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

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This is a presentation of IEEE 802.16..3c-01/13, with URL <http://ieee802.org/16/tg3/contrib/ 802163c-01_13.pdf>.

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

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

Presented by

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Intel

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

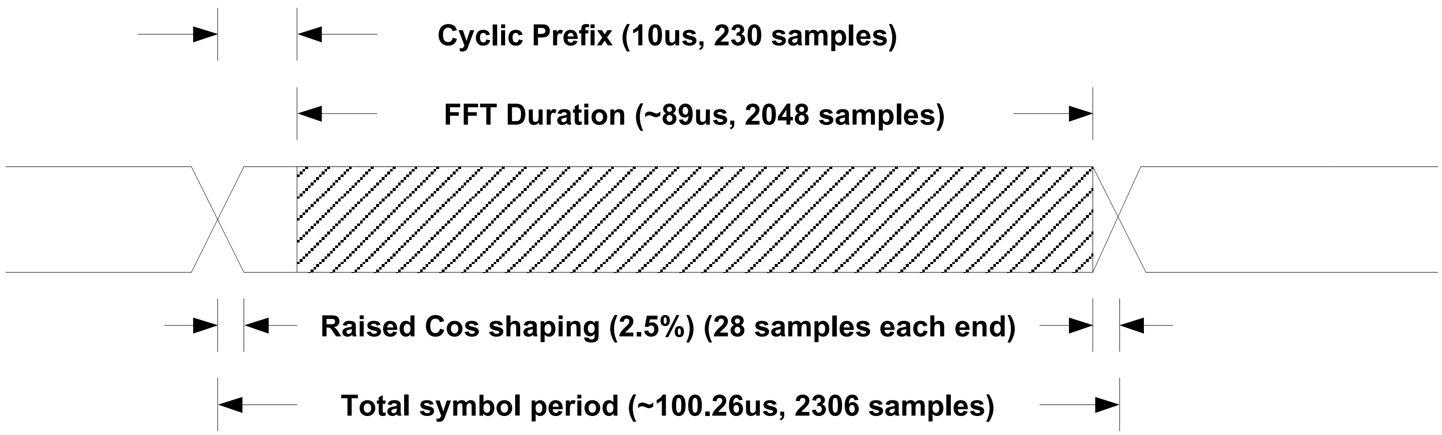
Indicated values are from Interim Channel Models for G2 MMDS Fixed Wireless Applications , IEEE Document 802.16.3c-00/49r2

