2.7.5 *Mobilizing Supply Chain Management*
 - 2.7.6 *Concluding Comments about Mobile Supply Chain Management*
- 2.8 SPECIAL MOBILE APPLICATIONS (LBS, WSN, RFID)
 - 2.8.1 *Location-Sensitive Applications*
 - 2.8.2 *Wireless Sensor Network (WSN) Applications*
 - 2.8.3 *RFID Applications*
- 2.9 MOBILE AGENT APPLICATIONS
 - 2.9.1 *What are Mobile Agent Applications?*

- 2.9.2 *Mobile Agents Versus Client/Server Model*
- 2.9.3 *Sample Applications of Mobile Agents in Mobile Computing*
- 2.9.4 *Mobile Agent Requirements*
- 2.9.5 *Existing Mobile Agent Platforms and Architectures*
- 2.9.6 *Mobile Agent Application Summary*
- 2.10 SHORT CASE STUDIES AND EXAMPLES
 - 2.10.1 *Frankfurt Airport Mobile Asset Management*
 - 2.10.2 *SMS and Receipt-Reporting for Tax Purposes in the Philippines*
 - 2.10.3 *RFID for HomeLand Security*
- 2.11 CONCLUDING COMMENTS
- 2.12 SUGGESTED REVIEW QUESTIONS AND EXERCISES
- 2.13 REFERENCES

3 WIRELESS INTERNET, MOBILE IP, AND WIRELESS WEB

- 3.1 INTRODUCTION
- 3.2 INTERNET AND THE WEB: A QUICK REFRESHER
 - 3.2.1 *Internet, Intranets, and Extranets at a Glance*
 - 3.2.2 *The Web at a Glance*
 - 3.2.3 *World Wide Web Technologies – The First Generation*
- 3.3 HOW DOES WIRELESS WEB REALLY WORK?– QUICK EXAMPLES
 - 3.3.1 *A Simple Wired Access Example*
 - 3.3.2 *A Simple Wireless Web Example*
- 3.4 THE INTERNET AND IP – A CLOSER LOOK
 - 3.4.1 *What is the Internet?*
 - 3.4.2 *IP Overview*
 - 3.4.3 *The Internet Protocol (IP)*
 - 3.4.4 *The Transmission Control Protocol (TCP)*
 - 3.4.5 *The User Datagram Protocol (UDP)*
 - 3.4.6 *Additional Transport Layer Protocol – SCTP (Simple Control Transmission Protocol).*
 - 3.4.7 *Sample Higher (Application) Layer Protocols*
 - 3.4.8 *Common TCP/IP Implementations*
 - 3.4.9 *Next Generation Network and Internet*
- 3.5 MOBILE IP – SUPPORTING MOBILE DEVICES OVER THE INTERNET
 - 3.5.1 *Overview*
 - 3.5.2 *Internet Routing – A Quick Tour*
 - 3.5.3 *How Does Mobile IP Work?*
 - 3.5.4 *Capabilities of Mobile IP*
- 3.6 WORLD WIDE WEB FOR WIRELESS – A CLOSER LOOK
 - 3.6.1 *Accessing the Web from Mobile Devices and the Wireless Gateways*
 - 3.6.2 *Semantic Web and its Role in Mobile Web Access*
 - 3.6.3 *XML Overview*
 - 3.6.4 *Document Type Declarations (DTD)*
 - 3.6.5 *XSL (XML Stylesheet Language)*
- 3.7 WEB SERVICES AND MOBILE WEB SERVICES
 - 3.7.1 *What are Web Services and Why are they Important to Mobile Computing?*
 - 3.7.2 *A Quick Example – Accessing Web Services from a Mobile Device*
 - 3.7.3 *Mobile Web Services*
- 3.8 SHORT EXAMPLES AND CASE STUDIES
 - 3.8.1 *How Mobile IPV6 is used in Cellular Networks*
 - 3.8.2 *AOL Anywhere: The Mobile Access Portal*
 - 3.8.3 *A Mobile Purchasing System*
 - 3.8.4 *Wireless Internet and the Arab World*
- 3.9 CONCLUDING COMMENTS
- 3.10 SUGGESTED REVIEW QUESTIONS AND EXERCISES
- 3.11 REFERENCES

