Course Level

Intermediate

Next Generation 802.11 Wireless Local Area Networks

This is a 2 day course technical course intended to give student a solid understanding of the emerging IEEE 802.11 standards, how it works including the emerging mesh, fast handover and high throughput standards. The course is divided into five distinct modules.

1. Overview of 802.11 and Update on Specification Status
2. 802.11 QoS and MAC Frame Structure
3. 802.11n High Throughput
4. 802.11s Mesh Networking
5. 802.11r Fast Handover and VoWLAN

Course Objectives:

At the end of this course the student should be able to:

- Understand the status of the emerging IEEE 802.11 enhancements
- List the major strength of the ODFM air interface and understand why this has become the air interface of choice for next generation wireless broadband networks
- Describe the major features of the emerging 802.11n High Throughput standard
- Explain the major enhancements 802.11 currently under definition, including 802.11r Fast Transition to support voice over WLANs and 802.11s Mesh Networking
- Define how QoS may be maintained over a mesh network
- Discuss how 802.11 is being used to provide mobile voice services and interworking with cellular and fixed wired voice services

Who should attend this course:

This will be of benefit to any one working with Wi-Fi, including marketing and sales, technical support and product development staff.

Course Prerequisites

There are no prerequisite requirements to attend this course, however it is strongly recommend that students first attend the Basics of 802.11 Wireless Local Area networks training course.

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1. Overview of 802.11 Enhancements

By the end of this module, course attendees will be able to:

- Describe the major operational aspects of 802.11 WLAN
- Understanding the difference between the different 802.11 physical layers
- List the major enhancements to the 802.11 specifications
- Be aware of the current status of the 802.11 enhancements

Module Outline

Changing Wireless Market

- Traditional 802.11 Network Deployments
- Mesh Networks
- "Hot Spot in a BOX" – Interworking with WiMAX
- Municipal Wi-Fi (MUNI Wi-Fi)
- Municipal Wireless Projects in the US
- MUNI Wi-Fi Deployment Examples
- Illustration of MUNI Wi-Fi Network
- Voice over WLANs
- Voice over Wireless LAN Products
- Market Reacting to VoWLAN Opportunity
- Dual Mode Wi-Fi / Cellular Phones
- VoWLAN Standards
- Fixed Mobile Convergence (FMC) Standards
- Cellular Carrier T-Mobile offers VoWLAN
- Wireline Carrier SBC Bundles Wi-Fi with DSL

Overview of How 802.11 Works

- Wireless LAN Deployments
- 802.11 Terminology
- Operations in Unlicensed Frequency Bands
- 802.11b Direct Sequence Spread Spectrum
- 802.11a Orthogonal frequency Division Multiplexing
- 802.11g Backward Compatibility
- Contrasting 802.11a, b and g
- Connecting to an 802.11 Network
- Authentication and Association
- Acquiring Resources to Send data
- Distributed Coordination Functions (DCF)
- RTS/CTS Management Frames
- Point Coordination Functions (PCF)
- Polling Mechanism and Known Weaknesses
- InterFrame Spacing Prioritizes Traffic
- Overview of Contention Handling

802.11 Standards Evolution

- Timeline
- Status of 802.11k Radio Measurements
- Status of 802.11n High Throughput
- Status of 802.11r Fast BSS Transition
- Status of 802.11s Mesh Networking
- Status of 802.11y Contention Based Protocol
- New Study Groups

Module Summary

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2. 802.11n Physical Layer

By the end of this module, course attendees will be able to:

- Discuss the advantage of OFDM for broadband data
- Explain the key aspects an MIMO antenna technology
- Understanding the major difference between 802.11a, b, g and n
- List the techniques used by the 802.11n Physical Layer to attain data rates of over 100Mb/s

Module Outline

Introduction to 802.11 Physical Layer

- IEEE 802.11 Protocol Stack
- 802.11 Supports Multiple Physical Layers
- Contrasting the different 802.11 Physical Layers
- Achieving Higher Data Rates
- Next Generation 802.11 WLANs

Orthogonal Frequency Division Multiplexing (OFDM)

- History of OFDM
- Overview of Orthogonal Frequency Division Multiplexing
- How OFDM Works
- OFDM – Users take Turns in Transmitting
- 802.11n Combines OFDM and MIMO

Advantages of OFDM

- Range of Bandwidths Supported
- Multipath
- Inter-Symbol Interference (ISI)
- Higher Data Rates Introduce Complexity
- OFDM – Simpler At Very High Data Rates
- How OFDM Overcomes Inter Symbol Interference
- Multipath Causes Fading at the Receiver
- Frequency Selective Fading
- Simplifies MIMO Implementation
- Why OFDMA is Better for Mobility
- High peak to Average Power Ration (PAPR)
- The Disadvantages of OFDM Systems
- Low density Parity Check (LDPC) Codes
- Summary of OFDM Advantages