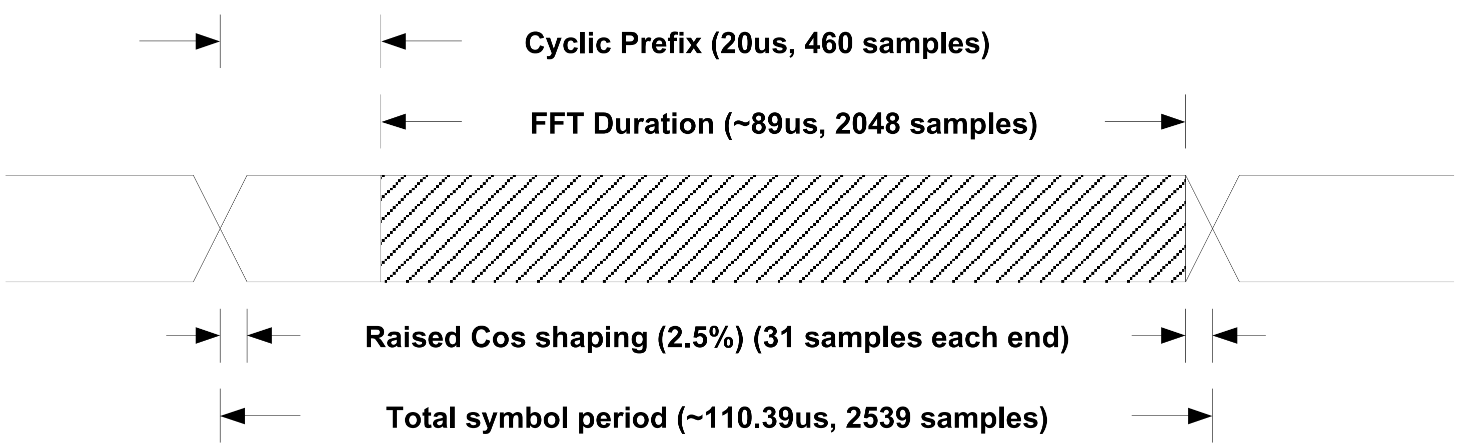
Separate Delay Spread Cases

- 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.

