OFDMA Related Issues in VHTL6

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Abstract

- **Multi-user OFDM schemes adapt to the wireless channels by adjusting power and/or modulation per sub-carrier and user. Multiple contributions [1]-[4] show that such an approach is able to reduce the packet error rate and increase the PHY/ MAC efficiency (exploiting multi-user diversity as proposed by the PAR) in WLAN.**
- **This channel dependent data transmission is another source to improve PHY and link layer performance (so far neglected by 802.11 standards). These beneficial effects are especially observed for low SNR conditions. However, appropriate protocol extensions are required.**
- **This talk resumes an example OFDMA protocol approach for VHTL6 and contributes to the process of elaborating comparison procedures by addressing special comparison issues in the context of OFDMA.**

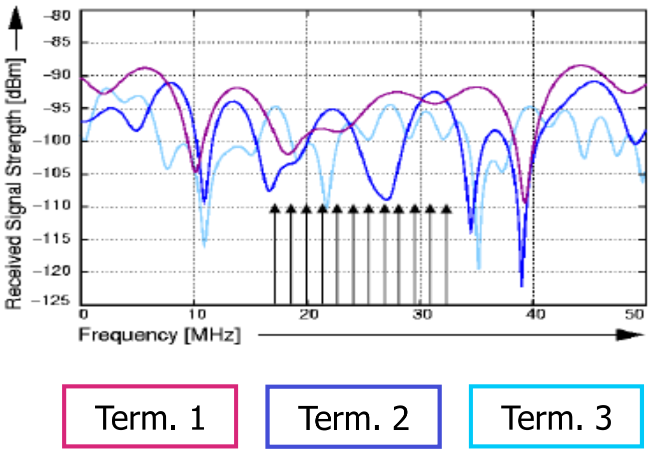
Goals of Today's Talk / Outline

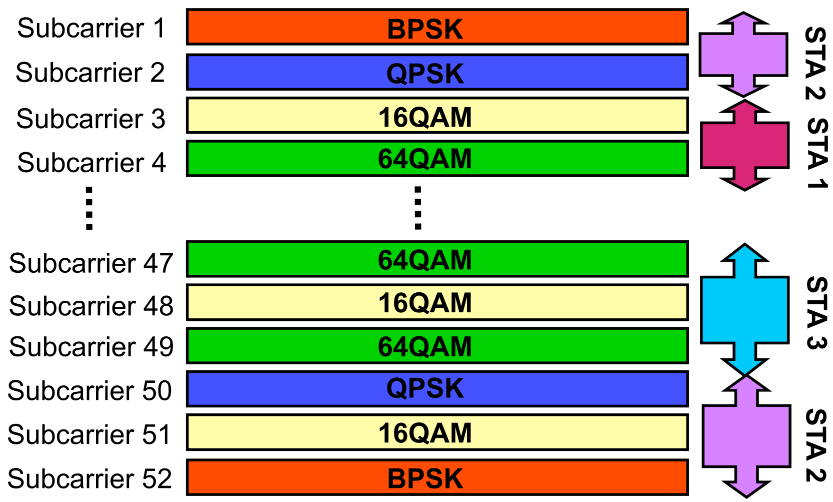
- **Short summary of the proposed technique, focus on an example protocol extension.**
- **Discussion of OFDMA comparison issues to be taken into account for the elaboration of usage models and comparison procedures in VHTL6.**
- **Feedback / Straw poll**

Dynamic Multi-user OFDMA

- A wireless transmission suffering multi-path propagation experiences frequency selective fading. Hence, the channel gain varies over multiple subcarriers of a certain station (frequency selectivity) as well as for a certain subcarrier among different stations (multi-user selectivity).
- Adaptation in two ways: 1) React to frequency variations by specific modulation/ power setting per subcarrier 2) Enable simultaneous data transmission to different stations via (channel dependent) OFDMA

