

Proposed Modifications of 802.16 MAC and 802.11a PHY for a WirelessHUMAN™ 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

Source:

Octavian Sarca
Redline Communications
200 Cochrane Dr. #3
Markham, ONT, L3R 8E8 CA

Voice: 905-479-8344
Fax: 905-479-7432
E-mail: osarca@redlinecommunications.com

Venue:

Session #11

Base Document:

IEEE 802.16.4c-01/16

Purpose:

Explain contribution.

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Octavian Sarca, Radu Selea

RedLine Communications Inc., Toronto

John Sydor

Communications Research Centre, Ottawa

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 μ s / OFDM symbol = 3.2 μ s data + 0.8 μ s 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 μ s 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

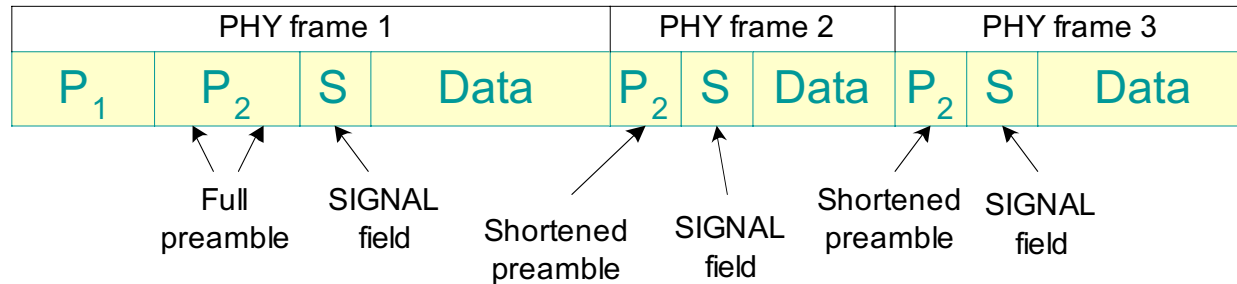
■ Drawbacks:

- ◆ preamble overhead
- ◆ round-trip delay overhead
- ◆ interference in sectorized environments

PHY Preamble Overhead

- 802.11a PHY overhead:
 - ◆ inter-frame gap + 16 μ s preamble + 4 μ s 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 μ s) for first PHY frame
 - ◆ use shortened preamble (last 4 μ s) for others
 - ◆ use 9 bits from SERVICE

Concatenated PHY frames



- First PHY frame:
 - ◆ P₁ (8 μs) + P₂ (8 μs) + S + Data
- Next PHY frames:
 - ◆ P₂ (4 μs) + S + Data
 - ◆ synchronization preserved via pilots
 - ◆ 4 μs of P₂ => equalization
 - ◆ marked by setting reserved bit in SIGNAL

Round-Trip Delay

■ Problem

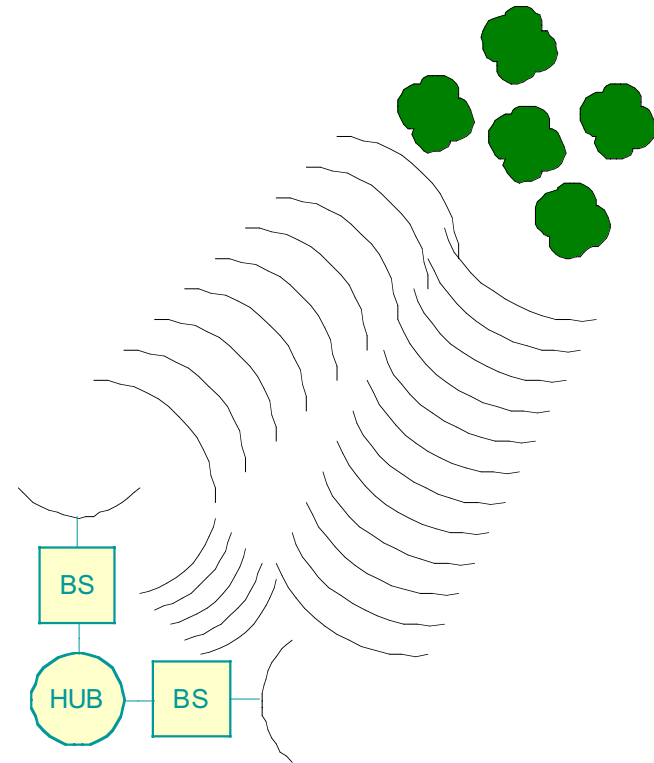
- ◆ LOS: 5..50 km @ 5.7 GHz => 333 μ s round-trip
- ◆ NLOS: 3..10 km @ 5.7 GHz => 66 μ s round-trip

