Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Symbol duration Extended Interleaved FDMA as Uplink Multiple Access Technique for 802.16m**
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Re:	IEEE C802.16m-08/015 - Call for Contributions on Project 802.16m System Description Document (SDD)
Abstract	Proposed Symbol duration Extended I-FDMA for uplink gives unity PAPR and better link level coded BER performance than DFT-spread OFDMA and OFDMA
Purpose	To be discussed by TGm for incorporating the proposal into IEEE 802.16m standard
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Symbol duration Extended Interleaved FDMA as Uplink Multiple Access Technique for 802.16m

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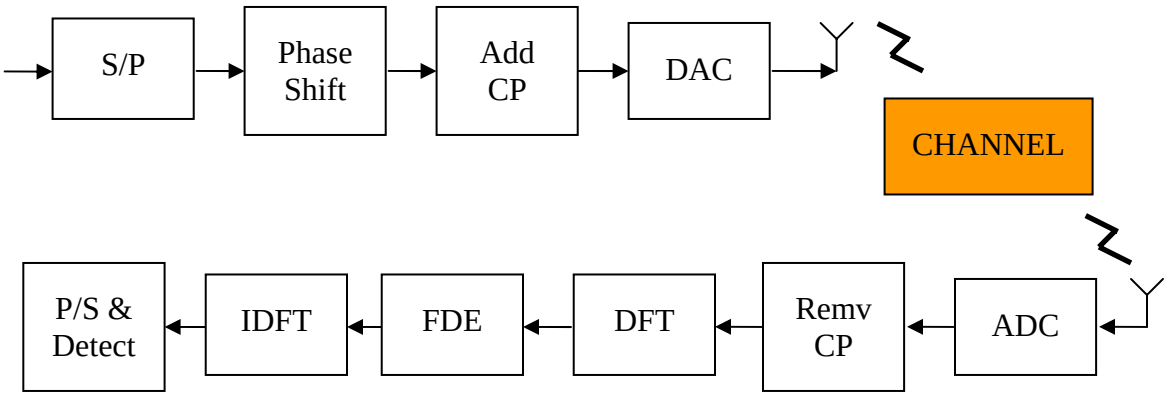
Motivation

OFDMA is used for UL and DL in IEEE 802.16e [1]. DFT-spread OFDMA has CM and PAPR less than OFDMA [2]. Tile based resource allocation is used in uplink of IEEE 802.16e where pilots are embedded into data subcarriers. Resource allocation in uplink and detection process at base station are quite cumbersome in IEEE 802.16e.