4 MOBILE COMPUTING PLATFORMS, MIDDLEWARE, AND SERVERS

- 4.1 INTRODUCTION
- 4.2 LOCAL PLATFORM SERVICES FOR MOBILE DEVICES
 - 4.2.1 *Mobile Devices at a Glance*
 - 4.2.2 *Operating Systems (OSs) for Mobile Devices*
 - 4.2.3 *Mobile Database Management*
 - 4.2.4 *Mobile Transaction Management*
 - 4.2.5 *Utilities for Mobile Devices*
- 4.3 WIRELESS MIDDLEWARE
 - 4.3.1 *What is Wireless Middleware?*
 - 4.3.2 *Operational Issues in Supporting Mobile Computing Applications*
 - 4.3.3 *Design and Development Issues in Mobile Computing Applications*
 - 4.3.4 *Wireless Middleware Services Needed for Mobile Computing Applications*
 - 4.3.5 *Example: Message-Oriented Middleware for Mobility*
- 4.4 WIRELESS GATEWAYS AND MOBILE APPLICATION SERVERS
 - 4.4.1 *What is a Wireless Gateway?*
 - 4.4.2 *What is a Mobile Application Server?*
 - 4.4.3 *Examples of Mobile Application Servers*
- 4.5 THE WIRELESS APPLICATION PROTOCOL (WAP)
 - 4.5.1 *Overview*
 - 4.5.2 *Why WAP is Needed*
 - 4.5.3 *The New WAP – WAP 2.0*
 - 4.5.4 *Wireless Application Environment (WAE)*
 - 4.5.5 *Wireless Markup Language (WML)*
 - 4.5.6 *WAP Microbrowsers*
 - 4.5.7 *WMLScript*
 - 4.5.8 *Wireless Telephony Application (WTA)*
 - 4.5.9 *WAP Push Model*
 - 4.5.10 *The Role of WAP in SMS and MMS*
 - 4.5.11 *The Traditional WAP Protocol Stack*
 - 4.5.12 *WAP Gateway*
 - 4.5.13 *WAP Security*
 - 4.5.14 *WAP Software Development Kit (SDK), Toolkits, and Infrastructure*
 - 4.5.15 *WAP Applications*
 - 4.5.16 *Example of WAP and Bluetooth Together*
 - 4.5.17 *WAP Summary*
- 4.6 I-MODE, WIRELESS JAVA, MMIT, AND BREW
 - 4.6.1 *Overview*
 - 4.6.2 *i-mode*
 - 4.6.3 *Wireless Java and J2ME (Java 2 Micro Edition)*
 - 4.6.4 *Microsoft Mobile Internet Toolkit (MMIT)*
 - 4.6.5 *QualComm's Binary Runtime Environment for Wireless (BREW)*
- 4.7 VOICE COMMUNICATIONS – VOICE BROWSERS AND VOICE XML
 - 4.7.1 *Overview*
 - 4.7.2 *Voice Browsers*
 - 4.7.3 *VOICE XML*
- 4.8 EXAMPLES AND CASE STUDIES
 - 4.8.1 *Texas Instruments' OMAP – Platform for Building 3G Applications*
 - 4.8.2 *Example: Platforms and Middleware for Wireless Sensor Networks (WSNs)*
 - 4.8.3 *AIRTIS Wireless Traffic and Weather Solution*
 - 4.8.4 *City of Seattle Public Utilities Chooses Wireless Middleware*
 - 4.8.5 *M-Commerce: Nokia and Amazon.com Collaboration*
 - 4.8.6 *Drexel University Wireless Network*
- 4.9 CONCLUDING COMMENTS

