

Wireless Technology

(Code : ITC603)

Semester VI – Information Technology
(Mumbai University)

Strictly as per New Choice Based Credit and Grading System Syllabus
(Revise 2019 'C' Scheme) of Mumbai University with effective from Academic Year 2021-2022

J. S. Katre

M.E. (Electronics and Telecommunication)

Formerly, Assistant Professor

Department of Electronics Engineering

Vishwakarma Institute of Technology (V.I.T.), Pune.

Maharashtra, India

Vaishali S. Joshi



Wireless Technology (Code : ITC603)

(Semester VI – Information Technology, Mumbai University)

J. S. Katre, Vaishali S. Joshi

Copyright © Authors. All rights reserved. No part of this publication may be reproduced, copied, or stored in a retrieval system, distributed or transmitted in any form or by any means, including photocopy, recording, or other electronic or mechanical methods, without the prior written permission of the publisher.

This book is sold subject to the condition that it shall not, by the way of trade or otherwise, be lent, resold, hired out, or otherwise circulated without the publisher's prior written consent in any form of binding or cover other than which it is published and without a similar condition including this condition being imposed on the subsequent purchaser and without limiting the rights under copyright reserved above.

First Printed in India : January 2001

First Edition : January 2022 (**TechKnowledge Publications**)

This edition is for sale in India, Bangladesh, Bhutan, Maldives, Nepal, Pakistan, Sri Lanka and designated countries in South-East Asia. Sale and purchase of this book outside of these countries is unauthorized by the publisher.

ISBN : 978-93-5563-074-2

Published by :

TechKnowledge Publications

Head Office : B/5, First floor, Maniratna Complex, Taware Colony, Aranyeshwar Corner,

Pune - 411 009. Maharashtra State, India

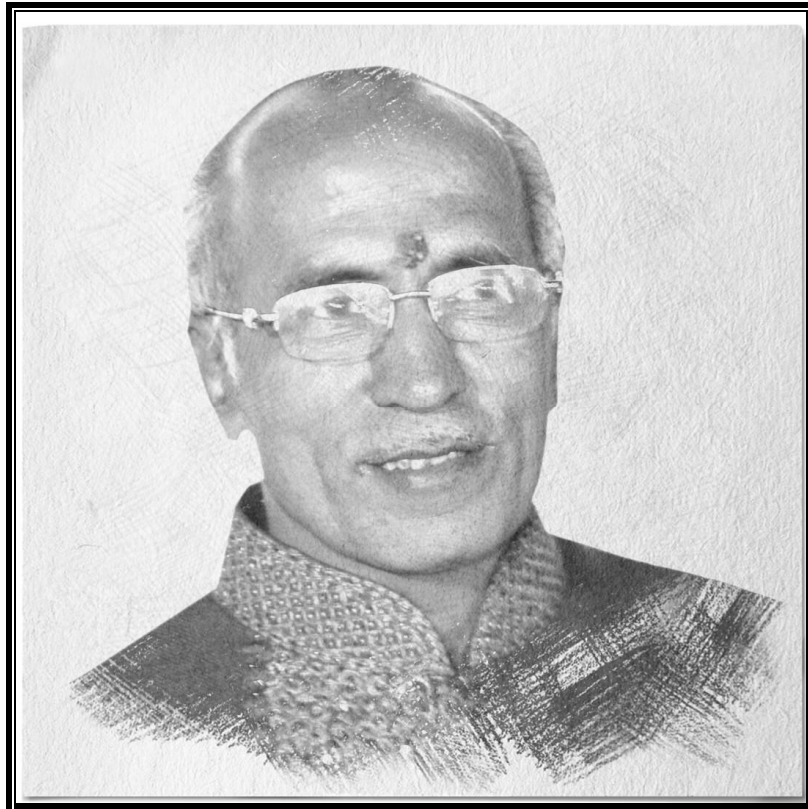
Ph : 91-20-24221234, 91-20-24225678.

Email : info@techknowledgebooks.com,

Website : www.techknowledgebooks.com

[ITC603] (FID : ME183) (Book Code : ME183A)

*We dedicate this Publication soulfully and wholeheartedly,
in loving memory of our beloved founder director,
Late Shri. Pradeepji Lalchandji Lunawat,
who will always be an inspiration, a positive force and strong support
behind us.*



“My work is my prayer to God”

- Lt. Shri. Pradeepji L. Lunawat

*Soulful Tribute and Gratitude for all Your
Sacrifices, Hardwork, and 40 years of Strong Vision...*

Syllabus...

Wireless Technology : Sem. VI (Information Technology, (MU))

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tut.	Total
ITC603	Wireless Technology	03	-	-	03	-	-	03

Course Code	Course Name	Examination Scheme							
		Theory				Exam Duration (Hrs.)	Term Work	Practical and Oral	Total
		Internal Assessment			End Sem. Exam.				
		Test 1	Test 2	Avg.					
ITC603	Wireless Technology	20	20	20	80	03	—	—	100

Course Objectives :

The course aims :

1. Discuss the Fundamentals of Wireless Communication.
2. Comprehend the Fundamental Principles of Wide Area Wireless Networking Technologies and their Applications.
3. Explain Wireless Metropolitan and Local Area Networks.
4. Describe Wireless Personal Area Networks and Ad hoc Networks
5. Learn and Analyze Wireless Network Security Standards.
6. Study the Design Considerations for Wireless Networks.