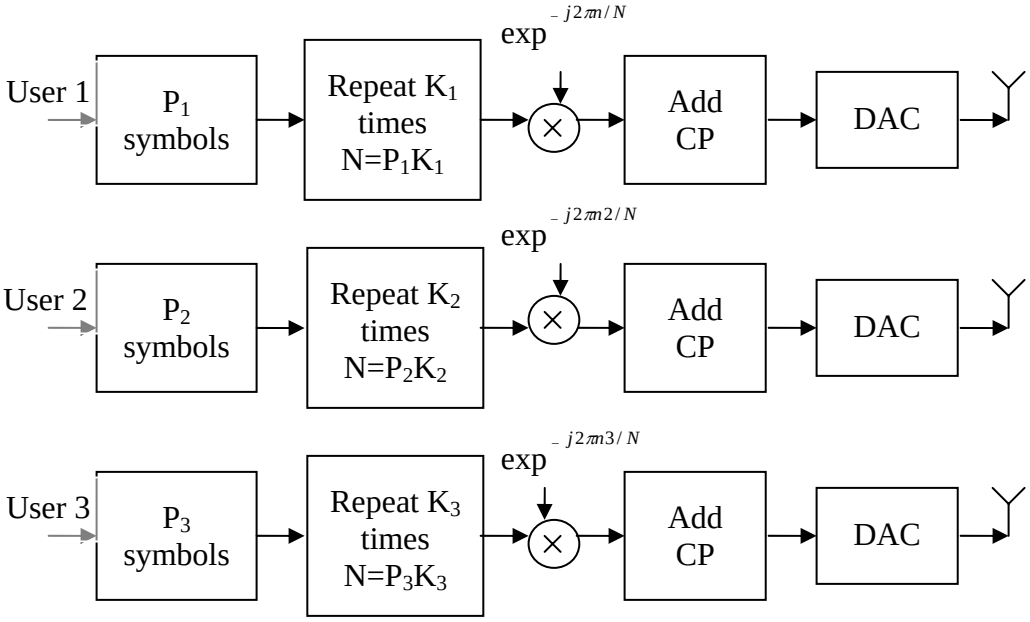
Proposed Technique

We propose Symbol duration Extended I interleaved FDMA as uplink multiple access technique. The proposed technique gives unity PAPR at transmitter. We also propose an uplink frame structure whereby every user is assigned a pilot slot followed by multiple data slots. Resource allocation in uplink and detection process at the base station are much easier in the proposed technique. We show that coded BER of proposed uplink transmission technique is better than that of DFT-spread OFDMA and OFDMA.

Transmitter–Receiver Block Diagram of Symbol duration Extended I-FDMA



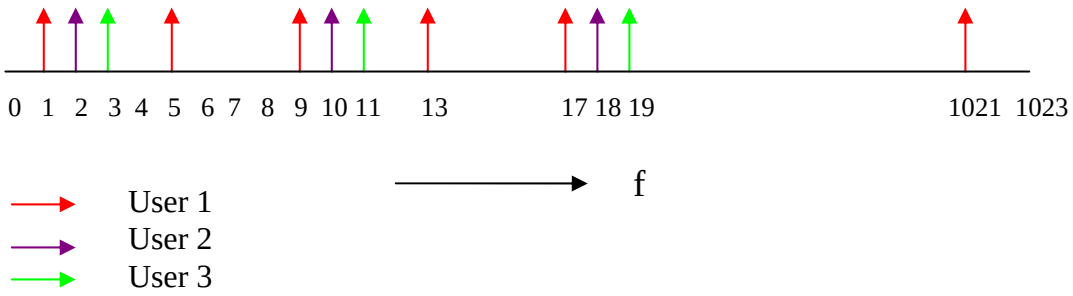
Transmission from multiple users in Uplink



n = [0 1 2 3 ….(N-1)]

Multiplexing multiple users in uplink

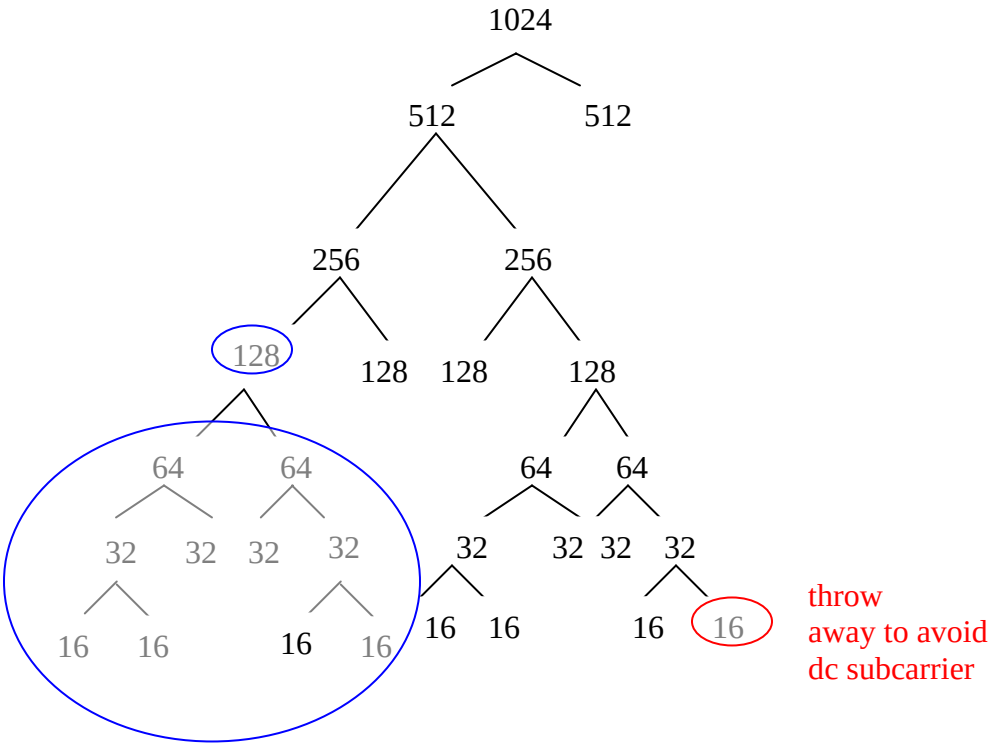
Ex: FFT size, N=1024, P_1=256, K_1=4, P_2=128, K_2=8, P_3=128, K_3=8