- 4.10 SUGGESTED REVIEW QUESTIONS AND EXERCISES
- 4.11 REFERENCES

PART II: Wireless Networks

5 WIRELESS NETWORK PRINCIPLES

- 5.1 INTRODUCTION
- 5.2 HOW DO WIRELESS NETWORKS WORK – A QUICK OVERVIEW
 - 5.2.1 *The Basic Operation of Wireless Networks*
 - 5.2.2 *A Quick Scan of the Wireless Network Landscape*
 - 5.2.3 *Quick Comparison of Wireless Networks*
 - 5.2.4 *Wireless Versus Wired Networks*
 - 5.2.5 *Technical Foundations of Wireless Networks*
- 5.3 WIRELESS FREQUENCY ALLOCATIONS AND REGULATIONS
 - 5.3.1 *Overview*
 - 5.3.2 *Classifications of Transmission Media*
 - 5.3.3 *General Frequency Ranges*
 - 5.3.4 *Broadcast Radio (30 MHz to 1 GHz) Frequency Band*
 - 5.3.5 *Microwave Frequency Band*
 - 5.3.6 *Infrared Frequency Band*
 - 5.3.7 *Licensed versus Unregulated Frequency Bands*
 - 5.3.8 *Relationship Between Wireless Frequency and Distance Covered*
 - 5.3.9 *Why Low Frequencies are More Congested*
 - 5.3.10 *Frequency Regulations*
- 5.4 LOCATION MANAGEMENT IN WIRELESS NETWORKS
 - 5.4.1 *Main Drivers and Approaches*
 - 5.4.2 *Cell-based Location Services*
 - 5.4.3 *Other Approaches*
 - 5.4.4 *Tradeoffs between Different Location Services*
- 5.5 WIRELESS ANTENNAS AND PROPAGATION
 - 5.5.1 *Introduction*
 - 5.5.2 *Transmitters/Receivers*
 - 5.5.3 *Antennas*
 - 5.5.4 *Smart Antennas*
 - 5.5.5 *Propagation of Wireless Waves*
 - 5.5.6 *Line of Sight – a Closer Look*
 - 5.5.7 *Line-of-Sight Transmission Impairments*
 - 5.5.8 *Fading in Mobile Environments*
 - 5.5.9 *Effect of Fading and Approaches to Deal With It*
- 5.6 ERROR DETECTION AND CORRECTION
- 5.7 ANALOG VERSUS DIGITAL COMMUNICATIONS IN WIRELESS SYSTEMS
- 5.8 SIGNAL ENCODING TECHNIQUES
 - 5.8.1 *Overview*
 - 5.8.2 *Analog Data to Analog Signal Encoding*
 - 5.8.3 *Digital Data to Analog Signal Encoding: Modems and Interfacing Devices*
 - 5.8.4 *Analog Data to Digital Signal (Pulse Code Modulation – PCM)*
- 5.9 MULTIPLE ACCESS MECHANISMS (FDMA, TDMA, CDMA)
 - 5.9.1 *Overview*
 - 5.9.2 *Frequency Division Multiple Access (FDMA)*
 - 5.9.3 *Time Division Multiple Access (TDMA)*

- 5.9.4 *Code Division Multiple Access (CDMA) Technology*
- 5.9.5 *TDMA Versus CDMA Controversy*
- 5.10 SPREAD SPECTRUM
 - 5.10.1 *Overview*
 - 5.10.2 *Frequency-Hopping Spread Spectrum*
 - 5.10.3 *Direct Sequence Spread Spectrum*
- 5.11 SHORT CASE STUDIES AND EXAMPLES
 - 5.11.1 *University Wireless Network Revisited*
 - 5.11.2 *A Village Area Network – Using Motorcycles as Communicating Devices*
 - 5.11.3 *Wireless Nurse Call System*
- 5.12 CONCLUDING COMMENTS
- 5.13 REVIEW QUESTIONS AND EXERCISES
- 5.14 REFERENCES

6 WIRELESS LANS – 802.11 AND MOBILE AD HOC NETWORKS

- 6.1 INTRODUCTION
- 6.2 WIRELESS LAN OVERVIEW
 - 6.2.1 *Principles of Wireless LANS*
 - 6.2.2 *Wireless LAN Technologies at a Glance*
 - 6.2.3 *Wireless LAN Applications and Requirements*
 - 6.2.4 *Wireless LAN Technologies*
 - 6.2.5 *Wireless Communication Technologies*
 - 6.2.6 *Wireless LAN Configurations*
 - 6.2.7 *The Wireless LAN Stack*
- 6.3 IEEE 802.11 ETHERNET STANDARD FOR WIRELESS LANS
 - 6.3.1 *Overview*
 - 6.3.2 *A Closer Look at IEEE 802.11*
 - 6.3.3 *IEEE 802.11 Physical Layer*
 - 6.3.4 *IEEE 802.11 Medium Access Control (MAC) Layer*
 - 6.3.5 *IEEE 802.11 Logical Link Control (LLC)*
 - 6.3.6 *Additional 802.11 Standards and Industrial Notes*
- 6.4 MOBILE AD-HOC NETWORKS (MANETS)
 - 6.4.1 *Overview*
 - 6.4.2 *MANET Examples*
 - 6.4.3 *Routing Protocols for Ad Hoc Mobile Wireless Networks*
 - 6.4.4 *Media Access Control Protocols for Mobile Ad Hoc Networks*
- 6.5 HIPERLAN2
 - 6.5.1 *Overview*
 - 6.5.2 *HiperLAN2 – Technology Overview*
 - 6.5.3 *Tradeoffs Between HiperLAN2 and 802.11*
- 6.6 SHORT CASE STUDIES AND EXAMPLES
 - 6.6.1 *Example of an 802.11 LAN at Home*
 - 6.6.2 *A Mobile Access Point on a Passenger Bus*
 - 6.6.3 *Delivering Voice Over 802.11*
 - 6.6.4 *Honeywell uses WLAN for Production Tracking*
 - 6.6.5 *Using Wireless Carts for Patient Care*
 - 6.6.6 *Wireless Network for a Delivery System*
- 6.7 CONCLUDING COMMENTS
- 6.8 REVIEW QUESTIONS AND EXERCISES
- 6.9 REFERENCES