MULTI-USER DIVERSITY

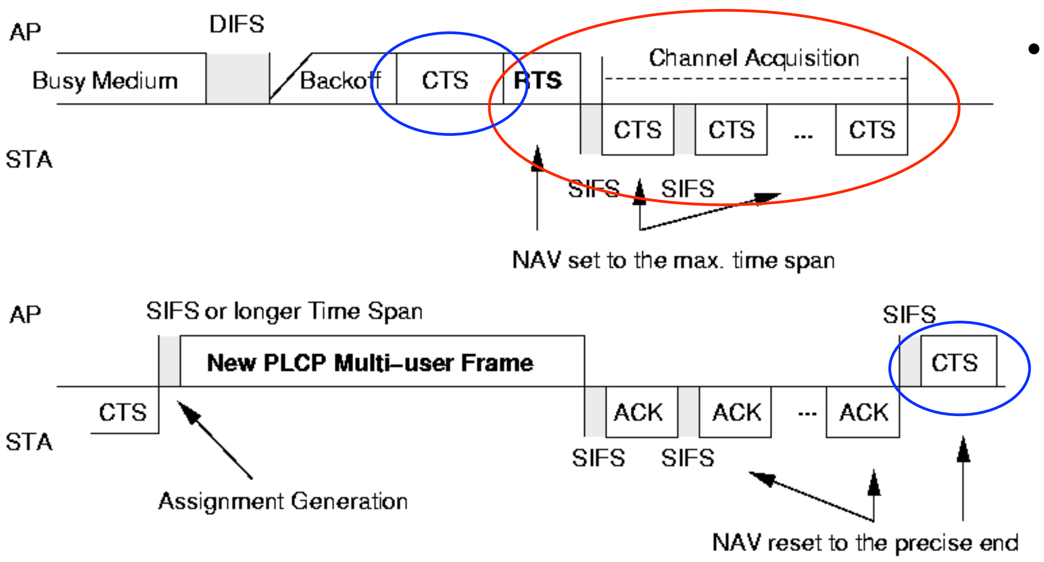




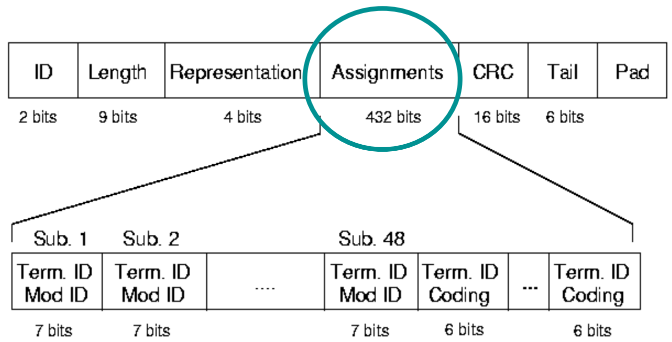
Example Protocol for OFDMA in 802.11

- **OFDMA approach requires some overhead:**
  - Backward compatibility
    - ➔ **2 CTS-to-self frames (NAV setting)**
  - Channel acquisition
    - ➔ **RTS/CTS mandatory**
  - Resource allocation signaling
    - ➔ **PLCP header extension**

Comparison procedure issues:
- Base rate for overhead frames
- Maximum degree of freedom in resource allocation
- Time variation of subcarrier gains due to fast fading



- Extension of the PLCP header by a „**Signaling**" field, containing the sub-carrier and modulation assignments