- Every user occupies a comb (red/magenta/green) in frequency domain
- Phase shift applied to a user's data determines the comb occupied by the user's data in frequency domain

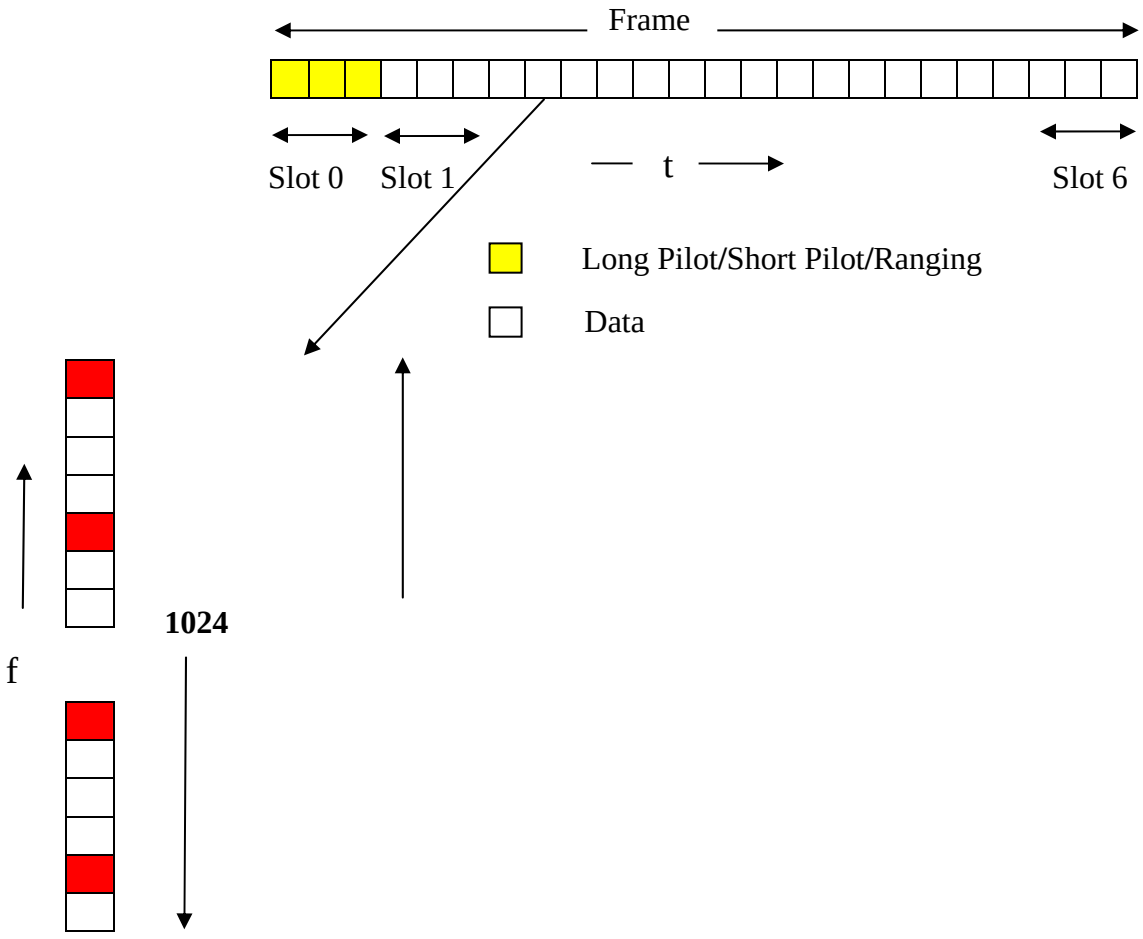
Subcarrier assignment to users in uplink