7 WIRELESS PERSONAL AREA NETWORKS – BLUETOOTH, UWB AND SENSOR NETWORKS

- 7.1 INTRODUCTION
- 7.2 PRINCIPLES AND IEEE 802.15 STANDARDS
 - 7.2.1 *Principles and Technical Foundations at a Glance*
 - 7.2.2 *IEEE 802.15 Standards for WPANs – A Quick Overview*
- 7.3 WIRELESS HOME NETWORKS: CORDLESS NETWORKS AND HOMERF
 - 7.3.1 *Overview of Wireless Home Networking*
 - 7.3.2 *Cordless Networks*
 - 7.3.3 *Home RF*
- 7.4 BLUETOOTH WIRELESS LANS
 - 7.4.1 *Overview*
 - 7.4.2 *Main Features of Bluetooth*
 - 7.4.3 *Bluetooth versus Wi-Fi*
 - 7.4.4 *Setting Up a Bluetooth Network*
 - 7.4.5 *How Does Bluetooth Work – Piconets and Scatternets*
 - 7.4.6 *Sample Applications of Bluetooth*
 - 7.4.7 *Bluetooth Stack and Bluetooth Protocols – An Overview*
 - 7.4.8 *Closer Look at Bluetooth Core Protocols*
 - 7.4.9 *Logical Link Control and Adaptation Protocol (L2CAP)*
 - 7.4.10 *Concluding Comments on Bluetooth*
- 7.5 ULTRA WIDEBAND (UWB) – A QUICK OVERVIEW
- 7.6 WIRELESS SENSOR NETWORKS AND ZIGBEES – AN OVERVIEW
 - 7.6.1 *What are Wireless Sensor Networks?*
 - 7.6.2 *ZigBees*
 - 7.6.3 *Components of a Sensor (Mote)*
 - 7.6.4 *WSN Applications and Platforms*
 - 7.6.5 *Wireless Sensor Network Design at a Glance*
- 7.7 SHORT CASE STUDIES AND EXAMPLES
 - 7.7.1 *UPS Adopts Bluetooth and GPS-enabled Scanners*
 - 7.7.2 *Wireless Sensor Networks as a Replacement for Land Mines*
 - 7.7.3 *Automobile Network Solutions with Bluetooth*
 - 7.7.4 *Examples of Mobile Sensor Networks*
 - 7.7.5 *Bank Tests Bluetooth-based Biometric ID System*
- 7.8 ANALYSIS OF WPAN TECHNOLOGIES AND CONCLUSIONS
- 7.9 REVIEW QUESTIONS AND EXERCISES
- 7.10 REFERENCES

8 CELLULAR NETWORKS – FROM 1G TO 5G

- 8.1 INTRODUCTION
- 8.2 PRINCIPLES OF CELLULAR NETWORKS
 - 8.2.1 *Overview*
 - 8.2.2 *How Cellular Phones Work – A Quick Look*
 - 8.2.3 *Highlights of Cellular Networks*
 - 8.2.4 *Cell Design and Frequency Utilization*
 - 8.2.5 *Location Services and Roaming Support*
 - 8.2.6 *Multiple Access Techniques and Transmission Errors*
- 8.3 FIRST GENERATION (1G) CELLULAR
- 8.4 PAGING NETWORKS
 - 8.4.1 *What are Paging Networks?*
 - 8.4.2 *Characteristics of Paging Networks*
- 8.5 SECOND GENERATION (2G) CELLULAR NETWORKS
 - 8.5.1 *Overview*
 - 8.5.2 *GSM (Global System for Mobile Communications) – The Popular 2G System*

