

Air Interface Proposal Using OFDM with SDM/TDM and OFDMA/TDMA

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Purpose:

This presentation is submitted as a PHY layer proposal for 802.16.3.

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Air Interface Proposal using OFDM with SDM/TDM and OFDMA/TDMA

*Presented by
Eric Jacobsen
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Motivation

- Architect System to enable Soft-PHY Implementations
- Reduce *peak* processing requirement by utilizing subset processing.

Constraints

- Channel Delay Spread
 - Peak delay values assumed as 10us.
 - Sprint Channel Model, Terrain A has a peak delay of 20us.
- Channel Bandwidth
 - Assume 6Mhz channel, used contiguously.

Channel Model Delay Spreads

Terrain Model	A	B	C
Peak Delay	20us	4us	0.6us
RMS Delay	5.2us	1.3us	0.2us

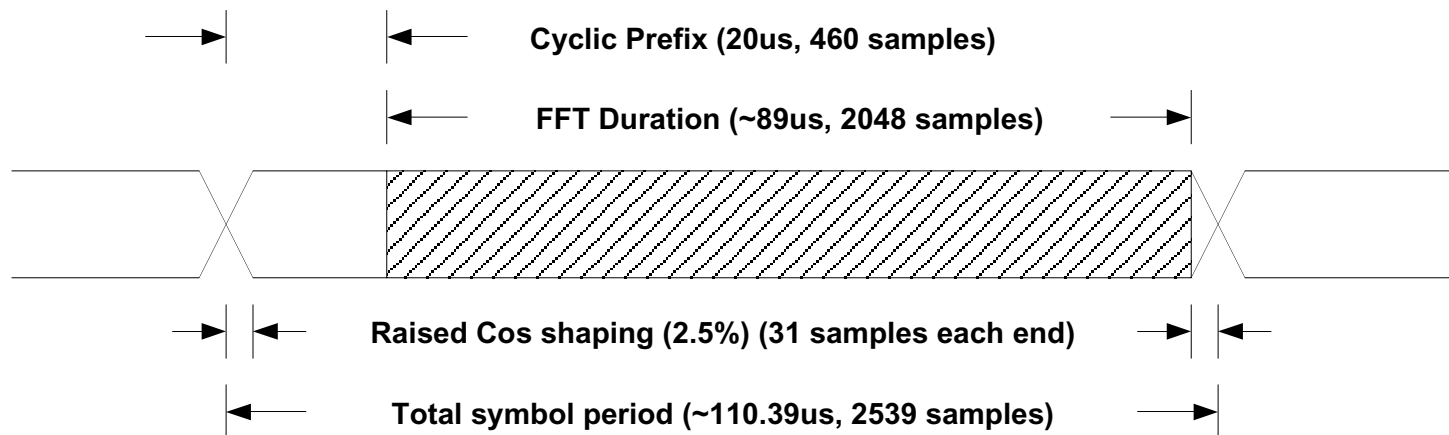
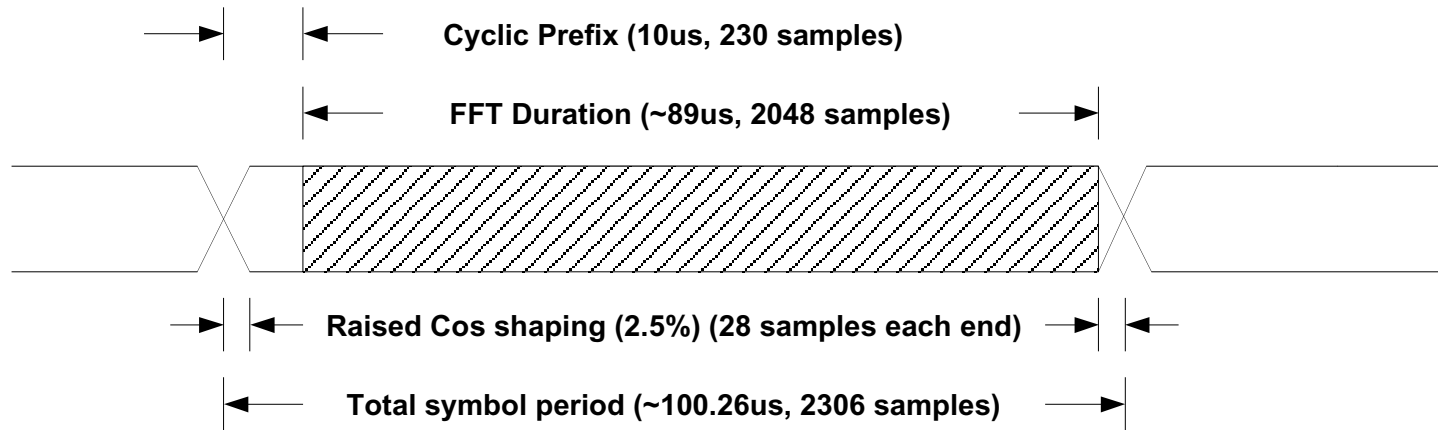
Indicated values are from Interim Channel Models for G2 MMDS Fixed Wireless Applications , IEEE Document 802.16.3c-00/49r2