Course Outcomes :

On successful completion, of course, learner/student will be able to :

1. Describe the basic concepts of Wireless Network and Wireless Generations.
2. Demonstrate and Evaluate the various Wide Area Wireless Technologies.
3. Analyze the prevalent IEEE standards used for implementation of WLAN and WMAN Technologies
4. Appraise the importance of WPAN, WSN and Ad-hoc Networks.
5. Analyze various Wireless Network Security Standards.
6. Review the design considerations for deploying the Wireless Network Infrastructure.

Prerequisite : Principle of Communication, Computer Network and Network Design, Computer Network Security.

Module 0

Prerequisite :

Digital Modulation Techniques : ASK, FSK, BPSK, QPSK, Electromagnetic Spectrum. **Multiplexing Techniques** : FDM, TDM, OFDM. OSI and TCP / IP Model. Need for Security, Types of Security Threats and Attacks. **(Refer Article-A)**

Module I

Fundamentals of Wireless Communication :

Introduction to Wireless Communication : Advantages, Disadvantages and Applications, **Multiple Access Techniques** : FDMA, TDMA, CDMA, OFDMA ; **Spread Spectrum Techniques** : DSSS, FHSS ; **Evolution of Wireless Generations** : 1G to 5G (Based on technological differences and advancements) ; **5G** : Key requirements and drivers of 5G systems, Use cases, Massive MIMO. **(Refer Chapter 1)**
Self-learning Topics : Modulation Techniques - QAM, MSK, GMSK.

Module II

Wide Area Wireless Networks :

Principle of Cellular Communication : Frequency reuse concept, Cluster size and System capacity, Cochannel interference and Signal quality ; **GSM** : System architecture, GSM radio subsystem, Frame structure ; **GPRS and EDGE** : System architecture ; **UMTS** : Network architecture ; **CDMA 2000** : Network architecture ; **LTE** : Network architecture ; Overview of LoRa and LoRaWAN. **(Refer Chapter 2)**
Self-learning Topics : IS-95.

Module III

Wireless Metropolitan and Local Area Networks :

IEEE 802.16 (WiMax) : Mesh mode, Physical and MAC layer ; **IEEE 802.11(Wi-Fi)** : Architecture, Protocol stack, Enhancements and Applications. **(Refer Chapter 3)**
Self-learning Topics : WLL(Wireless Local Loop).

Module IV

Wireless Personal Area Networks and Ad hoc Networks :

IEEE 802.15.1 (Bluetooth) : Piconet, Scatter net, Protocol Stack ; **IEEE 802.15.4 (ZigBee)** : LR- WPAN Device Architecture, Protocol Stack ; **Wireless Sensor Network** : Design Considerations, Issues and Challenges, WSN Architecture, Applications ; **Introduction of Ad hoc Networks : MANET and VANET** : Characteristics, Applications, Advantages and Limitations ; Overview of E-VANET (Electrical Vehicular AdHoc Networks). **(Refer Chapters 4 and 5)**

Self-learning Topics : HR-WPAN (UWB)

Module V

Wireless Network Security :

Security in GSM ; UMTS Security; Bluetooth Security ; WEP ; WPA2.

(Refer Chapter 6)

Self-learning Topics : Study of Wireless Security Tools.

Module VI

Wireless Network Design Considerations :

Cisco Unified Wireless Network ; Designing Wireless Networks with Lightweight Access Points and Wireless LAN Controllers.

(Refer Chapter 7)

Self-learning Topics : Cisco Unified Wireless Network Mobility Services.

□□□

Module 0

Article A : Prerequisite A-1 to A-22

Syllabus : Digital Modulation Techniques : ASK, FSK, BPSK, QPSK, Electromagnetic spectrum. Multiplexing Techniques : FDM,TDM,OFDM. OSI and TCP/IP model. Need of security, Types of security threats and attacks.

A.1 Digital Modulation Techniques..... A-2
 A.1.1 Types of Digital Carrier Modulation A-2
 A.2 Binary and M-ary Transmission A-3
 A.2.1 Binary Transmission A-3
 A.2.2 M-ary Transmission A-3
 A.3 Binary Amplitude Shift Keying (BASK) A-4
 A.3.1 Bandwidth of BASK Signal A-4
 A.3.2 Merits and Demerits of ASK A-4
 A.4 Phase Shift Keying (PSK) A-4
 A.4.1 Binary Phase Shift Keying (BPSK) A-5
 A.4.2 Bandwidth of BPSK A-5
 A.4.3 Advantages of BPSK A-6
 A.4.4 Disadvantage of BPSK A-6
 A.4.5 Applications A-6
 A.5 Binary Frequency Shift Keying (FSK) A-6
 A.5.1 Bandwidth of BFSK A-6
 A.5.2 Advantages of BFSK A-7
 A.5.3 Disadvantages of BFSK A-7
 A.5.4 Applications of BFSK A-7
 A.6 Quadrature PSK (QPSK) A-7
 A.6.1 Mathematical Representation of QPSK A-8
 A.6.2 Symbol Transmission Rate A-9
 A.6.3 Bandwidth of QPSK A-9
 A.6.4 Advantages of QPSK A-10
 A.6.5 Disadvantage A-10
 A.6.6 Applications A-10
 A.7 The Electromagnetic Spectrum A-10
 A.7.1 Different Frequency Bands A-11

