

Course ID	Course Title
<b>WIFI-ADV</b>	<b>Advanced Wi-Fi Training: Technology, Security, Deployment; Coexistence with LTE and 5G</b>
Course Duration	
<b>2-3 days</b>	
<b>Aimed At</b>	<i>Advanced Wi-Fi Training</i> is aimed at engineers, technicians, managers, marketing/sales, and other professionals who need to understand the advanced Wi-Fi standards.
<b>Prerequisites</b>	<i>Advanced Wi-Fi Training</i> requires a background in Information Technology or Telecommunications.
<b>Related Courses</b>	<ul style="list-style-type: none"><li>• <i>WiFi Training in Depth: Technology, Security, Deployment ... with M2M, IoT, 5G</i> (WIFI-DIVE, 2-5 days)</li><li>• <i>5G Wireless Technology/Applications</i> (5GTA, 5 days)</li><li>• <i>LTE / LTE-A Deep Dive: RAN and Core</i> (LTE-DIVE, 4 days)</li><li>• <i>IoT-enabling Technologies Training: IEEE 802.15.4, WLLN, ZigBee, WAVE, Next Gen WiFi</i> (EIOT5D, 5 days)</li></ul>
<b>Course in a Nutshell</b>	<i>Advanced Wi-Fi Training</i> is a 2-to-3 day subset of our 5-day <i>WiFi Training in Depth: Technology, Security, Deployment; Relationship with M2M, IoT, 5G</i> course that emphasizes the emerging IEEE 802.11 Wi-Fi protocols. For purposes of illustration, this outline is centered around IEEE 802.11ah. But the course can focus on any advanced standard(s) of interest to your team. Following an overview of IEEE 802.11, the course covers the specifications of interest, deployment, optimization, security, and coexistence with LTE and 5G.
<b>Customize It!</b>	We can tailor the content and tech level of <i>Advanced Wi-Fi Training</i> to audiences such as developers; network design, deployment, trouble-shooting, and security professionals; and marketing/sales professionals or others who need a less technical course. A design or troubleshooting lab can also be added if desired.
<b>Outline</b>	<b>Advanced WiFi Training Part 1: IEEE 802.11 Overview</b> <ul style="list-style-type: none"><li>• <b>WiFi: Market Landscape</b></li><li>• <b>Short-Range Wireless Characteristics</b><ul style="list-style-type: none"><li>○ Wired vs wireless<ul style="list-style-type: none"><li>▪ Comparison of networks</li><li>▪ Comparison of security challenges</li><li>▪ Short-range wireless systems</li></ul></li></ul></li><li>• <b>Categories of Information Transmission</b></li></ul>

- Asynchronous, isochronous, and synchronous requirements
- Voice and data
- **IEEE 802.11 Network Architecture**
  - General IEEE 802.11 architecture
  - Basic, extended, and independent service sets
  - Examples of implementations

## **Advanced WiFi Training Part 2: IEEE 802.11 Physical Link**

- **Radio Frequency (RF) Basics**
  - The electromagnetic spectrum
  - RF propagation and fading
  - RF modulation techniques
  - Reflection, refraction, and diffraction
  - Basics of digital RF communication
  - Free space loss
- **Link Budget and Path Loss**
  - Review of decibels
  - Calculating maximum range
  - Multipath characteristics and mitigation
- **Multipath**
  - Doppler and delay spread
  - Diversity combining
- **Basic Modulation Techniques**
  - Amplitude, frequency, and phase shift keying (ASK, FSK, PSK)
  - Complementary Code Keying (CCK)
  - Quadrature Amplitude Modulation (QAM)
- **OFDM**
  - What is OFDM
  - OFDM Advantages and Challenges
  - OFDM parameters
- **Error Control**
  - Error characteristics
  - Cyclic Redundancy Check(CRC)
  - Convolutional coding
  - Automatic Repeat ReQuest (ARQ)

## **Advanced WiFi Training Part 3: IEEE 802.11 MAC**

- **MAC Methods**
  - Carrier-sense multiple access
    - Basic concept and operation
    - Avoiding network instability

- CSMA and Denial-of-Service (DoS) attacks
- Distributed Coordination Function (DCF) operation
  - Channel access and backoff
  - DCF and Man-in-the-Middle (MITM) attacks
- Point Coordination Function (PCF) operation
  - Channel access and scheduling
- Operation in an independent basic service set (ad-hoc)
- **IEEE 802.11e Quality-of-Service (QoS) operation**

