Proposed Modifications of 802.16 MAC and 802.11a PHY for a WirelessHUMAN^{TM} standard employing TDD/TDM

IEEE 802.16 Presentation Submission Template (Rev. 8.2)

Document Number:

IEEE 802.16.4p-01/16

Date Submitted:

2001-01-25

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Venue:

Session #11

Base Document:

IEEE 802.16.4c-01/16

Purpose:

Explain contribution.

Proposed Modifications of 802.16 MAC and 802.11a PHY for a WirelessHUMAN standard employing TDD/TDM

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Introduction

- Proposed system
  - 802.11a PHY + 802.16 MAC
  - TDD/TDM
  - minimal PHY and MAC changes
- Presentation outline
  - 802.11a, multi-path, TDD or TDM
  - PHY preamble overhead
  - Round-trip delay
  - Interference in sectorized environments
  - Power control
  - Interference, noise and rate control

IEEE 802.11a PHY

- Features
  - 8 rates: 6..54 Mb/s, 6..27 dB SNR for PER=10%
  - 52 carriers = 48 data + 4 pilots
  - 4 μs / OFDM symbol = 3.2 μs data + 0.8 μs GI
- Properties
  - robust, self-contained PHY frame:
    - AGC
    - symbol and carrier synchronization
    - channel equalization
    - length and rate
  - long-distance => directional antennas => shorter relative delay spread => 0.8 μs is enough

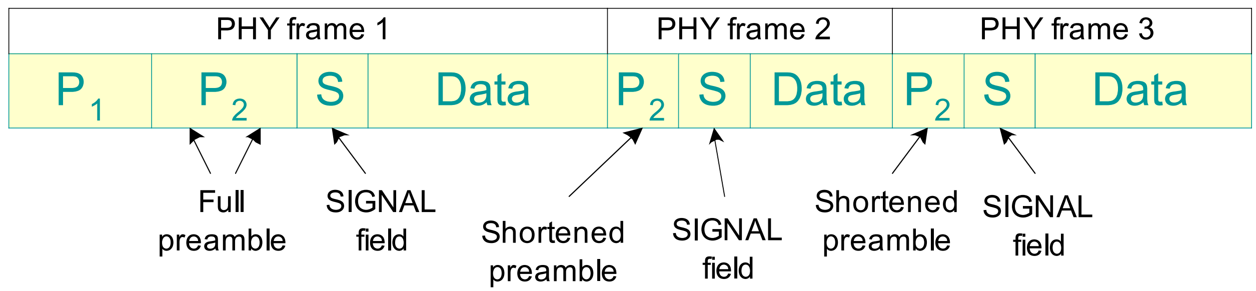
Why TDD/TDM

- Advantages:
  - flexible BW allocation - up/down-link
  - easy channel/frequency selection
  - simple HW
  - easy power control due channel reciprocity
  - behaves better under interference
  - possible spatial diversity / adaptive beam-forming
- Drawbacks:
  - preamble overhead
  - round-trip delay overhead
  - interference in sectorized environments

PHY Preamble Overhead

- 802.11a PHY overhead:
  - inter-frame gap + 16 μs preamble + 4 μs SIGNAL
  - 16 bits (7 used) SERVICE + 6 bits (8 actually) TAIL
- 802.16 MAC:
  - different channels => different DL rates => different PHY frames
  - different services => different rates => different PHY frames
- Proposal:
  - group data by rate
  - concatenate PHY frames where possible
  - keep full preamble (16 μs) for first PHY frame
  - use shortened preamble (last 4 μs) for others
  - use 9 bits from SERVICE

Concatenated PHY frames



- First PHY frame:
  - P_1 (8 µs) + P_2 (8 µs) + S + Data
- Next PHY frames:
  - P_2 (4 µs) + S + Data
  - synchronization preserved via pilots
  - 4 µs of P_2 => equalization
  - marked by setting reserved bit in SIGNAL