A.8 Multiplexing and Demultiplexing A-11
 A.8.1 Types of Multiplexing A-12
 A.9 Frequency Division Multiplexing (FDM) A-12
 A.9.1 Advantages of FDM A-13
 A.9.2 Disadvantages of FDM A-13
 A.9.3 Applications of FDM A-13
 A.10 Time Division Multiplexing A-13
 A.10.1 Advantages of TDM A-14
 A.10.2 Disadvantages of TDM A-14
 A.10.3 Applications of TDM A-14
 A.11 OSI Model A-14
 A.11.1 Peer to Peer Processes A-15
 A.12 Functions of Various Layers in the OSI Model A-16
 A.13 TCP / IP Protocol Model A-18
 A.13.1 Layered Architecture A-18
 A.13.2 Layers in the TCP/IP Protocol Model . A-19
 A.14 Overview of TCP / IP Architecture A-19
 A.14.1 Description of TCP / IP Model A-20
 A.15 Security A-21
 A.15.1 Security Attacks A-21
 A.15.2 Attacks on Confidentiality A-21
 A.15.3 Attacks on Integrity A-22
 A.15.4 Attacks on Availability A-22
 • **Review Questions..... A-22**

Module I

Chapter 1 : Fundamentals of Wireless Communication

1-1 to 1-42

Syllabus : Introduction to Wireless Communication : Advantages, Disadvantages and Applications, **Multiple Access techniques :** FDMA, TDMA, CDMA, OFDMA ; **Spread Spectrum Techniques :** DSSS, FHSS : **Evolution of Wireless Generations :** 1G to 5G (Based on technological differences and advancements); **5G :** Key requirements and drivers of 5G systems, Use cases, Massive MIMO.



1.1	Introduction to Wireless Communication	1-2	1.10	Time Division Multiple Access (TDMA)	1-16
1.1.1	Need of Wireless Communication	1-2	1.10.1	TDMA Features	1-16
1.1.2	Wired and Wireless Networks	1-3	1.10.2	Advantages of TDMA	1-16
1.2	Fundamentals of Wireless Communication	1-3	1.10.3	Advantages of TDMA over FDMA	1-17
1.2.1	Elements of a Wireless Communication System	1-3	1.10.4	Disadvantages	1-17
1.2.2	Signal Transmission	1-4	1.10.5	Problems with FDMA and TDMA	1-17
1.2.3	Path Loss of Radio Signals	1-5	1.11	Code Division Multiple Access (CDMA)	1-17
1.2.4	Propagation of EM Waves (Types of Wave Propagation)	1-5	1.11.1	Spread Spectrum and CDMA	1-18
1.2.5	Additional Signal Propagation Effects ..	1-5	1.11.2	Basic Structure of CDMA System	1-19
1.2.6	Multipath Propagation	1-7	1.11.3	Salient Features of CDMA Systems	1-20
1.2.7	Fading	1-7	1.11.4	Multiple Access Techniques in Cellular Systems	1-20
1.2.8	Important Definitions	1-7	1.11.5	Advantages of CDMA	1-21
1.3	Advantages of Wireless Communication	1-8	1.11.6	Disadvantages	1-21
1.4	Limitations of Wireless Communication	1-9	1.11.7	CDMA Applications	1-21
1.5	Applications of Wireless Communication	1-9	1.12	OFDMA (Orthogonal Frequency Division Multiple Access)	1-21
1.5.1	Vehicles	1-9	1.12.1	Features of OFDMA	1-22
1.5.2	Emergencies	1-9	1.12.2	Disadvantage of OFDMA	1-22
1.5.3	Business	1-9	1.12.3	Applications of OFDMA	1-22
1.5.4	Replacement of Wired Networks	1-10	1.12.4	Comparison of Multiple Access Strategies	1-23
1.5.5	Infotainment	1-10	1.13	Spread-Spectrum Multiple Access (SSMA)	1-24
1.5.6	Location Dependent Services	1-10	1.14	Spread Spectrum Technologies	1-25
1.5.7	Mobile and Wireless Devices	1-10	1.14.1	Frequency Hopping Spread Spectrum (FHSS)	1-25
1.6	The Wireless Media	1-11	1.14.2	Direct Sequence Spread Spectrum (DSSS)	1-26
1.6.1	Radio Frequency Waves	1-11	1.15	DSSS System	1-26
1.7	Multiple Access.....	1-12	1.15.1	Advantages and Disadvantages of the DS-SS System	1-27
1.7.1	Frequency Division Duplexing (FDD) ..	1-12	1.15.2	Applications of DS-SS System	1-28
1.7.2	Time Division Duplexing (TDD)	1-13	1.16	Frequency Hop Spread Spectrum (FH-SS) Multiple Access	1-28
1.8	Multiple Access Techniques	1-13	1.16.1	Operation of FHSS	1-29
1.9	Frequency Division Multiple Access (FDMA)	1-14	1.16.2	Types of Frequency Hopping	1-29
1.9.1	Features of FDMA	1-14			
1.9.2	Nonlinear Effects in FDMA	1-15			
1.9.3	Merits of FDMA	1-15			
1.9.4	Demerits of FDMA	1-15			