Separate Delay Spread Cases

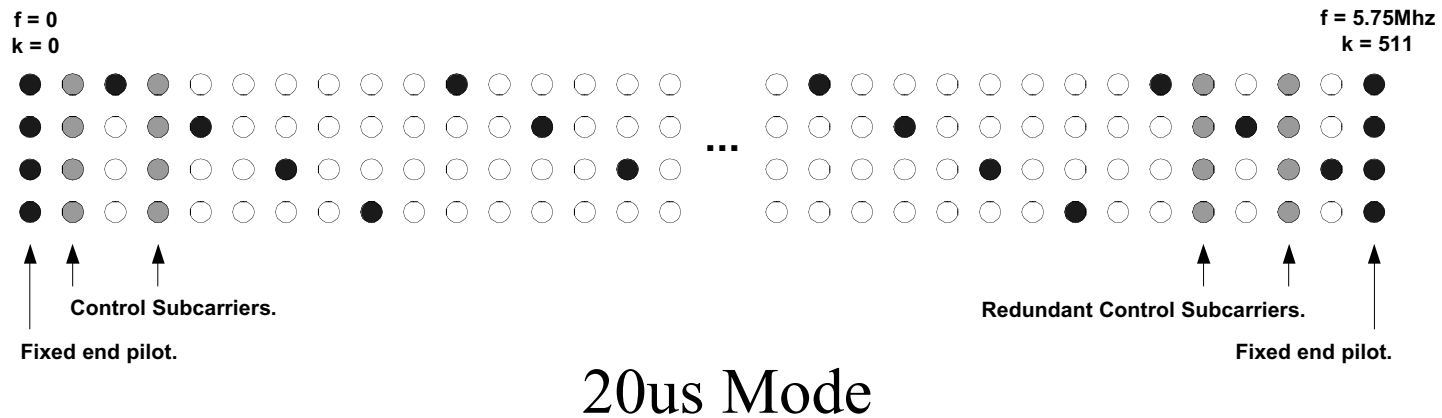
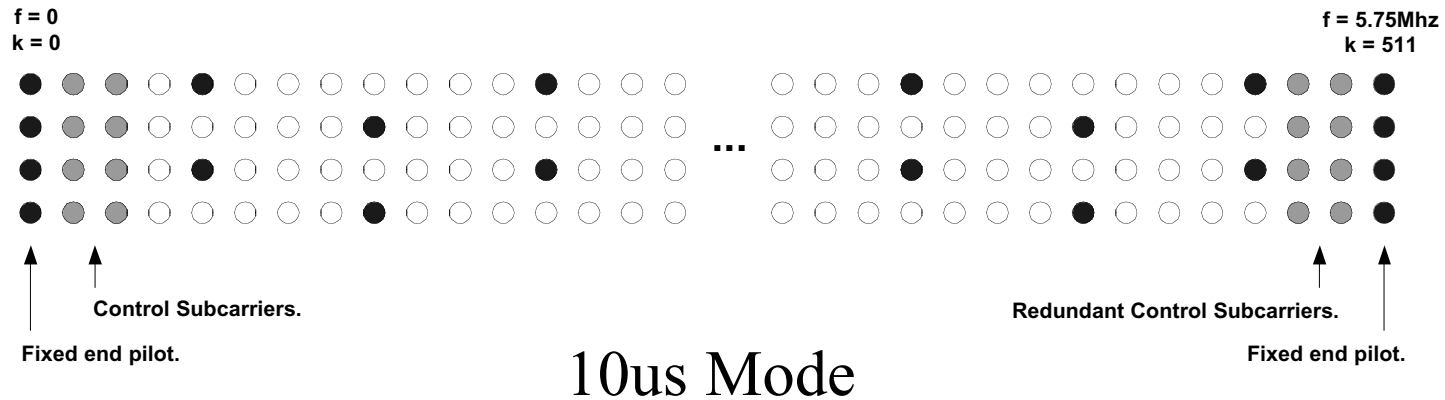
- 10us guard time will cover majority of cases.
- Separate 20us mode for areas with long delay spreads.
 - Avoid incurred inefficiency for other cases.
- Modes can be mixed in deployment.
 - Per cell, per sector, etc.