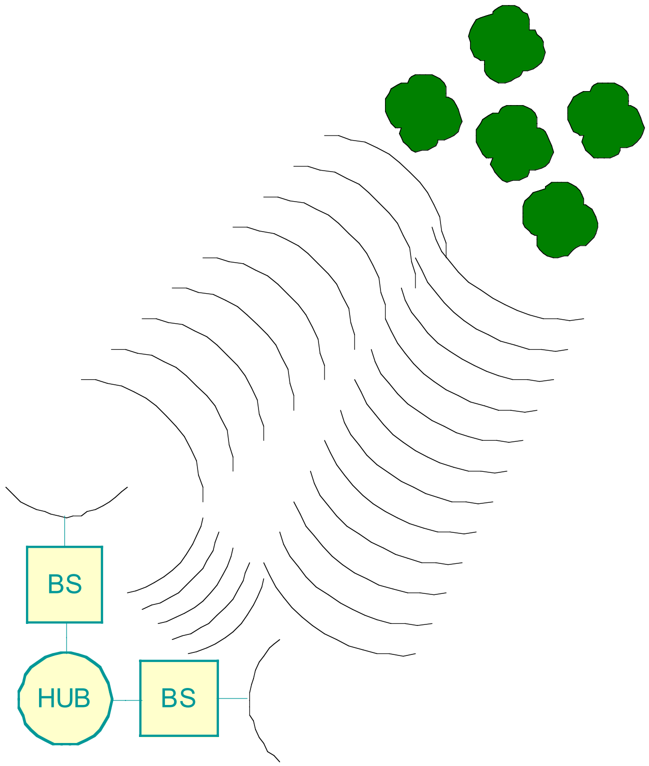
Round-Trip Delay

- Problem
  - LOS: 5..50 km @ 5.7 GHz => 333 μs round-trip
  - NLOS: 3..10 km @ 5.7 GHz => 66 μs round-trip

- Proposal:
  - allow larger MAC frame size:
    0.5, 1, 2 and 4, 8, 16 ms
  - reduces round-trip overhead
  - reduces protocol overhead
  - let provider choose the tradeoff between network delay and coverage

Interference in sectorized environments

- Problem:
  - BS in Tx to BS in Rx
  - adjacent channel Rx saturates
  - co-channel if frequency reuse
- Proposal:
  - synchronize BS's in HUB
  - MAC reports to HUB the DL/UL statistics/requests
  - HUB controller decides the DL/UL split
  - common HW time base



Power Control

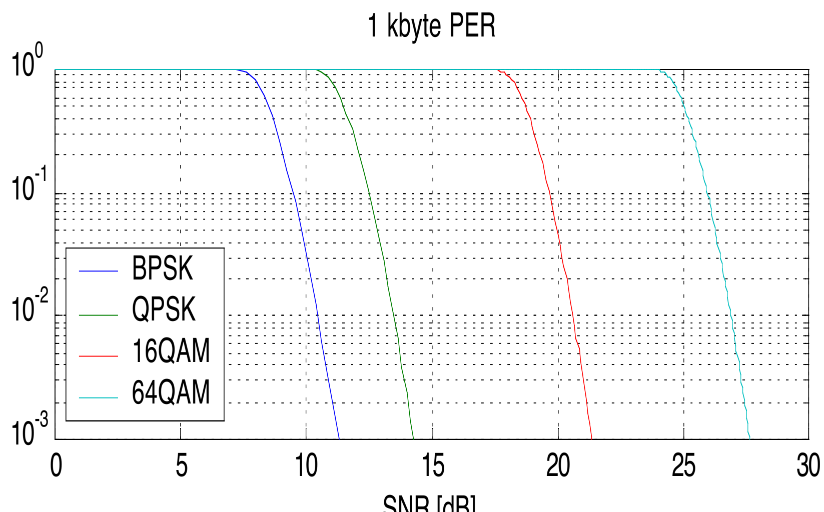
- Power control
  - at SS = variable, to equalize received level at BS
  - at BS in non-sectorized system = variable
  - same for all BS’s in a HUB, adjusted for politeness
  - fastest/easiest = based on RSSI