1.16.3	Advantages and Disadvantages of FH-SS System	1-30
1.16.4	Applications of FHSS	1-30
1.17	Wireless Generations	1-30
1.17.1	First Generation Analog Cellular Voice	1-31
1.17.2	Second Generation Digital Voice	1-32
1.17.3	Third Generation Digital Voice and Data	1-32
1.17.4	Fourth Generation (4G)	1-33
1.18	5G and Above Wireless Networks	1-34
1.18.1	Why 5G ?	1-34
1.18.2	Features of 5G	1-34
1.18.3	Features of Fifth Generation	1-35
1.18.4	Expectations in 5G Network	1-35
1.18.5	Technologies of 5G	1-35
1.18.6	Advantages of 5G Technology	1-35
1.18.7	Applications of 5G	1-35
1.18.8	Challenges for 5G Networks	1-35
1.19	Comparison of Various Mobile System Generations	1-36
1.20	Introduction to Multi-antenna Technologies	1-37
1.21	Multi-antenna Techniques	1-37
1.22	MIMO (Multiple Input Multiple Output) Systems	1-38
1.22.1	A 2 x 2 MIMO	1-39
1.22.2	Parameters for Maximum Throughput	1-40
1.22.3	Space Time Codes (STCs)	1-40
1.22.4	Advantages of MIMO	1-41
1.22.5	Disadvantages of MIMO	1-41
1.22.6	Applications of MIMO	1-41
•	Review Questions	1-41

Module II**Chapter 2 : Wide Area Wireless Networks 2-1 to 2-54**

Syllabus : Principle of Cellular Communication : Frequency reuse concept, Cluster size and System capacity, Cochannel interference and Signal quality ; **GSM :** System architecture, GSM radio subsystem, Frame structure ; **GPRS and EDGE :** System architecture ; **UMTS :** Network architecture ; **CDMA 2000 :** Network architecture ; **LTE :** Network architecture ; Overview of LoRa and LoRaWAN.

2.1	Introduction to Cellular Telephone System	2-2
2.1.1	Important Definitions	2-2
2.2	Basic Cellular System	2-3
2.2.1	Structure of Cellular System	2-4
2.2.2	Advantages of Cellular Concept	2-5
2.3	Concept of Frequency Reuse	2-5
2.3.1	Frequency Reuse Schemes	2-6
2.3.2	Capacity of Cellular System (C)	2-7
2.3.3	Frequency Reuse Distance	2-7
2.4	Hand Off	2-12
2.4.1	Handoff Strategies	2-13
2.4.2	Different Types of Hand Offs	2-14
2.5	Improving Coverage and Capacity in Cellular Systems	2-15
2.5.1	Cell Splitting	2-16
2.5.2	Cell Sectoring	2-17
2.5.3	Repeaters for Range Extension	2-17
2.6	Wireless Technologies	2-18
2.7	2G and 3G Cellular Systems	2-18
2.7.1	Evolution from 2G to 3G Cellular Networks	2-19
2.7.2	Third Generation Digital Voice and Data	2-20
2.7.3	Services Provided by 3G Systems	2-21
2.8	Global System for Mobile (GSM)	2-21



2.8.1	GSM The European TDMA Digital Cellular Standard	2-21	2.16.1	Advantages of 3G Wireless Networks	2-41
2.8.2	Features of GSM	2-21	2.16.2	Disadvantages of 3G Wireless Networks	2-41
2.8.3	GSM Services	2-22	2.16.3	Applications of 3G Networks	2-42
2.8.4	Telephone Services	2-23	2.16.4	Various 3G Standards	2-42
2.8.5	Bearer Services	2-24	2.17	CDMA 2000	2-42
2.8.6	Teleservices	2-24	2.17.1	Advanced Versions of CDMA 2000	2-42
2.8.7	Supplementary Services	2-25	2.17.2	Specifications of CDMA 2000	2-43
2.9	GSM System Architecture	2-25	2.17.3	Features of CDMA 2000	2-43
2.9.1	GSM Frequency Spectrum	2-26	2.17.4	Advantages of CDMA 2000	2-44
2.9.2	Detail GSM Architecture	2-26	2.17.5	Disadvantages of CDMA 2000	2-44
2.9.3	GSM Air Interface	2-27	2.18	Universal Mobile Telecommunication Service (UMTS) or W-CDMA	2-44
2.10	GSM Logical Channel Types	2-27	2.18.1	Features of UMTS	2-45
2.10.1	GSM Traffic Channels (TCHs)	2-28	2.18.2	UMTS Releases and Standards	2-45
2.10.2	GSM Control Channels (CCH)	2-28	2.18.3	Features of UMTS Standards	2-45
2.11	Frame Structure of GSM System	2-30	2.19	UMTS Architecture	2-46
2.12	Signal Processing in GSM	2-31	2.19.1	UMTS Domain and Interfaces	2-46
2.13	Call Processing in GSM / Typical Call Flow Sequences in GSM	2-32	2.19.2	UTRA-Network (UTRAN) Architecture	2-47
2.13.1	Handover in GSM	2-34	2.19.3	Core Network of UMTS (UMTS Network Architecture)	2-49
2.13.2	Types of Handover in GSM	2-34	2.19.4	UMTS Specifications / UMTS Air Interface Specification	2-49
2.14	General Packet Radio Service (GPRS)	2-35	2.19.5	Comparison of UMTS and GSM	2-50
2.14.1	Architecture of GPRS	2-36	2.19.6	UMTS Security Process	2-50
2.14.2	GPRS Services	2-37	2.19.7	Advantages of UMTS	2-51
2.14.3	Logical Channels in GPRS	2-38	2.19.8	Disadvantages of UMTS	2-51
2.14.4	Characteristics of GPRS	2-39	2.19.9	UMTS Applications	2-51
2.14.5	Advantages of GPRS	2-39	2.19.10	Comparison of WCDMA (UMTS) and CDMA 2000	2-51
2.14.6	Disadvantages / Drawbacks of GPRS	2-39	2.20	Fourth Generation (4G) LTE	2-51
2.14.7	Applications of GPRS	2-39	2.20.1	4G (LTE) Network Structure (Architecture)	2-52
2.14.8	Comparison of GSM and GPRS	2-39	2.20.2	Applications of 4G	2-53
2.15	EDGE for 2.5G GSM and IS-136	2-39	2.20.3	Features of 4G Systems	2-53
2.15.1	Comparison of EDGE 2.5G and GPRS	2-40			
2.16	Need of 3G and 4G Technology	2-40			