Performance Evaluation

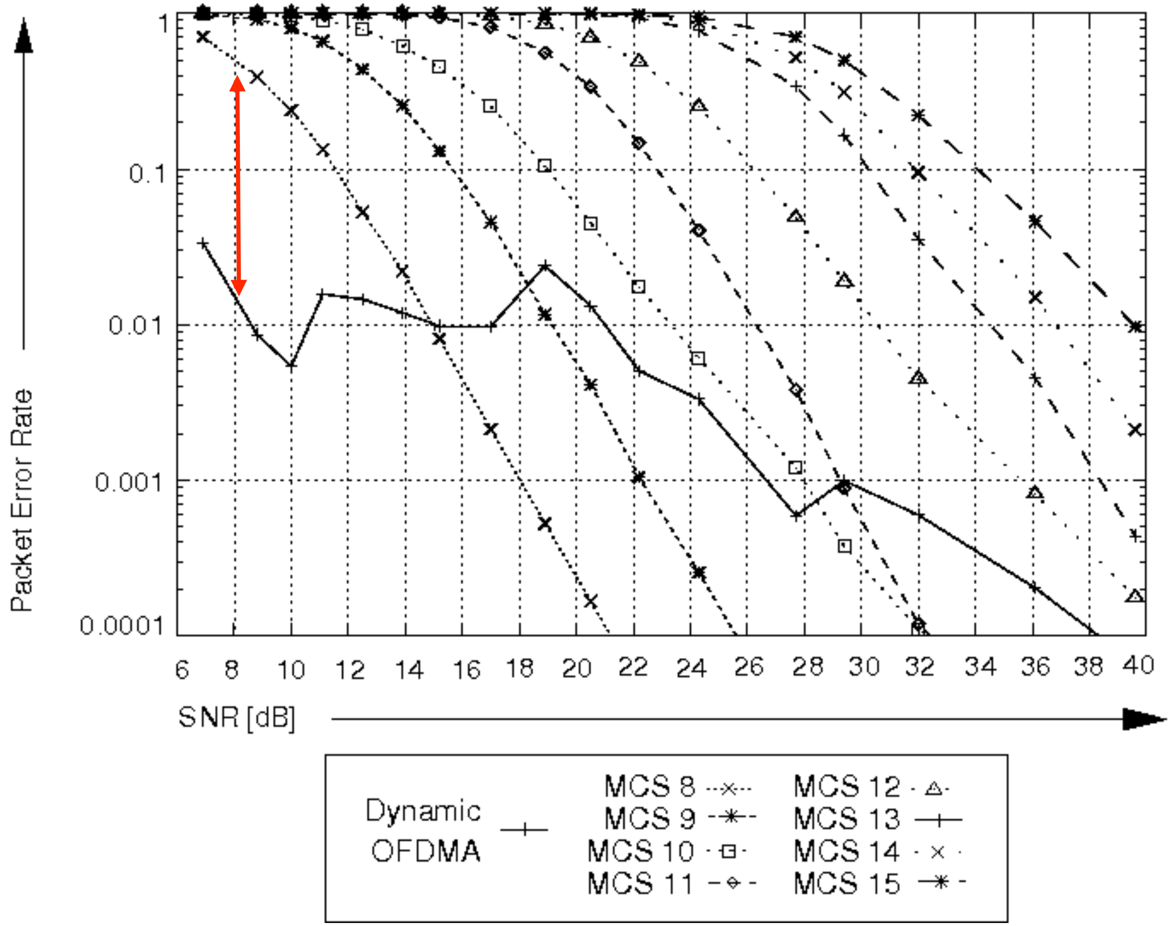
- **Basic Metrics: Goodput above MAC and MAC Packet Error Rate**
- **Scenario Settings:**
  - Traffic model
    - Saturation mode
    - Either large (1570 Byte) or small packets sizes (234 Byte)
    - Uni-directional transmission (pure downlink)
  - Further features
    - A-MPDU Frame Aggregation
    - 2x2x20 MHz Spatial Multiplexing with MMSE receiver
    - Channel Model E (Matlab [5] for the generation of the channel's impulse response)
- **Comparison schemes of OFDMA WLAN**
    - IEEE 802.11n without RTS/CTS
    - IEEE 802.11n applying RTS/CTS

Comparison procedure issues:
- Consider multiple packet sizes for performance comparison

Packet error rate results of multi-user dynamic OFDMA and IEEE 802.11n modes (MCS 8-15) (various SNR levels and a packet size of 234 Byte). J=4 stations are present in the cell