Ex: N = 1024



- A user can occupy only one node
- A node corresponds to a particular comb/subcarrier allocation in frequency domain
- Number associated with a node indicates number of subcarriers per symbol allocated to the user occupying the node
- When a node is occupied by a user, none of the children of that node can be occupied by a different user
- A user has a fixed number of comb/subcarrier allocation choices for a given number of subcarriers per symbol and FFT size

Frame Structure of Symbol duration Extended I-FDMA

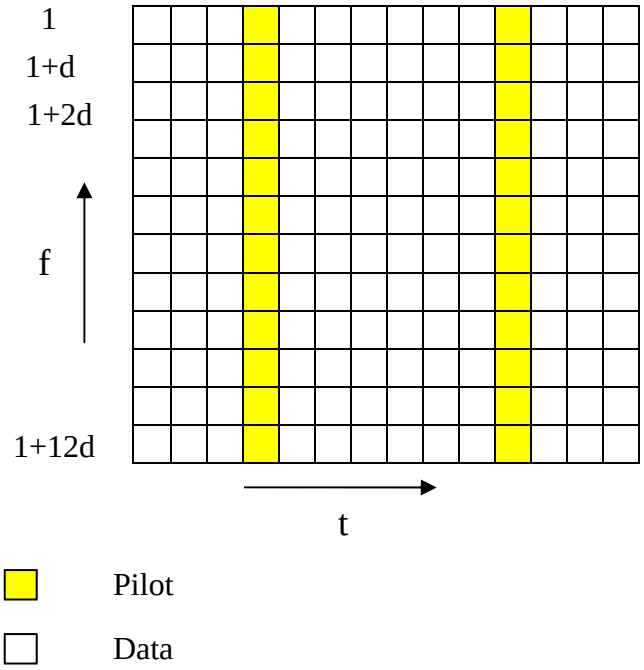


- 1 Frame = 7 Slots
- Size of resource block : 16X3 (16 subcarriers and 3 symbols)
- A user must be allocated at least one resource block per slot
- A user can be allocated multiple resource blocks per slot
- A user can be allocated minimum 16 to maximum 512 subcarriers in a symbol
- Slot 0 is for Long Pilot, Short Pilot and Ranging; Slot 1- Slot 6 is for data
- Allocated subcarriers must be equally spaced and spread over the entire frequency band
- Physical location of subcarriers assigned to a user remains fixed for a frame

Comparison with DFT-spread OFDMA

We know that DFT-spread OFDMA and OFDMA perform very similar in terms of block error rate with gaps less than 0.5 dB [2]. Again Cubic Metric and PAPR of DFT-spread OFDMA is less than OFDMA [2]. We therefore compare our proposed uplink MA technique with DFT-spread OFDMA with localized subcarrier allocation and DFT-spread OFDMA with equally spaced subcarrier allocation.

Frame Structure of DFT-spread OFDMA (as per LTE)