2.20.4 Advantages and Disadvantages of 4G 2-53

2.21 4G LTE 2-54

- **Review Questions 2-54**

Module III

Chapter 3 : Wireless MANs & Wireless LANs 3-1 to 3-54

Syllabus : IEEE 802.16 (WiMax) : Mesh mode, Physical and MAC layer ; IEEE 802.11(Wi-Fi) : Architecture, Protocol stack, Enhancements and Applications.

<p>3.1 Introduction 3-2</p> <p> 3.1.1 Why Wireless LANs 3-2</p> <p>3.2 Wireless LANs 3-2</p> <p> 3.2.1 IEEE Standards 3-3</p> <p> 3.2.2 Wi-Fi 3-3</p> <p> 3.2.3 Advantages of WLANs 3-3</p> <p> 3.2.4 ISM Band 3-3</p> <p>3.3 WLAN Equipment 3-4</p> <p> 3.3.1 LAN Adapter 3-4</p> <p> 3.3.2 Access Point (AP) 3-4</p> <p> 3.3.3 Outdoor LAN Bridges 3-5</p> <p>3.4 WLAN Topologies 3-6</p> <p> 3.4.1 Peer-to-peer (ad hoc) Topology 3-6</p> <p> 3.4.2 AP Based Topology 3-6</p> <p>3.5 WLAN Propagation Technologies 3-7</p> <p>3.6 Characteristics of WLANs 3-7</p> <p> 3.6.1 Attenuation 3-7</p> <p> 3.6.2 Interference 3-7</p> <p> 3.6.3 Multipath Propagation 3-7</p> <p> 3.6.4 Error 3-7</p> <p>3.7 Medium Access Control (MAC) 3-8</p> <p> 3.7.1 MAC Protocol Issues 3-8</p> <p> 3.7.2 Hidden Terminal Problem 3-8</p>	<p> 3.7.3 Exposed Station Problem 3-9</p> <p>3.8 The IEEE 802.11 Standard for WLAN 3-10</p> <p> 3.8.1 Classification of WLANs 3-10</p> <p> 3.8.2 The IEEE 802.11 Protocol Stack 3-10</p> <p> 3.8.3 802.11 Network Architecture 3-11</p> <p> 3.8.4 Types of Stations 3-12</p> <p>3.9 The Physical Layer 3-13</p> <p> 3.9.1 IEEE 802.11 FHSS 3-14</p> <p> 3.9.2 IEEE 802.11 DSSS 3-15</p> <p> 3.9.3 IEEE 802.11 Infrared 3-17</p> <p> 3.9.4 IEEE 802.11 a OFDM 3-17</p> <p> 3.9.5 IEEE 802.11 b HR-DSSS 3-18</p> <p> 3.9.6 IEEE 802.11 g OFDM 3-18</p> <p> 3.9.7 IEEE 802.11 n OFDM 3-18</p> <p>3.10 MAC Sub-layer 3-19</p> <p> 3.10.1 RTS and CTS Messages 3-19</p> <p> 3.10.2 The Retry Counters 3-19</p> <p> 3.10.3 Different Time Intervals 3-19</p> <p> 3.10.4 Distributed Co-ordination Function (DCF) 3-20</p> <p> 3.10.5 Hidden Station Problem 3-21</p> <p>3.11 Point Co-ordinate Function (PDF) 3-22</p> <p> 3.11.1 Fragmentation 3-23</p> <p>3.12 Framing 3-23</p> <p> 3.12.2 Exposed Station Problem 3-24</p> <p>3.13 Advantages of WLANs 3-25</p> <p> 3.13.1 Disadvantages of WLAN 3-25</p> <p>3.14 Applications of Wireless LAN 3-25</p> <p>3.15 Wireless Metropolitan Area Network (WMAN) 3-25</p> <p> 3.15.1 WiMAX 3-26</p>
---	--