- 8.5.3 *Using GSM and GSM Roaming Support*
- 8.5.4 *2G CDMA Cellular (IS-95)*
- 8.5.5 *Controversy: CDMA Versus TDMA*
- 8.6 DATA OVER CELLULAR NETWORKS
 - 8.6.1 *Overview*
 - 8.6.2 *Data Over Analog Cellular and CDPD*
 - 8.6.3 *Digital Cellular and GSM*
 - 8.6.4 *PCS (Personal Communication Services)*
- 8.7 THE 2.5G CELLULAR NETWORKS (GPRS)
 - 8.7.1 *GPRS (General Packet Radio Service)*
 - 8.7.2 *EDGE*
- 8.8 THIRD GENERATION (3G) CELLULAR NETWORKS
 - 8.8.1 *Highlights of 3G Networks*
 - 8.8.2 *MMS -- the Main Driver for 3G?*
 - 8.8.3 *3G Alternative Interfaces and Implementations*
 - 8.8.4 *IEEE 802.11 Versus 3G Cellular*
 - 8.8.5 *3G Design Considerations*
 - 8.8.6 *Industrial Issues – Evolution to 3G Cellular*
 - 8.8.7 *3G Summary*
- 8.9 BEYOND 3G – 4G AND 5G SYSTEMS
 - 8.9.1 *4G Cellular Networks*
 - 8.9.2 *5G Cellular Networks*
- 8.10 ALTERNATIVES TO 3G – PUBLIC DATA NETWORKS AND FLASH OFDM
 - 8.10.1 *Why Alternatives to 3G?*
 - 8.10.2 *Mobitex*
 - 8.10.3 *Ricochet*
 - 8.10.4 *Flash OFDM (Orthogonal Frequency Division Multiplexing)*
- 8.11 CELLULAR NETWORK ENGINEERING ISSUES
 - 8.11.1 *General Network Design Considerations for Next Generation Cellular Networks*
 - 8.11.2 *Mobile Telecommunications Switching Office (MTSO) Operations*
 - 8.11.3 *Mobile Wireless TDMA Design Considerations*
 - 8.11.4 *3G-CDMA Design Considerations*
 - 8.11.5 *Mobile Radio Propagation Effects and Handoff Performance*
 - 8.11.6 *Cellular Power Engineering*
 - 8.11.7 *Cellular Network Performance and Traffic Engineering – A Quick Overview*
- 8.12 SHORT CASE STUDIES AND EXAMPLES
 - 8.12.1 *Do Cellular Phones Cause Brain Cancer?*
 - 8.12.2 *CVS (Compressed Voice System) Reduces the Number of Leased Lines in Kazakhstan*
 - 8.12.3 *Wi-Fi as a Competition to 3G Cellular*
- 8.13 SUMMARY OF CELLULAR NETWORKS
- 8.14 REVIEW QUESTIONS AND EXERCISES
- 8.15 REFERENCES

9 WIRELESS LOCAL LOOPS AND SATELLITE COMMUNICATIONS

- 9.1 INTRODUCTION
- 9.2 WIRELESS LOCAL LOOPS – THE BROADBAND WIRELESS NETWORKS
 - 9.2.1 *Overview*
 - 9.2.2 *Wireless Local Loop Configurations*
 - 9.2.3 *Benefits of Wireless Local Loops*
 - 9.2.4 *Highlights of WLLs*
 - 9.2.5 *Propagation Considerations for WLL*
 - 9.2.6 *Determining Clear Space – The Fresnel Zones*
 - 9.2.7 *Examples of Wireless Local Loop Services – MMDS and LMDS*
 - 9.2.8 *Standards for Fixed Wireless Development – IEEE 802.16*

- 9.3 FREE SPACE OPTICS (FSO) – A QUICK OVERVIEW
- 9.4 SATELLITE SYSTEMS
 - 9.4.1 *Overview*
 - 9.4.2 *Highlights of Satellite Communications*
 - 9.4.3 *Satellite Systems – Classifications and Terms*
 - 9.4.4 *GEO Orbit and GEO Satellites*
 - 9.4.5 *LEO Satellite Characteristics*
 - 9.4.6 *MEO Satellite Characteristics*
 - 9.4.7 *VSAT (Very Small Aperture Terminal) Systems*
 - 9.4.8 *Examples of Satellite Systems*
 - 9.4.9 *Global Positioning System (GPS)*
 - 9.4.10 *Satellites Talking to Satellites – The “Satellite Constellations”*
 - 9.4.11 *Key Benefits of Satellite Communications*
 - 9.4.12 *Limitations of Satellite Communication*
 - 9.4.13 *Satellite versus Fiber Optics and Cellular Phones*
 - 9.4.14 *Satellite Design Issues*
- 9.5 DEEP SPACE COMMUNICATIONS AND INTERPLANETARY INTERNET
 - 9.5.1 *What is Deep Space Communications?*
 - 9.5.2 *What is DSN (Deep Space Network)?*
 - 9.5.3 *Interplanetary Internet – Internet in the Sky*
 - 9.5.4 *Delay Tolerant Networking*
 - 9.5.5 *Concluding Comments about Deep Space Communications*
- 9.6 SHORT CASE STUDIES AND EXAMPLES
 - 9.6.1 *Telkom South Africa Deploys Wireless Local Loop*
 - 9.6.2 *Wireless Local Loop in Angola*
 - 9.6.3 *Satellites Help U.S. Troops in Iraq Feel Closer to Home*
 - 9.6.4 *Satellite-based Distance Learning Systems*
 - 9.6.5 *Communication Capabilities on Mission for Mars*
- 9.7 CONCLUDING COMMENTS
- 9.8 REVIEW QUESTIONS AND EXERCISES
- 9.9 REFERENCES

