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From IEEE 802.11n to 802.11ac and ad
Design Details & System Engineering

Course Duration:

- 2 days

Course Description:

- This course focus is on the VHT-related enhancements which the IEEE specified in the 802.11ac extension of the WLAN / WiFi standard series. However, the course also explains the specifics of 802.11 ad and the differences between these two amendments.
- Starting out with a primer on "before ac", the course initially focuses on 802.11 operation with respect to channel access and resource sharing. Namely the different channel access functions DCF, PCF, EDCA and HCCA are dealt with in detail and their differences and specifics are pointed out.
- During this part, the course also repeats the most important other characteristics of the OFDM-PHY and the MAC-layer. This includes a detailed consideration as to how QoS may be enabled in 802.11.
- The following chapter starts with an overview of the different groups of features which are added by the "ac"-extension of the standard. This chapter concludes with the “live”-calculation of the ac-related performance figures under different circumstances (e.g. modulation scheme, channelization).
- After this, the course focuses on the description and discussion of smart antenna techniques, namely SU-MIMO (up to 8 streams), MU-MIMO, and beamforming with ECFB as defined for 802.11ac. The students will learn *without needing any mathematical formulas*, how these techniques work and how they are applied in 802.11ac.
- We also explain in details the channelization options and rules of 802.11ac, considering 20 MHz to 160 MHz operation (with 80+80) and the various constraints affecting the channel bandwidth. Part of this consideration is a detailed introduction into the enhanced RTS/CTS-operation in 802.11ac.
- Another chapter is dedicated to all PHY-related aspects of 802.11ac that have not been discussed yet. This includes features like the ac-specific but backwards compatible PPDU-format, spectrum mask, 256-QAM-operation etc.
- The MAC-related chapter starts with pointing out the differences in the MAC-frame structure with respect to new information elements. The MAC-chapter also explains A-MPDU and A-MSDU aggregation in detail. This includes a comparison of the two methods with respect to performance.
- The different security options and issues of 802.11 are dealt with in another chapter and explain the details of WEP, WPA with 802.1X and WPS.
- The course concludes with an introduction into 802.11ad and the underlying technology, applications and performance numbers.

Prerequisites:

- The student must possess a thorough understanding in wireless and/or cellular communication technology before coming to this course. This knowledge should stem from multiple years of design or test experience with these technologies.
- At the least, we recommend our webinars or web based training courses on WiFi to be taken beforehand.

Course Target:

- The student is enabled to develop, test and integrate 802.11ac/ad-equipment and to operate related networks.

Who should attend this Course:

- Test engineers who need to understand the 802.11ac / ad -features and their implications in detail.
- Designers of WiFi-equipment who require a deep inside view of the various enhancements with 802.11ac and 802.11ad.

Some of your Questions that will be answered:

- How does 802.11ac differ from 802.11n? Which features are inherited from 802.11n?
- How does WiFi support the distinction of different QoS-requirements?
- What are the various 802.11ac-related enhancements? And how does 802.11ac differ from 802.11ad?
- How shall session switching operate between legacy WiFi, 802.11ac and 802.11ad?
- Why does 802.11ac not support “greenfield” PPDU?
- How does CCA (Clear Channel Assessment) operate in 802.11ac?
- When is 256-QAM feasibly used in 802.11ac?
- How does the improved RTS/CTS-operation work in 802.11ac?
- What are the consequences of 802.11ad operating at 60 GHz?
- How does beam steering work in 802.11ad?
- What is the relationship between WiGig 1.2 and 802.11ad?
- How does MU-MIMO work in 802.11ac?
- How do WPA and 802.1X improve the WiFi-security?
- Which additional gain is provided by EAP?
- How do different EAP-procedures like EAP-TLS or EAP-AKA work?
- How exactly do A-MPDU and A-MPDU aggregation work and how do they differ from each other?

Table of Contents:

Chapter 4: Security in 802.11

- **Overview Security and Security Challenges**
  Attack and threat types, symmetric vs. asymmetric keys, authentication and encryption, integrity protection
- **Security in WiFi**
  WEP, WPA 1 and 2, 802.1X and RSNA, Key setup and generation
- **Advanced Options**
  Intro to EAP, operation of EAP-TLS, operation of EAP-AKA, generation of key material

Chapter 5: IEEE 802.11ad and its Playground

- **The “Playground” of 802.11ad**
  Applications, spectrum, history,
- **Joined Operation of 802.11 (2.4 GHz), 802.11ac (5 GHz) and 802.11ad (60 GHZ)**
- **DMG (Directional Multi Gigabit)**
  operation modes, packet structure and contents, modulation types, channel coding, single carrier vs. OFDM, Beamsteering operation for NLOS (non line of sight)