Multiple Input Multiple Output Antennae (MIMO)

- Antenna Basics
- Smart Antennae
- Introduction to MIMO
- Space Time Coding
- Spatial Multiplexing
- Benefits of MIMO

802.11n High Throughput

- 802.11n High Throughput
- 802.11n Extends Wi-Fi into Consumer Electronics
- 802.11n Usage Models
- Emerging Applications and Services
- Combining WWISE and TGnSync Proposals
- Enhanced Wireless Consortium (EWC)
- Pre 802.11n Products
- Wi-Fi Alliance Certify Pre .11n Products
- Mandatory and Optional Physical Features
- 802.11n PHY Enhancements
- High Throughput Mode (HT Mode)
- Adaptive Modulation and Coding
- Data Rates in HT Mode
- Achieving Data Rates of 600 Mb/s
- Contrasting the 802.11 Physical Layers

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3. 802.11 Medium Access Control (MAC) Quality of Service and Frame Structure

By the end of this module, course attendees will be able to:

- Describe the major enhancements made to the MAC layer to support Quality of Service (QoS)
- Draw the structure of the MAC Service data Unit (MSDU) and different frame types
- Understand the limitations of Point Coordination Function (PCF) in delivery QoS
- Explain the 802.11n MAC enhancements to optimize for high data rates

Module Outline

802.11e MAC Quality of Service Enhancements

- 802.11 Quality of Service (QoS)
- Enhanced Channel Access Mechanisms
- Enhanced Distributed Channel Access (EDCA)
- Traffic Priority
- Access Categories
- Arbitration Inter Frame Spacing (AIFS)
- Illustration: Accessing the Medium
- Calculating the QoS Backoff Interval
- Virtual Collisions
- Illustration of Virtual Collision Resolution
- Building on the Existing Specifications
- HCF Controlled Channel Access (HCCA)
- Hybrid Coordinator
- Unpredictable PCF
- Beacons Suffer Delays
- Extending PCF
- Guaranteed Channel Access
- Action Frames
- Traffic Specification (TSPEC)
- Negotiating the Traffic Stream Specification
- How HC Gains Control of the Medium
- Illustration of QoS CF-Poll
- Contrasting EDCA and HCCA
- Acknowledgment Enhancements
- Illustration of Block Acknowledgment

MAC Frame Structure

- Generic Frame Format
- Frame Control
- Frame Types
- Frame Sub-Types
- Duration / Association ID
- Sequence Control and Frame Check Sequence
- Fragmentation for Difficult RF Environments
- Sending Fragmented Frames
- Address Fields
- Address Field in "Data Frames"
- Sending "Data Frames"
- Subnet Address Transparency
- "Data Frame" Body
- Example "Control Frames"
- Example "Management Frames"
- 802.11e QoS Data Frames
- 802.11e QoS Control Field
- Wi-Fi Multimedia (WMM)
- WMM Default Parameters

802.11n MAC Enhancements

- Summary of 802.11n MAC and PHY Enhancements
- 802.11n Operating Modes
- Mixed Mode Operations
- Improving 802.11 Throughput Efficiency
- Two levels of MAC Packet Aggregation
- MPDU Packet Aggregation
- Reduced Inter-Frame Spacing (RIFS)

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4. 802.11s Mesh Networking

By the end of this module, course attendees will be able to:

- Understand the benefits of mesh networking the current status of 802.11s deployments
- Describe the major functional components of an 802.11 mesh network
- Define the operational procedures for how a Subscriber Station finds and joins an 802.11 mesh network
- Explain the changes made to the MAC SDU to support mesh networking

Module Outline

Introduction to Mesh Architecture

- Definition of a Wireless Mesh Network
- Benefits of Mesh Networking
- Usage Models
- Metropolitan Community Mesh Networks
- Digital Home Mesh Network
- Enterprise Mesh Network
- Peer to Peer Ad Hoc Mesh Networks
- Emergency Response and Military Mesh

802.11s Mesh Network Architecture and Components

- Objectives of 802.11s Task Group
- Status of 802.11s Specifications
- 802.11s Enhance the MAC Layer
- 802.11s Mesh Architecture
- 802.11 Mesh Network Nodes
- Mesh Identifier
- Unified Channel Graph
- Single and Multi-Channel Meshes

Connecting to a Mesh and Selecting a Path

- Joining a Mesh
- Mesh Discovery
- Beacon
- Association
- Mesh Profile
- Selecting the Best Path between Two Mesh Points
- Path Selection Metrics
- Airtime Link Metric
- Illustration of Airtime Costs
- Link Quality Measurement
- Path Selection Protocol
- WLAN Mesh capability Sub Fields
- Path Selection Protocol and Metric Identifiers
- Default Path Selection Protocol