OFDM Symbol Configuration

23MHz system Clock



Pilot Density Strategy



Proposed Configurations

Downstream

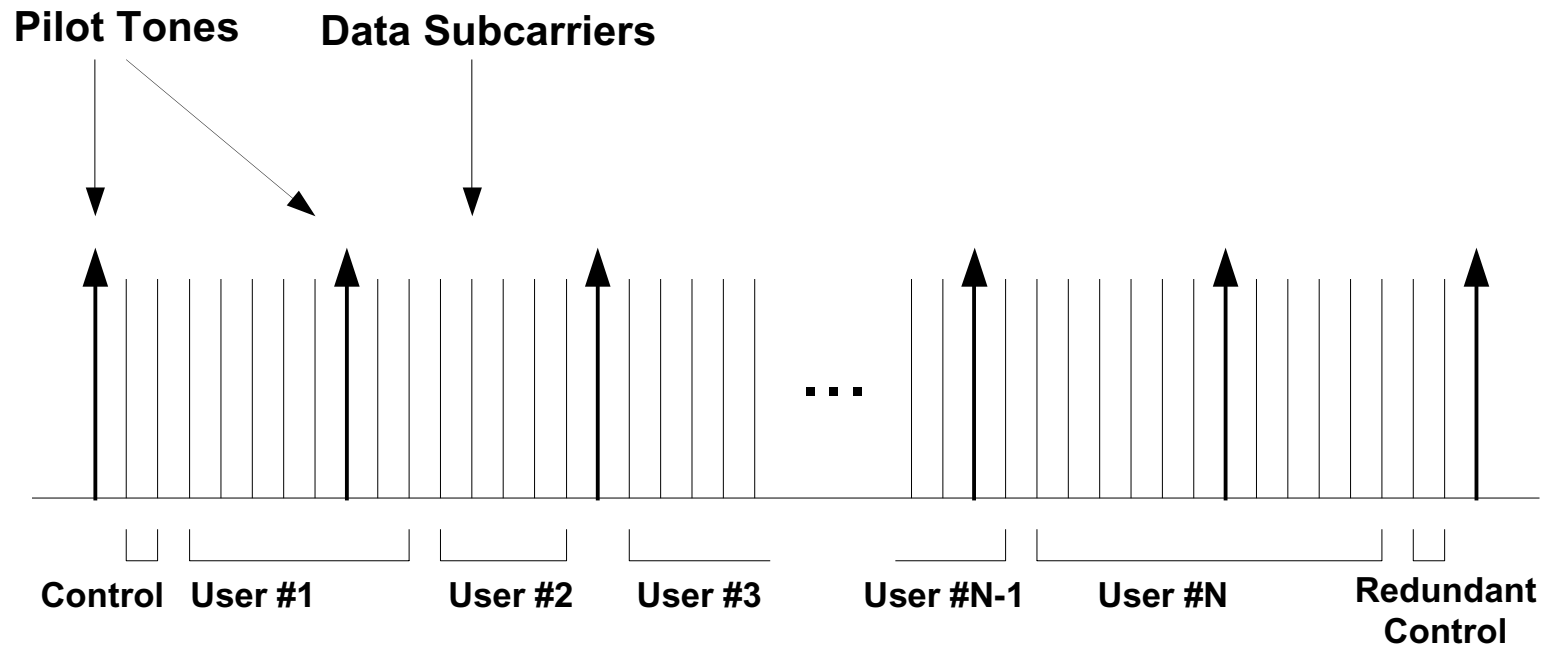
Subcarrier Quantity, N	Guard Interval, T_{guard}	Pilot Overhead	Symbol Rate, R_s (kHz)	Subcarrier Spacing, ΔF (kHz)	Uncoded Data Rate (Mbps) QPSK/ 16Q/ 64Q	Spectral Efficiency (bps/Hz) QPSK/ 16Q/ 64Q
512	10us	12.60%	9.974	11.23	8.93/ 17.85/ 26.78	1.55/ 3.1/ 4.66
512	20us	12.65%	9.056	11.23	8.10/ 16.21/ 24.31	1.41/ 2.83/ 4.23
1024	10us	6.30%	5.25	5.612	10.08/ 20.15/ 30.23	1.75/ 3.5/ 5.26
1024	20us	6.32%	4.986	5.612	9.56/ 19.13/ 28.70	1.66/ 3.33/ 4.99