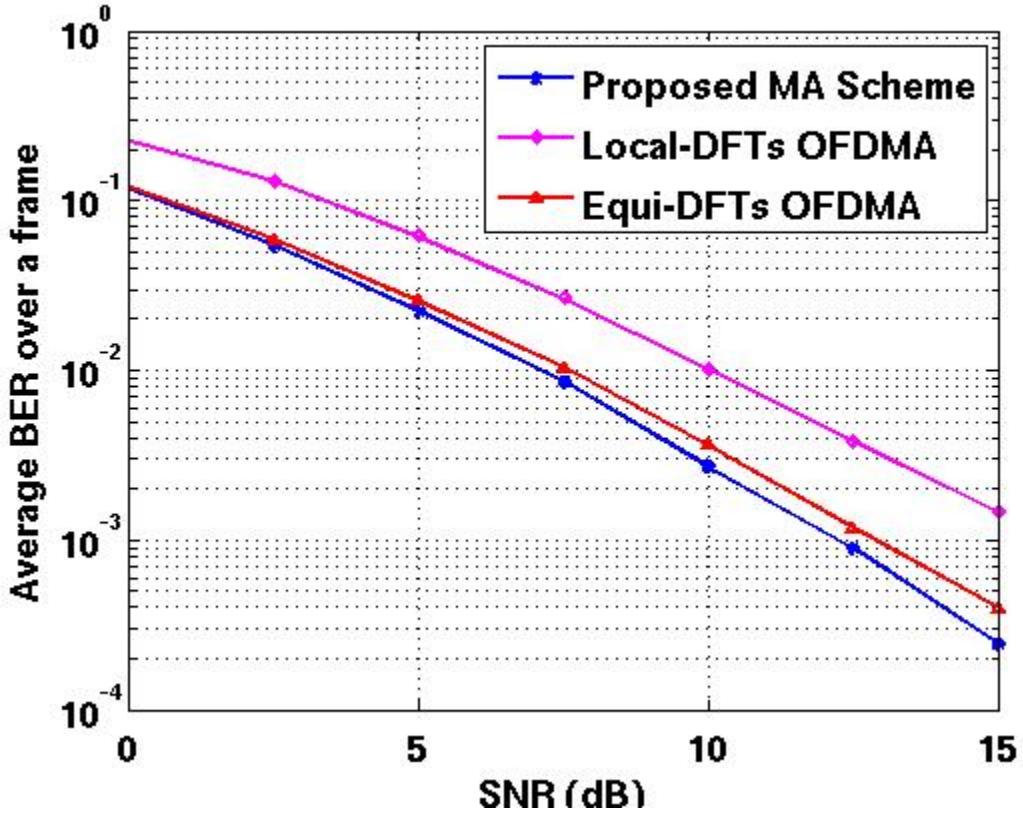


(1) Localized subcarrier allocation; d =1
(2) Equally spread subcarrier allocation; d >1

Parameters used in Simulation [3], [4]

Symbol duration Extended I-FDMA	DFT-spread OFDMA
Channel Model: WINNER Rural Macro-cell Vehicle speed: 30 km/h Modulation: QPSK Coder: ½ rate Turbo coder MIMO: 1X2 Pilot : Data = 1:7 BW = 10 MHz FFT size = 1024 Resource block: 64X3	Channel Model: WINNER Rural Macro-cell Vehicle speed: 30 km/h Modulation: QPSK Coder: ½ rate Turbo coder MIMO: 1X2 Pilot : Data = 1:7 BW = 10 MHz FFT size = 1024 Resource block: 48X7 (64X3)

Coded BER Plots



Comparison between Symbol duration Extended I-FDMA and WiMAX

Symbol duration Extended I-FDMA	**WiMAX**
Pilot : Data = 1:7 BW = 10 MHz FFT size = 1024 Subcarrier spacing = 8.9828 KHz Used subcarriers per symbol = 1008 Used BW = 9.1984 MHz Symbol duration (without CP) = 111.3 microsec Oversampling – NIL Data bits per msec = 7763 (assuming BPSK modulation)	Pilot : Data = 1:3 BW = 10 MHz FFT size = 1024 Subcarrier spacing = 10.9375 KHz Used subcarriers per symbol = 840 Used BW = 9.1984 MHz Symbol duration (without CP) = 91.43 microsec Oversampling factor = 28/25 Data bits per msec = 6860 (assuming BPSK modulation)

Disadvantages

- Inter-carrier Interference increases
- Effective Doppler increases
- Fixed options for comb/subcarrier allocation in uplink

Advantages

- PAPR at MS is unity for constant modulus constellation
- Uplink data bit rate increases by 13%
- Uplink overhead reduces drastically
- Uplink BER performance improves by 2 dB apart from an increase in uplink data transmission rate by 13%
- Turbo coder used for IEEE 802.16e-2005 can be used in MS

References

[1] IEEE 802.16e-2005
[2] IEEE C802.16m-07/239r1, “Proposal for Incorporating Single-carrier FDMA into 802.16m”
[3] IEEE 802.16m-07/002r4, “802.16m System Requirements”
[4] IEEE 802.16m-07/037r2, “Draft 802.16m Evaluation Methodology”

Proposed changes

[Insert in the ToC in the PHY layer in the appropriate sections (like Multiple Access Scheme, PHY Processing,Subcarrier Allocation, etc) provisions for SC-FDMA.]

x.x.x.x Symbol duration Extended I-FDMA