10 EMERGING WIRELESS NETWORKS: UWB, FSO, MANET, AND FLASH OFDM

- 10.1 INTRODUCTION
- 10.2 POWERLINE COMMUNICATIONS NETWORKS
 - 10.2.1 *Overview*
 - 10.2.2 *Powerline Communications Characteristics*
 - 10.2.3 *Powerline Communications Market*
- 10.3 ULTRA WIDEBAND WIRELESS (UWB)
 - 10.3.1 *Introduction*
 - 10.3.2 *Technology Characteristics and Description*
 - 10.3.3 *Applications of UWB Technology*
 - 10.3.4 *Advantages and Disadvantages of UWB*
 - 10.3.5 *Concluding Comments about UWB*
- 10.4 FREE SPACE OPTICS (FSO) – A “NEW” SOLUTION TO THE LAST MILE
 - 10.4.1 *Overview*
 - 10.4.2 *Characteristics of Free Space Optics (FSO)*
 - 10.4.3 *Free Space Optics (FSO) Advantages*
 - 10.4.4 *Free Space Optics (FSO) Security*
 - 10.4.5 *Free Space Optics (FSO) Challenges*
 - 10.4.6 *Case Study: FSO in Action*
 - 10.4.7 *FSO Summary*
- 10.5 MOBILE AD HOC NETWORKS (MANETS)
 - 10.5.1 *Overview*

- 10.5.2 *Examples of MANETs*
- 10.5.3 *Key Characteristics of a MANET*
- 10.5.4 *Advantages and Challenges of MANETs*
- 10.5.5 *Protocols and Algorithms for Dynamics and Access Controls*
- 10.5.6 *Routing Protocols and Algorithms*
- 10.5.7 *Standardizing MANET*
- 10.6 WIRELESS SENSOR NETWORKS (WSNs) – A CLOSER LOOK
 - 10.6.1 *A Quick Revisit*
 - 10.6.2 *Physical Layer Considerations*
 - 10.6.3 *Data Link Layer Considerations*
 - 10.6.4 *Network Layer Considerations*
 - 10.6.5 *Transport Layer Considerations*
 - 10.6.6 *Application Layer Considerations*
 - 10.6.7 *Location Services in WSNs*
 - 10.6.8 *Data Management in WSNs*
 - 10.6.9 *WSN Security*
- 10.7 FLASH OFDM
 - 10.7.1 *Overview*
 - 10.7.2 *OFDM Technology*
 - 10.7.3 *Flash OFDM Technology – A Closer Look*
 - 10.7.4 *Concluding Comments about Flash OFDM*
- 10.8 SYNTHESIS OF WIRELESS NETWORK ALTERNATIVES
- 10.9 REVIEW QUESTIONS AND EXERCISES
- 10.10 REFERENCES

PART III: Architectures, Security, and Management

11 INTEGRATED ARCHITECTURES FOR WIRELESS

- 11.1 INTRODUCTION
- 11.2 CONCEPTS AND A FRAMEWORK FOR DISCUSSION
 - 11.2.1 *What is an Integrated Architecture?*
 - 11.2.2 *A Framework for Integrated Architectures*
 - 11.2.3 *Horizontal versus Vertical Integrations*
- 11.3 WIRELESS VISION AND EXAMPLES
 - 11.3.1 *An Integrated Architecture Vision*
 - 11.3.2 *The Internet as an Example of Good Architectural Vision*
 - 11.3.3 *Example of a General Integrated Architecture*
- 11.4 INTEGRATED NETWORK ARCHITECTURES FOR WIRELESS – LAYER 1 TO 2 ISSUES
 - 11.4.1 *Adapter Cards for Detecting Different Wireless Systems*
 - 11.4.2 *Network Interconnectivity Devices and Protocol Converters*
 - 11.4.3 *Network Integration Examples*
- 11.5 ROAMING AND MOBILE IP FOR WIRELESS INTEGRATION
 - 11.5.1 *Roaming Revisited*
 - 11.5.2 *Mobile IP as a Basis for Integration*
 - 11.5.3 *Examples of Mobile IP*
- 11.6 MIDDLEWARE AND MOBILE COMPUTING PLATFORMS FOR INTEGRATED ARCHITECTURES
 - 11.6.1 *Overview*
 - 11.6.2 *Wireless Middleware Services*
 - 11.6.3 *Mobile Computing Platforms (Mobile Application Servers)*
 - 11.6.4 *Example of a Mobile Application Server – Oracle9iAS Application Server for Wireless*