Routing Protocol

- Types of Routing Protocols
- Hybrid Wireless Mesh Protocol (HWMP)
- Illustration: Route Request
- Illustration: Route Response
- Illustration: Sending Data Frames
- Intermediate Nodes
- Maintaining Best Metrics
- Illustration: On Demand, Destinations Outside Mesh
- Optional Root Tree
- Mesh Portals and Root Nodes
- Root Node Operations
- Illustration: Proactive Path to the Root
- Illustration: Proactive path to the Destination Node
- Illustration: Improving Path Efficiency
- Illustration: Proactive, Destination Outside Mesh
- Illustration: Losing a link
- Optimized Link State Routing (OLSR)
- Fisheye State Routing
- Multi Point Relay (MPR) Network Nodes
- Discovering Neighbors
- Contrasting AODV and OLSR

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Intermediate

4. 802.11s Mesh Networking

Mesh MAC Frame Structure and QoS Enhancements

- Mesh Frame Format
- Frame Subtype Values
- Mesh Data Frames
- Enhancements Required to Enable Mesh QoS
- The Need for Congestion Control
- 802.11s Congestion Control Mechanism
- Congestion Management Action Frames
- Common Channel Framework (CCF)
- Channel Coordination Window (CCW)
- Mesh Points Negotiate Channel Allocation
- Channel Selection on a Common Channel
- Request and Clear to Switch Control Frames
- Channel Selection on a Common channel
- Outside the Channel Coordination Window
- Mesh Deterministic Access (MDA)
- MDA Opportunities (MDAOP)
- Operations During MDAOP
- Synchronization between Mesh Points

Mesh Security Considerations

- Extension to 802.11i
- Authentication between Mesh Points
- Basic Security Model
- Mutual Authentication

Power Saving

- Power Management in a Mesh
- Mesh Power Save Mode
- Waking up to Receive Data
- Mesh DTIM Interval

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5. 802.11r Fast Transition and VoWLAN

By the end of this module, course attendees will be able to:

- Understand the 802.11 enhancements being defined to support Voice over Wireless LANs (VoWLAN)
- Explain the operational mechanisms for how 802.11r allows a Station to quickly transitions between two Access Points
- Define the major components of 802.21 Media Independent Handover
- Identify the major difference between Wi-Fi and cellular networks and the challenges of integrating these networks
- Discuss the standards activities to support voice handover between as users roam between Wi-Fi at the home or at a public hotspot to the mobile networks

Module Outline

Introduction to Voice Over WLAN (VoWLAN)

- Convergence Between VoIP and WLAN
- Voice Over Wireless LANs (VoWLAN) Products
- VoWLAN Implementation Options
- Sending Voice Over IP Networks
- VoIP Requirements
- Enhancements to Support Voice Over 802.11

802.11r Fast Base Station Transition

- Goal of 802.11r Fast Base Station Transition
- Mobility Domain
- Three Step Process to Transition Between APs
- "Fast" Authentication
- 801.11r Key Hierarchy
- R1 Key Distribution
- Reassociation with pre-Computed Keys
- Reserving Resources
- Base Mechanism Over the Air
- Reservation Mechanism Over the Air
- Communication Modes
- Base Mechanism Over the Distribution System
- Resource Reservation Policy

802.21 Media Independent Handover (MIH)

- 802.21 Media Independent Handover (MIH)
- Service Continuity
- Growing Need for 802.21
- 802.21 Provides Inter-Technology Handover
- Illustration of Inter & Intra Technology Handover
- Understanding what 802.21 Does & Does Not Do
- 802.21 Services
- Media Independent Information Service (MIIS)
- 802.21 Information Elements
- Media Independent Events Service (MIES)
- Illustration of Link Layer Events
- Media Independent Command Service (MICS)
- Handover Commands
- Handover Reference Model
- 802.21 Timeline

Interworking with Cellular

- Wi-Fi to Cellular Interworking
- Dual Mode Cellular and Wi-Fi Phones
- Contrasting 802.11 and 3G Cellular Technologies
- 3GPP Interworking Specifications
- 3GPP WLAN Deployment Scenarios
- WLAN 3G Interworking Specifications
- Roaming Reference Model
- WLAN Access Gateway (WAG)
- Packet Data gateway (PDG)
- 3GPP2 Interworking Specifications
- 3GPP2 Roaming Reference Model
- Packet Data Interworking Function (PDIF)

Fixed and Mobile Handover

- Fixed and Mobile Convergence (FMC) Standards
- Unlicensed Mobile Access (UMA)
- UMA Enabled Products
- UMA Functional Architecture
- MobileIGNITE Alliance
- Phased Implementation
- Voice Call Continuity Basic Concepts
- Voice Call Continuity Phase 1
- Voice Call Continuity Phase 3
- VCC Access and Remote Legs
- How 802.21 Fits with VVC

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