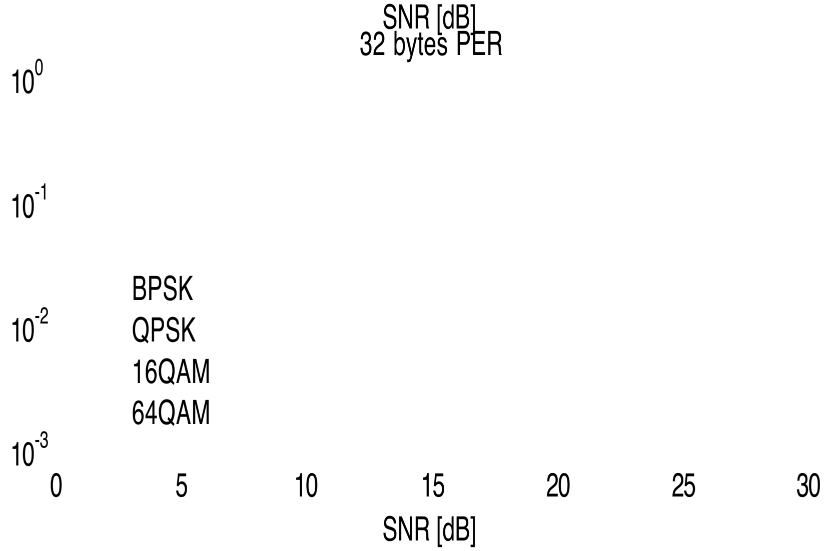
- Proposal
  - extend resolution for TXPWR_LEVEL in PHY-TXVECTOR
  - known relationship between TXPWR_LEVEL and RSSI for easy power control

Interference and Rate Control

- Problem
  - unlicensed bands => unknown interference
  - TDD => symmetric path loss but asymmetric interference
  - RSSI / interference level => optimum rate
- Proposal
  - Remove PHY - CCA (unused)
  - Add Received Interference Level Indication (RILI)
  - RILI uses same scale as RSSI
  - Measure RILI during Transition Gaps

PER vs. SNR, rate and length





- 802.11a PER
  - strongly depends on rate for same SNR
  - moving one rate low => PER improves 10..100 times
  - SNR varies widely in NLOS and interference
  - depends on packet length especially for higher rates and longer packets
- How to choose the rate?

A possible rate management

- For each link choose two rates:
  - HIGH rate = used at first Tx attempt
  - LOW rate = used at second Tx attempt
- Retransmission/Retry - for each fragment:
  - try first using the HIGH rate
  - if NACK, retry once using the LOW rate
  - for very sensitive protocols retry as many times as needed
- Advantage:
  - overall PER given by the LOW rate
  - overall rate close to the HIGH rate

Rate management - cont..

- Choosing LOW rate
  - for each service type assign a desired PER
  - for each CID choose the LOW rate such that it meets the desired PER for the given SNR
- Choosing HIGH rate
  - for given SNR and LOW rate => exists one HIGH rate that maximizes system throughoutput
    - if rate is too high => too many retries => low effective rate
    - if rate is too low => low effective rate
- Possible algorithms
  - adaptive = based on measured PERs
  - based on measured SNR = RSSI/RILI

Other Changes

- PHY slot = 4 µs (1 OFDM symbol)
- BW allocation in DL/UL Map based on OFDM symbols
- Tx/Rx and CPE Transition Gap = 4 µs
  - Easy implementation
  - RILI measurement

Summary of proposed changes

- 802.11a PHY
  - remove CCA
  - add Received Interference Level Indicator (RILI) w/ same scale as RSSI
  - increased and known resolution for TXPWR_LEVEL
  - reuse 9 reserved bits in SERVICE
  - concatenated frames capability
    - use reserved bit in SIGNAL for concatenated frames
- 802.16 MAC
  - PHY slot, gaps = 4 μs
  - add allowed frame lengths of 4, 8 and 16 ms
  - BS synchronization

Conclusions

- 802.11a PHY can be used with minimal changes
- TDD better than FDD for 802.16.4
- BS synchronization => reduced co- and adjacent-channel interference in sectorized environments
- frame concatenation => reduced PHY overhead
- larger MAC frames => reduced PHY overhead
- improved PHY power control
- RILI => interference and rate control