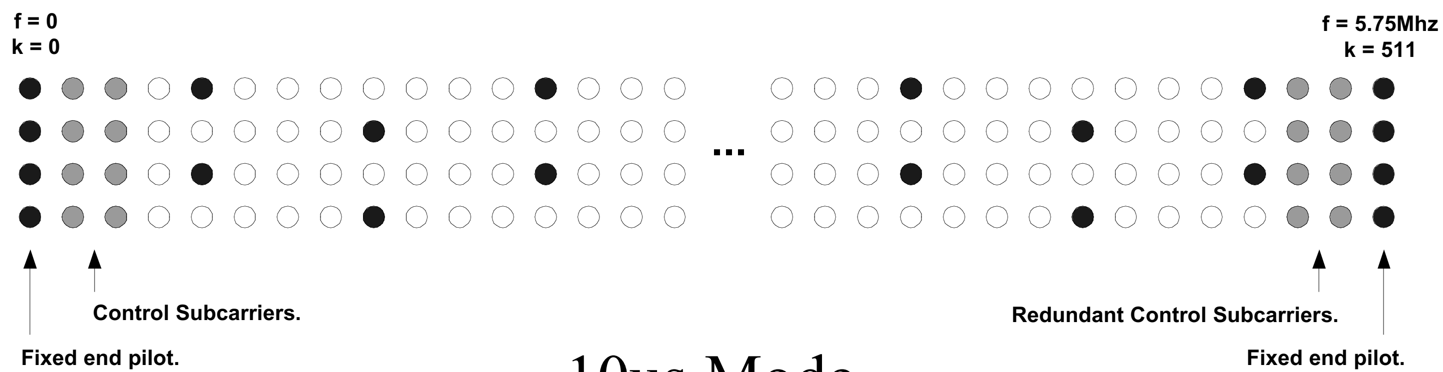
OFDM Symbol Configuration

23MHz system Clock

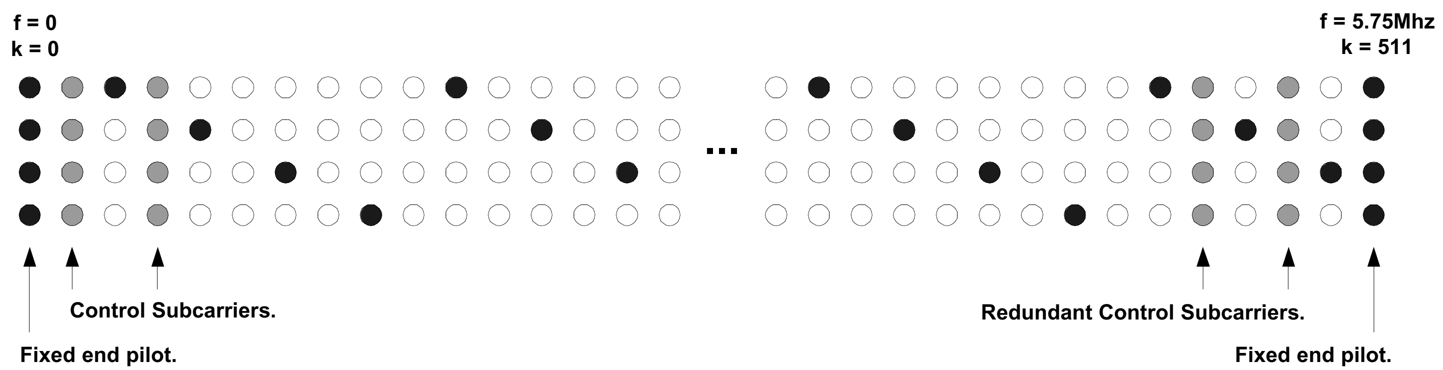




Pilot Density Strategy



10us Mode



20us Mode

Proposed Configurations

Downstream

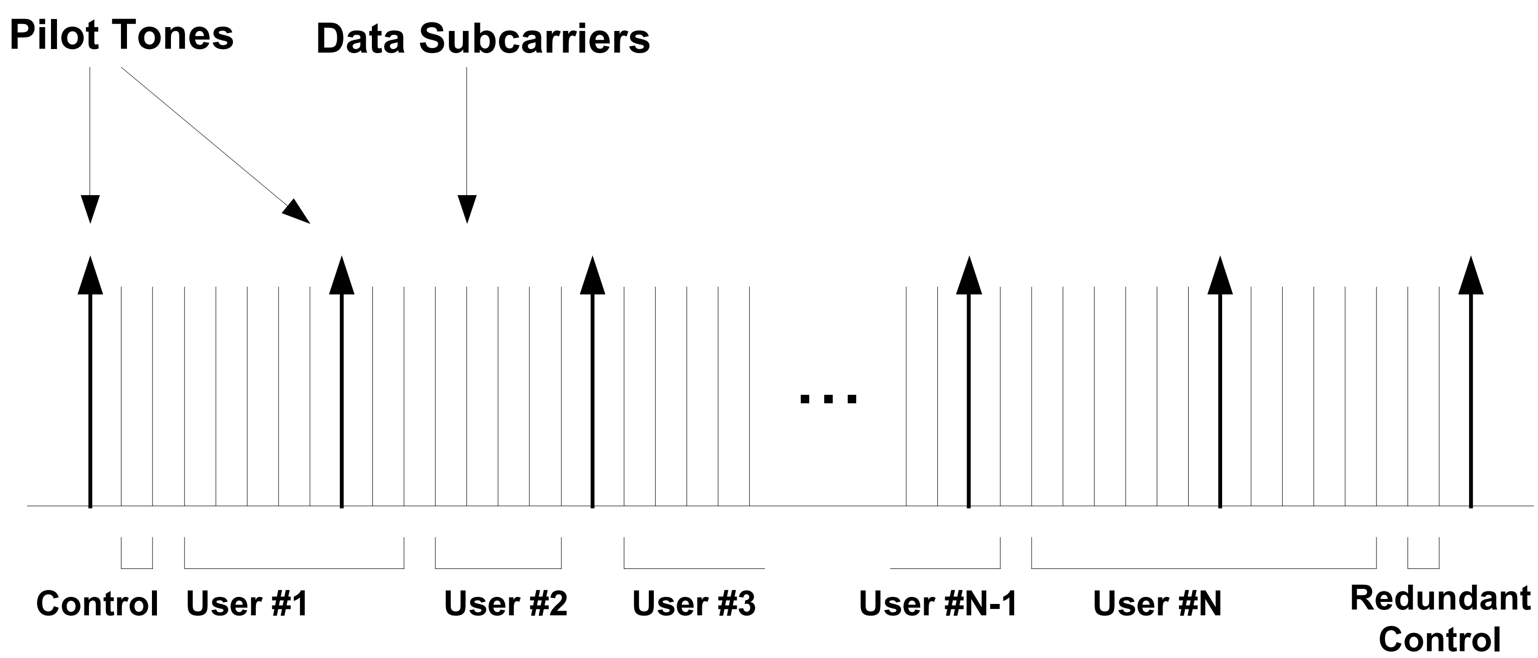
Subcarrier Quantity, N	Guard Interval, T_{guard}	Pilot Overhead	Symbol Rate, R_s (kHz)	Subcarrier Spacing, ΔF (kHz)	Uncoded Data Rate (Mbps) QPSK/ 16Q/ 64Q	Spectral Efficiency (bps/Hz) QPSK/ 16Q/ 64Q
512	**10us**	**12.60%**	**9.974**	**11.23**	**8.93/ 17.85/ 26.78**	**1.55/ 3.1/ 4.66**
512	**20us**	**12.65%**	**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