<p>3.15.2 WiBro (Wireless Broadband) 3-26</p> <p>3.15.3 Need of Wireless MAN (WMAN) 3-26</p> <p>3.16 IEEE 802.16 (Wi-MAX) 3-27</p> <p>3.17 Types of Wi-Max 3-28</p> <p>3.17.1 Fixed Wi-Max Services 3-28</p> <p>3.17.2 Mobile Wi-Max Services 3-29</p> <p>3.17.3 Comparison between Fixed and Mobile WiMAX 3-29</p> <p>3.18 IEEE 802.16 Standards 3-29</p> <p>3.18.1 Comparison of IEEE 802.16 Standards 3-30</p> <p>3.18.2 Advantages of IEEE 802.16 (WiMAX) 3-31</p> <p>3.18.3 Comparison of IEEE 802.11 and IEEE 802.16 3-32</p> <p>3.19 WMAN (802.16) Network Architecture 3-33</p> <p>3.19.1 Network Components 3-33</p> <p>3.19.2 Features / Characteristics of WiMAX 3-34</p> <p>3.19.3 WiMAX Mobility Support 3-36</p> <p>3.20 The 802.16 Protocol Stack / Architecture 3-36</p> <p>3.21 Physical Layer of IEEE 802.16 Protocol 3-38</p> <p>3.21.1 Scalable Orthogonal Frequency Division Multiple Access (SOFDMA) 3-38</p> <p>3.21.2 Frequency Bands Supported by IEEE 802.16 3-39</p> <p>3.21.3 IEEE 802.16 Physical Layer Mechanisms / Modes / Versions 3-39</p> <p>3.21.4 Specifications IEEE 802.16 Physical Layer Modes 3-40</p> <p>3.21.5 OFDM Version of WiMAX 3-40</p> <p>3.21.6 Other Mechanisms of the PHY Layer . 3-41</p> <p>3.21.7 Features of Physical Layer 3-42</p> <p>3.21.8 Advantages of Physical Layer 3-43</p>	<p>3.21.9 Radio Link Control (RLC)3-43</p> <p>3.22 MAC Layer (IEEE 802.16)3-44</p> <p>3.22.1 Sub-channelization3-44</p> <p>3.22.2 WiMAX Frame3-45</p> <p>3.23 MAC Sub-layers3-45</p> <p>3.23.1 Architecture of MAC Common Part Sub-layer3-47</p> <p>3.23.2 MAC PDU (Protocol Data Unit) Format3-47</p> <p>3.23.3 Frame Format of Wi-Max MAC Frame3-48</p> <p>3.23.4 Transmission of MAC PDUs3-49</p> <p>3.23.5 MAC Quality of Service (QoS)3-50</p> <p>3.23.6 Packet Scheduling in WiMAX3-52</p> <p>3.23.7 Features of IEEE 802.16 MAC Layer3-53</p> <p>3.23.8 Advantages of IEEE 802.16 MAC Layer...3-53</p> <p>• Review Questions..... 3-53</p>
--	--

Module IV

Chapter 4 : Wireless PANs 4-1 to 4-26

Syllabus : IEEE 802.15.1 (Bluetooth) : Piconet, Scatternet, Protocol stack ; IEEE 802.15.4 (ZigBee) : LRWPAN Device architecture, Protocol Stack.

<p>4.1 PAN (Personal Area Network) 4-2</p> <p>4.2 Introduction to Wireless PAN (WPAN) 4-2</p> <p>4.2.1 Need of Wireless PAN 4-3</p> <p>4.3 Bluetooth Technology (WPAN) (IEEE 802.15.1) 4-3</p> <p>4.3.1 Principle of Bluetooth 4-4</p> <p>4.4 Technical Overview 4-4</p> <p>4.4.1 Features of Bluetooth 4-5</p> <p>4.4.2 Radio Specifications of BT 4-5</p> <p>4.4.3 Bluetooth Devices 4-5</p> <p>4.5 Bluetooth Architecture 4-6</p> <p>4.5.1 Piconets 4-6</p>
--