■ 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

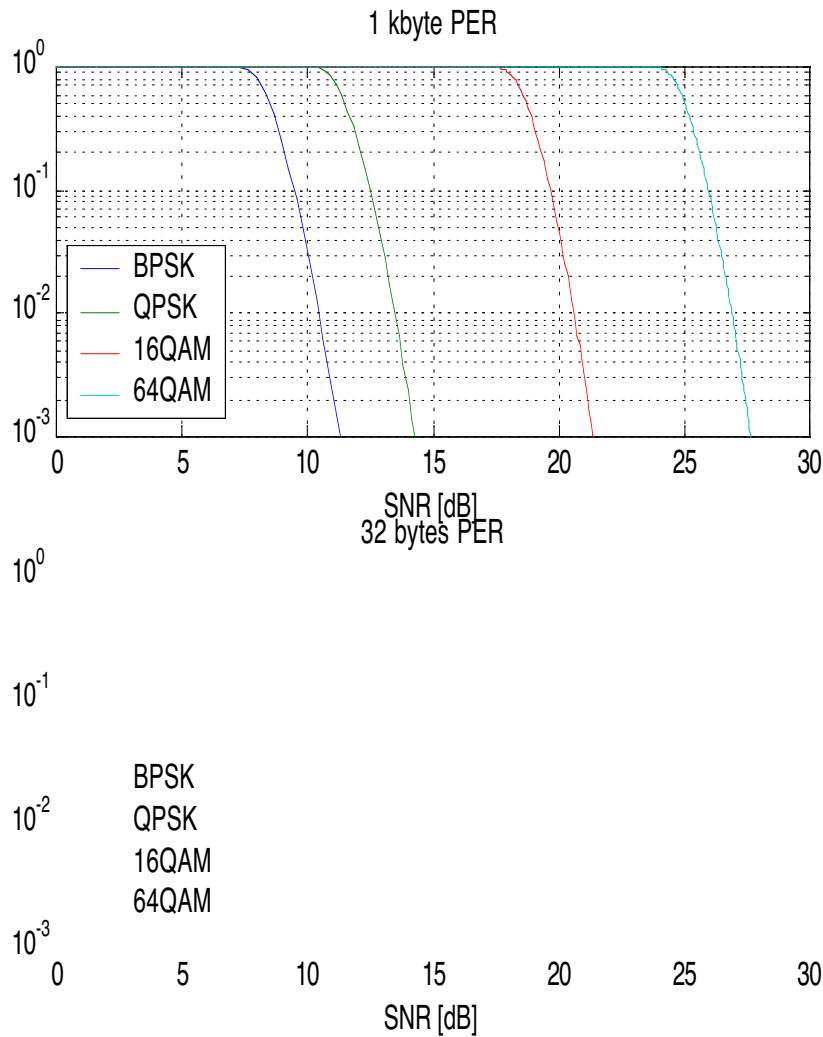
■ Problem

- ◆ 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 throughput
 - ✦ 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 μ s (1 OFDM symbol)
- ◆ BW allocation in DL/UL Map based on OFDM symbols
- ◆ Tx/Rx and CPE Transition Gap = 4 μ s
 - ✦ 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 μ s
- ◆ 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