- 11.7 INTEGRATED APPLICATION ARCHITECTURES FOR MOBILE SERVICES
 - 11.7.1 *Overview of Mobile Application Architectures*
 - 11.7.2 *Integrated Application Architecture Examples*
- 11.8 TECHNOLOGY TREND – COMPONENT-BASED INTEGRATED ARCHITECTURES
 - 11.8.1 *What is a Component?*
 - 11.8.2 *What is a Component-based Architecture?*
 - 11.8.3 *.NET and J2EE as Component-based Platforms*
 - 11.8.4 *Web Services – The Cornerstone of Component-based Platforms*
 - 11.8.5 *Mobile Web Services*
- 11.9 CONCLUDING COMMENTS
- 11.10 REVIEW QUESTIONS AND EXERCISES
- 11.11 REFERENCES

12 WIRELESS SECURITY

- 12.1 INTRODUCTION
- 12.2 SECURITY PRINCIPLES
 - 12.2.1 *Overview*
 - 12.2.2 *Security Tradeoffs and a Design Procedure*
 - 12.2.3 *Overview of Core Security Technologies*
 - 12.2.4 *Information Protection (Privacy and Integrity)*
 - 12.2.5 *Authentication and PKI*
 - 12.2.6 *Authorization and Access Control*
 - 12.2.7 *Accountability and Assurance*
 - 12.2.8 *Mapping Security Technologies to Security Needs*
- 12.3 WIRELESS LAN SECURITY
- 12.4 CELLULAR WIRELESS NETWORK SECURITY
- 12.5 SATELLITE COMMUNICATION SECURITY
- 12.6 WLL AND CORDLESS SECURITY
 - 12.6.1 *Wireless Local Loop (WLL) Security*
 - 12.6.2 *Cordless Phone Security*
- 12.7 EMERGING WIRELESS NETWORK SECURITY
 - 12.7.1 *Free Space Optics (FSO) Security*
 - 12.7.2 *Mobile Ad Hoc Network Security*
 - 12.7.3 *Wireless Sensor Network Security*
- 12.8 INTERNET LAYER SECURITY PROTOCOLS – VPNs AND IPSEC
 - 12.8.1 *Virtual Private Networks (VPNs)*
 - 12.8.2 *IPSec*
- 12.9 WIRELESS MIDDLEWARE SECURITY
 - 12.9.1 *Overview*
 - 12.9.2 *Secure Socket Layer (SSL) for Wireless Web Security*
 - 12.9.3 *WAP Security and WTLS*
 - 12.9.4 *i-mode Security*
 - 12.9.5 *Wireless VPN Versus WAP Security*
- 12.10 WIRELESS APPLICATION SECURITY
 - 12.10.1 *Overview*
 - 12.10.2 *Mobile Client Security*
 - 12.10.3 *Web Server Tier (Middle Tier) Security*
 - 12.10.4 *Back-end System and Transaction Security Through SET*
- 12.11 SHORT EXAMPLES AND CASE STUDIES
 - 12.11.1 *Wireless in Government Services*
 - 12.11.2 *Wireless Security in the Health Sector*
 - 12.11.3 *Wireless LANs at Texas A&M University*
- 12.12 ANALYSIS AND DESIGN OF WIRELESS SECURITY

- 12.12.1 *Analysis of Security Tradeoffs and Design Guidelines*
- 12.12.2 *Simple Design Procedure for Wireless Security*
- 12.13 SUMMARY AND CONCLUSIONS
- 12.14 REVIEW QUESTIONS AND EXERCISES
- 12.15 REFERENCES