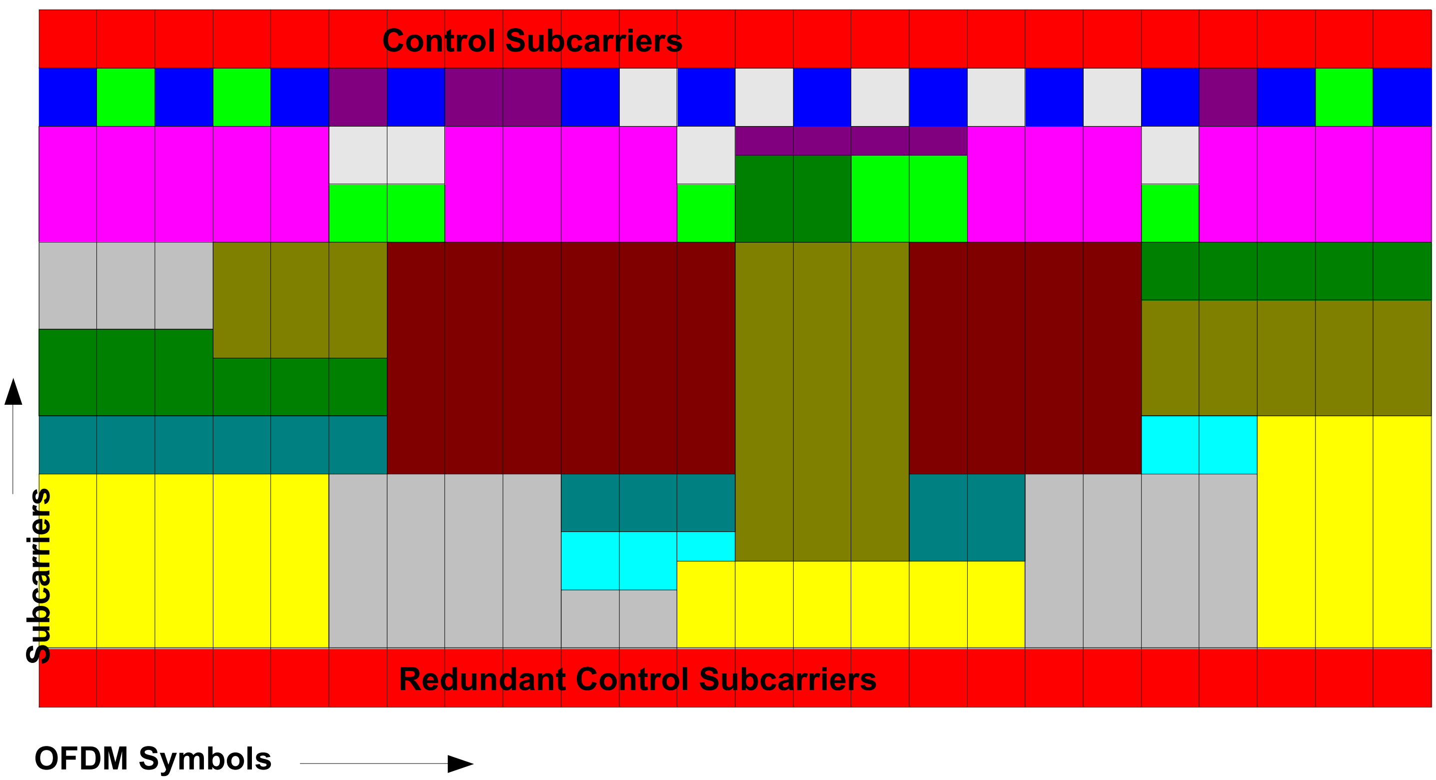
- Subcarrier quantity
  - 512
  - 1024 – Small throughput increase with tighter rf requirements.
  - Identical BW occupancy with end tones spaced 5.75MHz.
- Guard intervals of 10us and 20us.
- Staggered pilots schemes with end pilots (like DVB-T).
- Adaptive modulation and coding provides high system 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 = _, 2/3, _, 5/6, 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 = _, _, 7/8	16QAM (Mbps) R = _, 7/8	64QAM (Mbps) R = 2/3, 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