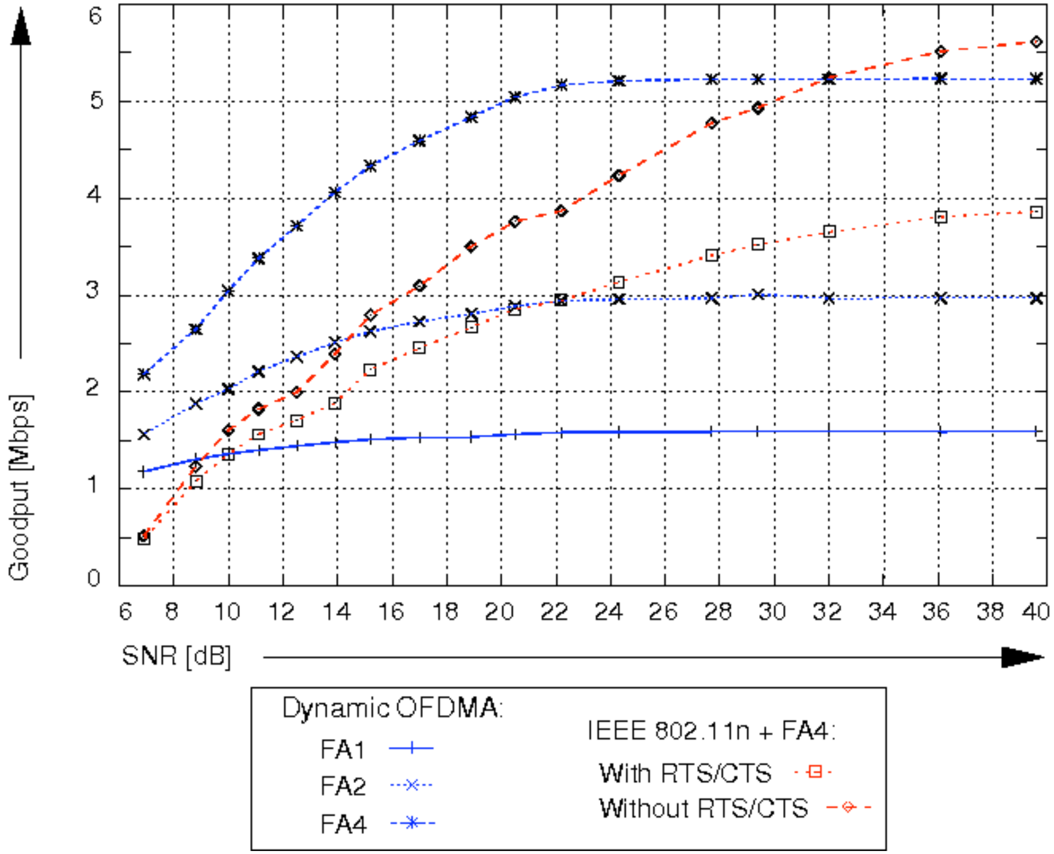
Comparison procedure issues:

- Error model required which takes subcarrier states and subcarrier resource allocations into account.



MAC goodput results (per user) of multi-user dynamic OFDMA and the envelope of the best performing IEEE 802.11n modes (MCS 8-15) at any SNR point with & without RTS/CTS handshake (various SNR levels and a packet size of 234 Byte). Dynamic OFDM aggregates (A-MPDU) 1, 2 and 4 packets while IEEE 802.11n always aggregates 4 packets.
J=4 stations are present in the cell

- **OFDMA benefits from larger packet sizes (less impact from overhead). Protocol overhead is determined by 1) backward compatibility 2) degree of freedom in resource allocation.**
- **Significant performance improvement for larger SNR can be expected by adding 256 QAM.**