Proposed Configuration

Downstream

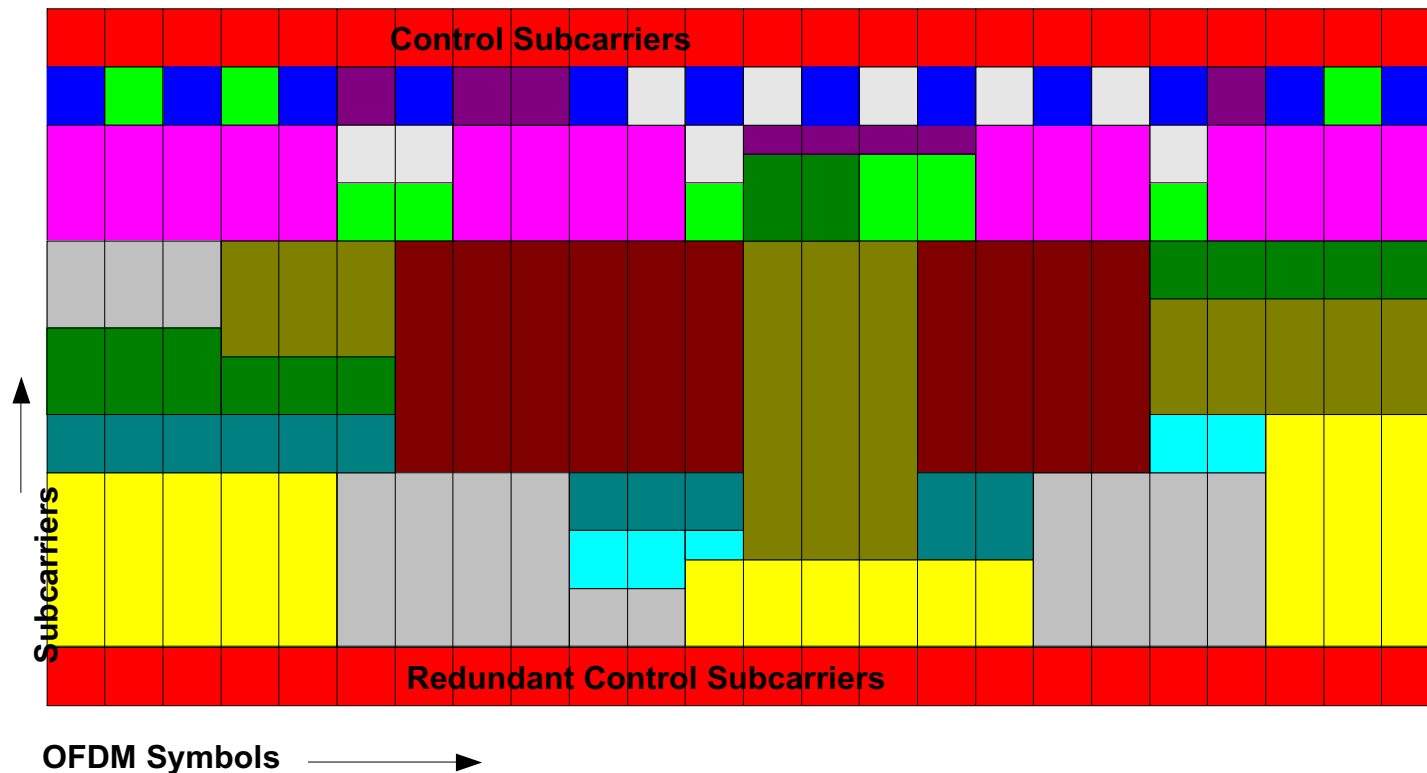
- Subcarrier quantity
 - 512
 - 1024 – Small throughput increase with tighter rf requirements.
 - Identical BW occupancy with end tones spaced 5.75MHz.
- Guard intervals of 10us and 20us.
- Staggered pilots schemes with end pilots (like DVB-T).
- Adaptive modulation and coding provides high system capacity.
- FDD, ARQ, etc.

OFDM Subcarrier Division



Subcarrier Division with TDM

Each color is for a distinct terminal.