13 MANAGEMENT AND SUPPORT ISSUES IN WIRELESS

- 13.1 INTRODUCTION
- 13.2 STRATEGIC PLANNING
 - 13.2.1 *Business Strategy Analysis*
 - 13.2.2 *Analyzing Business Processes and Business Workflows*
 - 13.2.3 *Mobile Application Identification and Selection*
- 13.3 CAPABILITY EVALUATION AND ARCHITECTURAL VISION
 - 13.3.1 *Architecture Analysis to Support Mobility*
 - 13.3.2 *Wireless Infrastructure Planning – Identifying Technical Capabilities*
 - 13.3.3 *Capacity Planning and Traffic Engineering*
 - 13.3.4 *Resource and Cost Estimation/Evaluation*
- 13.4 DEVELOPMENT AND DEPLOYMENT CONSIDERATIONS
 - 13.4.1 *Analysis of Mobile Application Development Choices*
 - 13.4.2 *In-House Development and Deployment of Mobile Applications*
 - 13.4.3 *Acquisition and Installation of Wireless Infrastructure*
 - 13.4.4 *Renting and Outsourcing Through Service Providers*
 - 13.4.5 *Application Renting and Outsourcing Through Wireless ASPs*
- 13.5 MONITORING AND CONTROL – WIRELESS NETWORK MANAGEMENT
 - 13.5.1 *Overview*
 - 13.5.2 *Management Platforms – The General Principles*
 - 13.5.3 *Principles of Wireless Network Management*
 - 13.5.4 *Wireless Network Management Special Cases*
 - 13.5.5 *Brief Examples of Wireless Network Management Systems*
- 13.6 ADMINISTRATIVE AND ORGANIZATIONAL ISSUES
 - 13.6.1 *Organizational Design in M-Business*
 - 13.6.2 *Location-Independent Mobile “Virtual” Teams – IT For Organization Design*
 - 13.6.3 *Organizational Design in Real-Time Enterprises*
- 13.7 CHAPTER SUMMARY
- 13.8 REVIEW QUESTIONS AND EXERCISES
- 13.9 REFERENCES

PART IV: Appendices

APPENDIX A: TUTORIAL ON NETWORKS CONCEPTS

- A.1 PHYSICAL COMMUNICATION CHARACTERISTICS
 - A.1.1 *Overview*
 - A.1.2 *Basic Terms and Definitions*
 - A.1.3 *Digital to Analog Conversion: Modems and Interfacing Devices*
- A.2 DIGITAL COMMUNICATION NETWORKS
 - A.2.1 *Analog Versus Digital Communications*
 - A.2.2 *Digitizing Techniques and Codecs*
- A.3 COMMUNICATION MEDIA CHARACTERISTICS

- A.4 TOPOLOGIES, COMPRESSION, AND ENCRYPTION
 - A.4.1 *Network Layout and Topologies*
 - A.4.2 *Asynchronous Versus Synchronous Transmission and Full/Half Duplex*
 - A.4.3 *Data Encryption and Compression Techniques*
- A.5 LANS, WANS, AND MANS
 - A.5.1 *Local Area Networks*
 - A.5.2 *Wide Area Networks*
 - A.5.3 *Metropolitan Area Networks*
- A.6 ENTERPRISE NETWORKS AND NETWORK ARCHITECTURE
 - A.6.1 *Overview*
 - A.6.2 *The Open System Interconnection (OSI) Reference Model*
 - 3.1.1 *Information Flow in the OSI Model: An Example*
 - A.6.3 *Network Interconnectivity*
 - A.6.4 *Broadband Networks*
- A.7 ENTERPRISE NETWORKS – THE REALITY CHECK
 - A.7.1 *Transmission Control Program/Internet Protocol (TCP/IP) Stack*
 - A.7.2 *LAN Network Stacks and Network Operating Systems*
- A.8 REFERENCES

APPENDIX B: A CLOSER LOOK AT PHYSICAL WIRELESS COMMUNICATIONS

- B.1 INTRODUCTION
- B.2 WIRELESS ANTENNAS AND PROPAGATION – A CLOSER LOOK
 - B.2.1 *Antenna Gain*
 - B.2.2 *Free Space Loss*
 - B.2.3 *More on Noise*
- B.3 ERROR DETECTION TECHNIQUES
 - B.3.1 *Overview*
 - B.3.2 *Synchronous/Asynchronous Communications*
 - B.3.3 *Flow Control*
 - B.3.4 *Error Handling in Flow Control*
 - B.3.5 *Sample Flow Control Protocols*
 - B.3.6 *Error Detection Schemes*
 - B.3.7 *Automatic Repeat Request (ARQ)*
- B.4 ERROR CORRECTION MECHANISMS
 - B.4.1 *Overview*
 - B.4.2 *Forward Error Correction*
 - B.4.3 *Turbo Codes*
- B.5 ANALYSIS OF ENCODING TECHNIQUES ;;;; EXAMINE ;;;
 - B.5.1 *Signal Encoding Criteria*
 - B.5.2 *Binary Frequency-Shift Keying (BFSK) and Multiple Frequency-Shift Keying (MFSK)*
 - B.5.3 *Phase-Shift Keying (PSK)*
 - B.5.4 *Performance*
 - B.5.5 *Quadrature Amplitude Modulation*
 - B.5.6 *Pulse Code Modulation*
 - B.5.7 *Delta Modulation (DM)*
 - B.5.8 *Spread Spectrum Generation and Evaluation*
- B.6 REFERENCES

INDEX