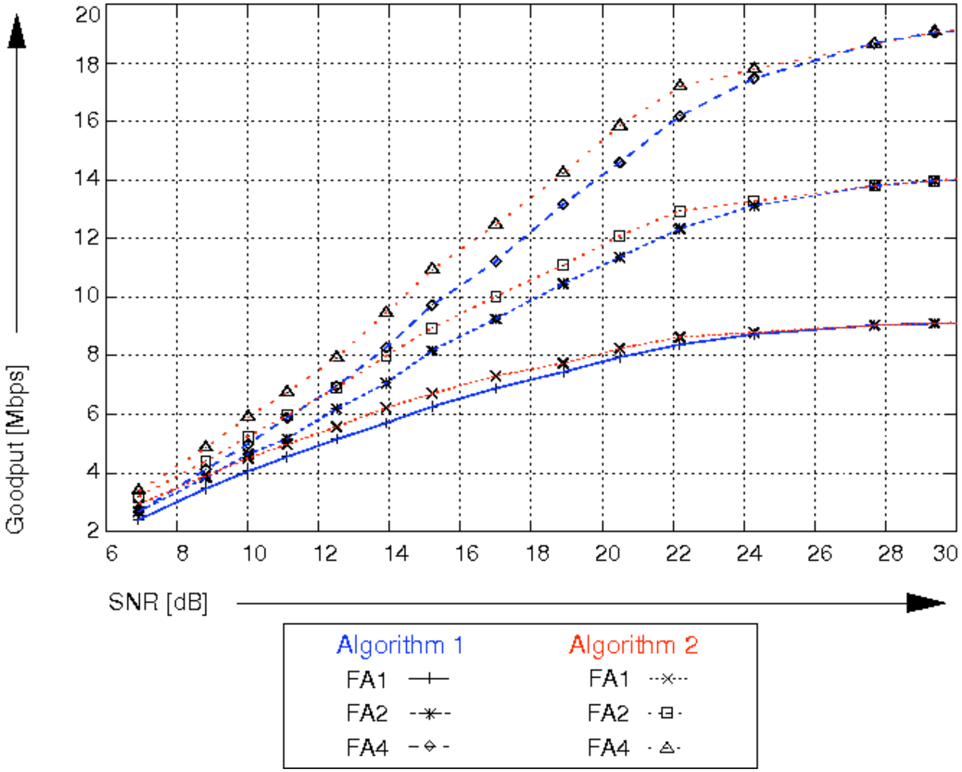


Comparison procedure issues:

- Scenario with higher number of stations reveals protocol efficiency in OFDMA (trade-off with multi-user diversity)

Different Resource Allocation Algorithms

- **Interplay between scheduler and resource allocation algorithm may have a strong impact on performance. Optimally assigning resources to multiple users is complex (depending on degree of freedom in the system). In this example we consider two different suboptimal allocation algorithms to demonstrate impact.**
- **Scenario characteristics:**
  - 2x2 MIMO (spatial MUX)
  - 1570 Byte packets
  - A-MPDU (1, 2 & 4 packets)
  - OFDMA WLAN with 4 users comparing Alg. 1 & Alg. 2.
- **Goodput varies about 5-15%**



Comparison procedure issues:

- Clear definition of resource assignment algorithm and scheduler

Summary on Issues Relevant for OFDMA Comparison Procedure I

- **Usage models:**
  - Include one model containing a larger number of stations (at least larger than maximum number of spatial streams). This emphasizes need for efficient protocol realization in OFDMA systems (larger number of stations require more overhead). Also, OFDMA can realize a better MAC efficiency than SDMA-based approaches for a large number of stations.
  - Evaluation of performance with small and large packet sizes due to the strong effect of the overhead/payload ratio in different protocol realizations.
- **Comparison criteria:**
  - CC should clearly specify the degree of freedom available for OFDMA resource allocation (i.e. allocation of power and/or modulation per subcarrier etc.).
  - CC should define a reference OFDMA allocation algorithm for objective comparison of different proposals.
  - CC should clearly specify a scheduling approach on top of resource allocation algorithm.

Summary on Issues Relevant for OFDMA Comparison Procedure II

- **Error models:**
  - Bit- and packet error models have to be considered (for MAC simulation for example) that take subcarrier-specific channel states into account together with subcarrier specific resource allocation.
- **Misc:**
  - Important to fix base rates for protocol specific control overhead

Audience's Feedback / Straw Poll

- **The goal of the following straw polls is to assist in helping to create usage model / comparison (simulation) criteria documents**

Straw Poll #1

In order to clearly highlight protocol efficiency and enabling a clear comparison of OFDMA- and SDMA-based approaches, scenarios for performance comparison shall also include a larger number of STAs (at least larger than number of spatial streams)

Yes

No

Abstain

Straw Poll #2

For a fair performance comparison, shall TGac clearly specify the degree of freedom available for OFDMA resource allocation (i.e. allocation of power and/or modulation per sub-carrier etc.)?

Yes

No

Abstain

Straw Poll #3

Should TGac define a reference OFDMA allocation algorithm for objective comparison of different proposals?

Yes

No

Abstain

Straw Poll #4

Should TGac clearly specify a scheduling approach on top of resource allocation algorithm?

Yes

No

Abstain

References

[1] 11-07/0720r2 – Dynamic Point-to-Point OFDM Adaptation for IEEE 802.11a/g Systems

[2] 11-07/2062r1 – Dynamic Multi-user OFDM for 802.11 systems

[3] 11-07/2187r1 – Another resource to exploit: multi-user diversity

[4] 11-07-2860r0 – Performance comparison of dynamic OFDM with 802.11n

[5] L. Schumacher "WLAN MIMO Channel Matlab program"

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J=4 stations are present in the cell

- **Aggregate rate equals here 80 MBit/s above MAC at highest SNR (for 20 MHz 2x2 MIMO)**
- **Effective PHY rate at highest SNR is 130 MBit/s (for 20 MHz 2x2 MIMO)**

Comparison procedure issues:

– Scenario with higher number of stations reveals protocol efficiency in OFDMA (trade-off with multi-user diversity)