FEC Configuration

- Concatenated Convolutional-RS
 - Inner Code Rates $R = \frac{1}{2}, \frac{2}{3}, \frac{3}{4}, \frac{5}{6}, \frac{7}{8}$
 - Programmable outer code rates
 - Supports variable block length.
 - Defaults: US (204, 188), DS (63, 55)
 - Configurable Interleaving schemes.
- Supports advanced coding such as Turbo Product Codes, other Turbo schemes.

Net DS Data Rates

Inner FEC code rates shown.

Outer FEC assumed to be (204,188) RS code.

Subcarrier Quantity, N	Guard Interval, T_{guard}	QPSK (Mbps) R = $\frac{1}{2}, \frac{3}{4}, \frac{7}{8}$	16QAM (Mbps) R = $\frac{1}{2}, \frac{7}{8}$	64QAM (Mbps) R = $\frac{2}{3}, \frac{5}{6}$
512	10us	4.11, 6.17, 7.20	12.34, 14.40	16.45, 20.57
512	20us	3.73, 5.60, 6.53	11.20, 13.07	14.93, 18.67
1024	10us	4.64, 6.96, 8.13	13.93, 16.25	18.57, 23.22
1024	20us	4.41, 6.61, 7.71	13.22, 15.43	17.63, 22.04

SDM/TDM Implications

- Maximizes statistical multiplexing flexibility.
 - Potential to optimize system capacity when used with adaptive modulation.
- Complicates Base Station.
 - Separate FEC encoding for each user.
 - Adaptive modulation per user.
 - MAC complexity increases.

SDM/TDM Implications

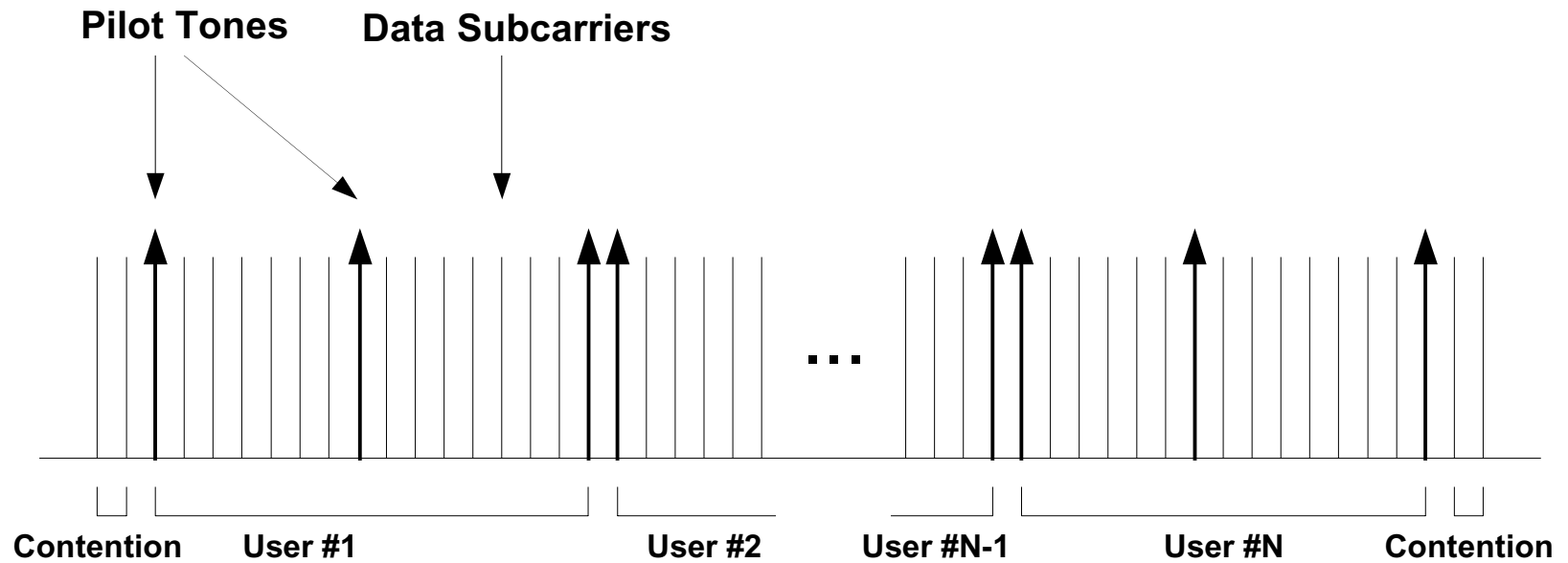
Continued

- Opportunity for CPE demodulator simplification.
 - Keeping user subcarriers contiguous simplifies channel estimation.
 - Soft-PHY friendly (*very* important).
- Can allocate best subcarriers/terminal.
 - Avoid deeply faded subcarriers.
- Use Channel Coding to flatten response.