#### **Advanced WiFi Training Part 4: IEEE 802.11ah**

- **Introduction to IEEE 802.11ah**
  - IEEE 802.11ah use cases
  - Issues for sub-one-gigahertz (900MHz) band
  - IEEE 802.11ah requirements
    - Functional requirements
    - System performance
    - Supporting band
    - Coverage and data rate
    - Coexistence
    - Enhanced power saving
  - Internet of Things (IoT) and Machine to Machine (M2M) communications.
  - One-hop network topologies
  - Short and infrequent data transmissions
  - Dense AP deployment number of stations
    - Traffic Indication Map (TIM) stations
    - Non-TIM stations
- **IEEE 802.11ah PHY and MAC**
  - Extended range Wi-Fi by IEEE 802.11ah
  - IEEE 802.11ah global ISM spectrum allocation
  - IEEE 802.11ah bandwidths
  - Downlink Multi-User MIMO-OFDM (DL MU-MIMO)
  - IEEE 802.11ah PHY optimization
    - Extended range
    - Power efficiency
    - Scalable operation
  - IEEE 802.11ah link-budget
    - Transmission range and data rates

#### **Advanced WiFi Training Part 5: Wi-Fi Security**

- **Wired Equivalent Privacy (WEP)**
  - Shared key and public key cryptography
  - Cryptanalysis attack methods

- WEP encryption process and weaknesses
- WEP data integrity process and weaknesses
- WEP access control process and weaknesses
- Denial-of-service (DoS) attack methods
- **IEEE 802.11i Access Control and Key Management**
  - Wired Equivalent Privacy (WEP) weaknesses
    - Weaknesses: Authentication, data confidentiality, data integrity
  - Introduction to Robust Security Network (RSN)
    - RSN security layers
    - Methods of authentication
    - IEEE 802.11i operational phases
  - IEEE 802.1X Port-Based Network Access Control
    - IEEE 802.1X authentication and key distribution
    - Digital certificate
    - Challenge-response using a RADIUS server
  - Extensible Authentication Protocol (EAP)
    - EAP request/response
    - EAP over LAN (EAPOL)
    - Key derivation and exchange
  - Transport Layer Security (TLS)
    - TLS handshake exchange
    - TLS and IEEE 802.11i
    - TLS over EAP
- **Advanced WiFi IEEE 802.11i Encryption**
  - Temporal Key Integrity Protocol (TKIP)
    - TKIP implementation
    - Encapsulation and de-capsulation processes
    - TKIP message integrity
    - TKIP attack countermeasures
  - Advanced Encryption Standard (AES)
    - Requirements for WEP replacement
    - AES operation
    - AES modes and algorithms
    - 802.11i counter/cipher block chaining with message authentication code (CCM) protocol
- **Advanced WiFi Wi-Fi Protected Access (WPA)**
  - IEEE 802.11i and Wi-Fi Protected Access (WPA)
    - Comparison of 802.11i and WPA
  - Versions of WPA
    - WPA Personal vs WPA Enterprise
    - WPA vs WPA2
  - WPA and RSN key hierarchy
    - Pairwise and group keys
    - Key hierarchy

- Key derivation
- WPA implementation requirements
  - Access points
  - Network adaptors
  - Client software
- WPA certification

## **Advanced WiFi Training Part 6: Wi-Fi Deployment and Optimization**

- **Operating Frequencies and Signal Spectrum**
  - Frequency hopping
- **Key Performance Indicators (KPI)**
  - Range
  - Data rate and throughput
  - Latency
  - Security
  - Others
- **Project Planning**
  - Requirements
  - Site Survey
  - Coverage vs. Capacity
  - AP Installation
  - Network Traffic Analysis

## **Advanced WiFi Training Part 7: WiFi Coexistence with LTE, and 5G**

- **LTE vs Wi-Fi**
  - Scenarios where Wi-Fi is best
  - Scenarios where LTE is best
- **LTE-WiFi Aggregation (LWA)**
- **WiFi vs. Unlicensed LTE (LAA/eLAA/MulteFire)**
  - Listen Before Talk (LBT)
- **WiFi and Spectrum Sharing**
- **WiFi in 5G**

## **Advanced WiFi Training Wrap-up: Recap and Discussion**

DCN PnTM-f