4.5.2	Scatternets	4-7	4.14.3	Network Layer	4-24
4.5.3	Comparison of Piconet and Scatternet	4-8	4.14.4	Application Layer	4-24
4.6	Bluetooth Protocol Stack	4-8	4.14.5	Applications of ZigBee	4-25
4.6.1	Logical Link Control and Adaptation Protocol (L2CAP)	4-10	4.14.6	Comparison between Bluetooth and ZigBee	4-25
4.6.2	Frame Format in Baseband Layer	4-11	4.15	Comparison of Wireless PAN, Wireless LAN and Wireless MAN	4-25
4.6.3	TDMA (Time Division Multiple Access)	4-12	•	Review Questions.....	4-26
4.6.4	Frequency Band	4-13	Module IV		
4.6.5	FHSS	4-14	<hr/>		
4.6.6	Modulation	4-14	Chapter 5 : Ad-hoc Networks 5-1 to 5-22		
4.7	Link Types	4-14	Syllabus : Wireless sensor Network : Design considerations, Issues and Challenges, WSN architecture, Applications. Introduction to Ad-hoc Networks : MANET and VANET : Characteristics and Application, Advantage and Limitations ; Overview of E-VANET (Electrical Vehicular Ad-hoc Networks).		
4.7.1	SCO Link	4-14	5.1	Introduction to Wireless Networks	5-2
4.7.2	ACL Link	4-14	5.1.1	An Example of Wireless Network	5-2
4.8	Packet Transmission in Bluetooth	4-14	5.2	Introduction to Wireless Sensor Networks (WSN)	5-3
4.9	State Model of Bluetooth	4-15	5.2.1	Issues and Challenges in Designing WSN	5-3
4.9.1	Standby Mode	4-15	5.2.2	Operating Environment Constraints in WSN	5-3
4.9.2	Connection Mode	4-15	5.2.3	Requirements of WSN	5-4
4.9.3	Connection Establishment in BT	4-16	5.3	WSN Architecture	5-4
4.9.4	Advantages of Bluetooth	4-17	5.4	WSN Technologies	5-5
4.9.5	Disadvantages of Bluetooth	4-17	5.4.1	WSN Characteristics	5-5
4.10	Applications of BT	4-18	5.4.2	Advantages of WSN	5-6
4.11	Comparison of B.T. and WLAN	4-18	5.4.3	Disadvantages of WSN	5-6
4.12	ZigBee (IEEE 802.15.4)	4-19	5.4.4	Applications of WSN	5-6
4.12.1	Features of ZigBee	4-19	5.5	Classification of Wireless Networks	5-7
4.12.2	Radio Specifications	4-19	5.5.1	Infrastructure Networks	5-7
4.12.3	Types of ZigBee Technology	4-20	5.5.2	Wireless Ad-hoc Networks	5-7
4.12.4	ZigBee Components	4-20	5.5.3	Comparison of Infrastructure and Infrastructure-less Networks	5-8
4.13	ZigBee Topologies	4-21			
4.13.1	Star Topology	4-21			
4.13.2	Mesh (Peer to Peer) Topology	4-22			
4.13.3	Cluster Tree Topology	4-22			
4.14	ZigBee Stack	4-22			
4.14.1	Physical Layer	4-23			
4.14.2	MAC Layer	4-23			

<p>5.6 Features of Wireless Ad-hoc Network5-9</p> <p>5.7 Advantages of Wireless Ad-hoc Network 5-10</p> <p>5.8 Applications of Wireless Ad-hoc Network 5-10</p> <p> 5.8.1 Comparison of Cellular Networks and Ad-hoc Wireless Networks 5-11</p> <p> 5.8.2 Comparison of Wireless Sensor Networks and Ad-hoc Networks 5-12</p> <p>5.9 Introduction to Mobile Ad-hoc Networks (MANETs) 5-12</p> <p> 5.9.1 Design Challenges in MANET 5-12</p> <p> 5.9.2 MANET Topology 5-13</p> <p>5.10 Network Architecture of MANETs 5-14</p> <p>5.11 Features / Characteristics of MANETs 5-15</p> <p> 5.11.1 Advantages of MANET 5-15</p> <p> 5.11.2 Limitations / Disadvantages of MANET 5-15</p> <p> 5.11.3 Applications of MANET 5-15</p> <p>5.12 Vehicular Ad-hoc Networks (VANETs) 5-16</p> <p> 5.12.1 Characteristics of VANETs 5-16</p> <p>5.13 Network Architecture of VANET 5-18</p> <p>5.14 VANET Technologies 5-19</p> <p> 5.14.1 Advantages of VANET 5-19</p> <p> 5.14.2 Disadvantages of VANET 5-19</p> <p> 5.14.3 Applications of VANETs 5-19</p> <p>5.15 Comparison of MANET and VANET 5-20</p> <p>5.16 Overview of E-VANET 5-21</p> <p> 5.16.1 E-VANET Architecture 5-21</p> <p> • Review Questions 5-22</p>	<p>6.4 Key Principles of Security 6-3</p> <p> 6.4.1 Security Goals / Security Issues of Wireless Networks 6-4</p> <p> 6.4.2 Threat 6-4</p> <p>6.5 Security Attacks 6-4</p> <p> 6.5.1 Attacks on Confidentiality 6-4</p> <p> 6.5.2 Attacks on Integrity 6-5</p> <p> 6.5.3 Attacks on Availability 6-5</p> <p>6.6 Model of Network Security 6-5</p> <p>6.7 Techniques to Achieve Security Goals 6-6</p> <p> 6.7.1 Cryptography 6-6</p> <p> 6.7.2 Steganography 6-8</p> <p>6.8 Cryptography Techniques 6-8</p> <p>6.9 Symmetric Key Cryptography 6-8</p> <p> 6.9.1 Types of Symmetric Key Ciphers 6-8</p> <p> 6.9.2 Traditional Symmetric Key Ciphers 6-8</p> <p> 6.9.3 A Modern Block Cipher 6-9</p> <p>6.10 Data Encryption Standard (DES) 6-9</p> <p> 6.10.1 Key Generation 6-10</p> <p>6.11 Asymmetric Key Cryptography 6-10</p> <p> 6.11.1 Public (Asymmetric) Key Cryptosystem 6-11</p> <p>6.12 Security Services 6-11</p> <p> 6.12.1 Message Integrity 6-12</p> <p> 6.12.2 Message Authentication 6-12</p> <p>6.13 Digital Signature 6-13</p> <p> 6.13.1 Digital Signature Process 6-13</p> <p> 6.13.2 Signing the Digest 6-14</p> <p> 6.13.3 Services Provided by Digital Signature 6-14</p> <p> 6.13.4 Entity Authentication 6-15</p> <p>6.14 Security in GSM 6-15</p> <p> 6.14.1 Access Control and Authentication 6-16</p> <p> 6.14.2 Confidentiality 6-16</p> <p> 6.14.3 Anonymity 6-16</p>
--	---