OFDMA Upstream

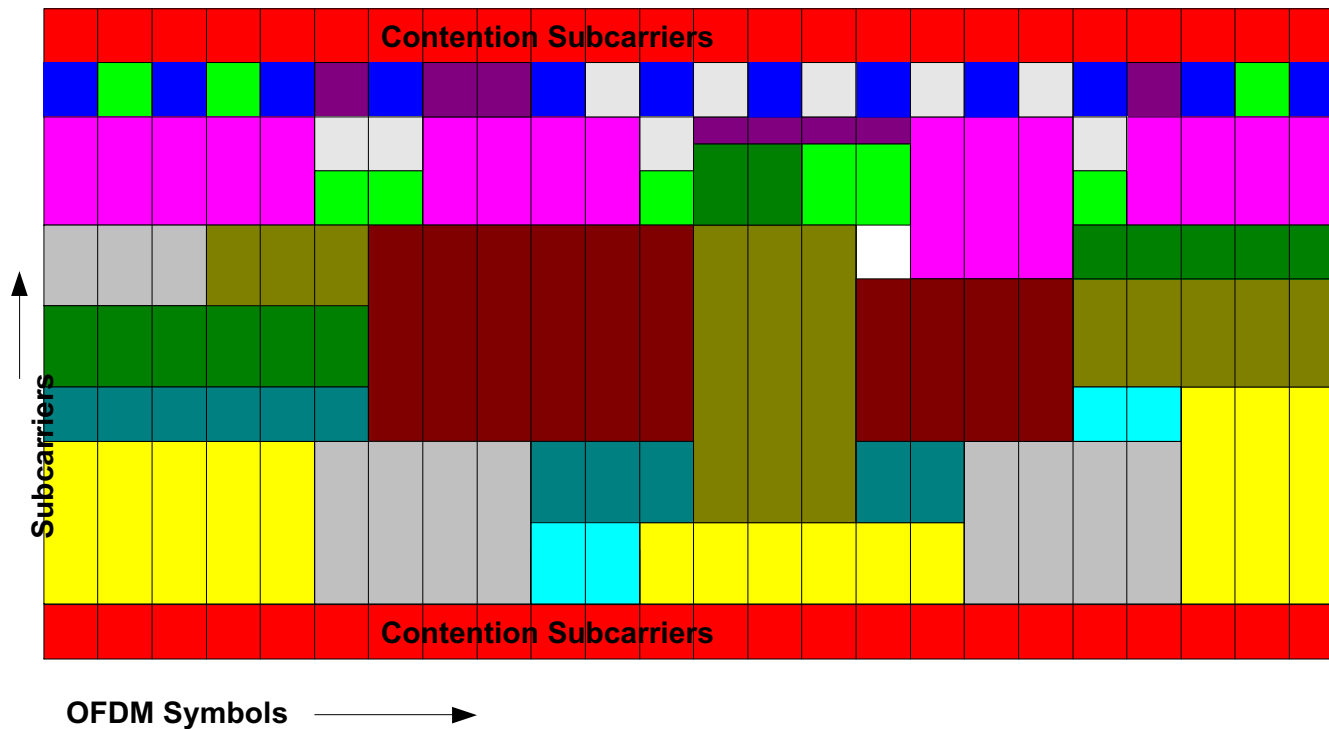
- OFDMA Benefits
 - Can reduce BW to increase link margin.
 - Reduced PAPR.
 - Similar to Downstream arguments.
 - Improved statistical multiplexing flexibility.
 - OFDMA/TDMA combination.
- Most Complications are in Base Station.
 - Some complexity increase in MAC.
 - Frequency registration is important.
 - Timing registration eased by OFDM, low R_s .

OFDMA



OFDMA with TDMA

Each color is for a distinct terminal



Conclusion

- FDD, Continuous Downstream.
 - OFDM with SDM/TDM.
 - 512 or 1024 subcarriers
 - 10us and 20us guard intervals.
- OFDMA Upstream.
 - Symmetric contention subcarriers.
 - OFDMA/TDMA
- Provides good efficiency, flexibility, best thing since sliced bread, end of prohibition, yada yada...