Module V

Chapter 6 : Wireless Network Security 6-1 to 6-32

Syllabus : Security in GSM ; UMTS security ; Bluetooth security ; WEP ; WAP2.

6.1 Introduction6-2
6.2 Security Services6-2
6.3 Need for Security6-3



6.14.4	Authentication in GSM	6-16	7.2.1	Classification of Wireless Networks based on their Range.....	7-4
6.14.5	Authentication Algorithm A-3	6-17	7.2.2	Comparison between Wireless Technologies.....	7-5
6.14.6	Data Encryption Process using A-5 and A-8 Algorithm	6-17	7.3	RF Theory	7-5
6.15	UMTS Security Process	6-18	7.3.1	Phenomena Affecting RF	7-6
6.16	Bluetooth Security	6-19	7.3.2	Units of RF	7-8
6.16.1	Security Architecture	6-19	7.3.3	RF Antennas	7-9
6.16.2	Security Levels / Security Features	6-20	7.4	Agencies and Standards Groups	7-10
6.16.3	Security at Link Layer	6-21	7.4.1	IEEE Standards.....	7-10
6.16.4	Key Management	6-21	7.5	IEEE 802.11 Operational Standards	7-10
6.16.5	Key Generation and Initialization	6-21	7.5.1	ISM Band.....	7-10
6.16.6	Ad Hoc Security Aspects	6-23	7.5.2	IEEE 802.11b/g Standards in the 2.4 GHz Band	7-11
6.16.7	Security Limitations in Bluetooth	6-23	7.5.3	IEEE 802.11a OFDM Standard in the 5-GHz Band	7-12
6.17	Wired Equivalent Privacy (WEP) Security.....	6-23	7.5.4	IEEE 802.11a/b/g Comparison.....	7-14
6.17.1	WEP Security Mechanisms	6-23	7.6	Comparison of Wired and Wireless LANs	7-14
6.17.2	WEP Security Flaws	6-24	7.7	Cisco WLAN Components	7-14
6.18	Wireless Application Protocol (WAP)	6-24	7.8	WLAN Operation	7-15
6.18.1	WAP Gateway	6-26	7.9	WLAN Security	7-17
6.18.2	WAP Protocol	6-26	7.9.1	Features of IEEE802.11i	7-17
6.18.3	WAP 2.0	6-29	7.9.2	Evolution of WLAN Security	7-18
6.19	WML (Wireless Markup Language)	6-30	7.10	Cisco Unified Wireless Network (Cisco UWN) ..	7-18
6.19.1	WML Script	6-31	7.11	Cisco UWN Architecture	7-18
6.19.2	Advantages of WAP	6-31	7.11.1	Elements of Cisco UWN Architecture.....	7-18
6.19.3	Disadvantages of WAP	6-31	7.11.2	Cisco UWN with Lightweight AP and WLC	7-20
6.19.4	Applications of WAP	6-31	7.11.3	Cisco UWN Wireless Authentication and Encryption	7-21
	Review Questions	6-31	7.12	Fundamentals of LWAPP	7-22

Module VI

Chapter 7 : Wireless Network Design Considerations

7-1 to 7-26

Syllabus : Cisco unified wireless network; Designing wireless networks with lightweight access points and wireless LAN controllers.

7.1	Wireless Technology	7-2	7.12.1	Layer 2 LWAPP Architecture	7-22
7.1.1	An Example of Wireless Network.....	7-2	7.12.2	Layer 3 LWAPP Architecture	7-22
7.2	Classification of Wireless Networks	7-3			



7.13	WLAN Controllers	7-22	7.17	Design Considerations for Guest Services in Wireless Networks	7-25
7.14	Designing Wireless Networks with Lightweight Access Points and Wireless LAN Controllers	7-23	7.18	Design Considerations for Outdoor Wireless Networks	7-25
7.15	RF Site Survey	7-23	7.19	Design Considerations for Campus Wireless Networks	7-25
	7.15.1 Process of RF Site Survey	7-23	7.20	Design Considerations for Branch Office Wireless Networks	7-26
7.16	WLC Redundancy Design	7-24		• Review Questions.....	7-26
	7.16.1 Dynamic Controller Redundancy	7-24			
	7.16.2 Deterministic Controller Redundancy	7-24			

□□□