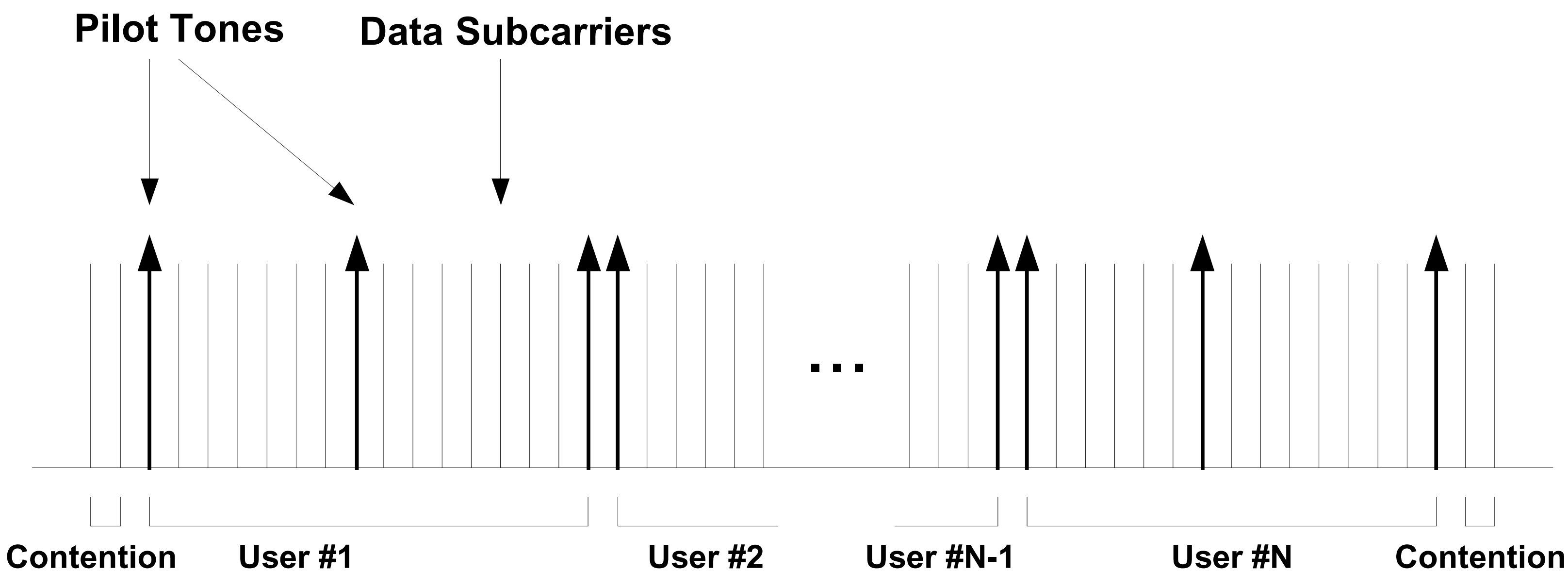
Continued

- 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 Rs.

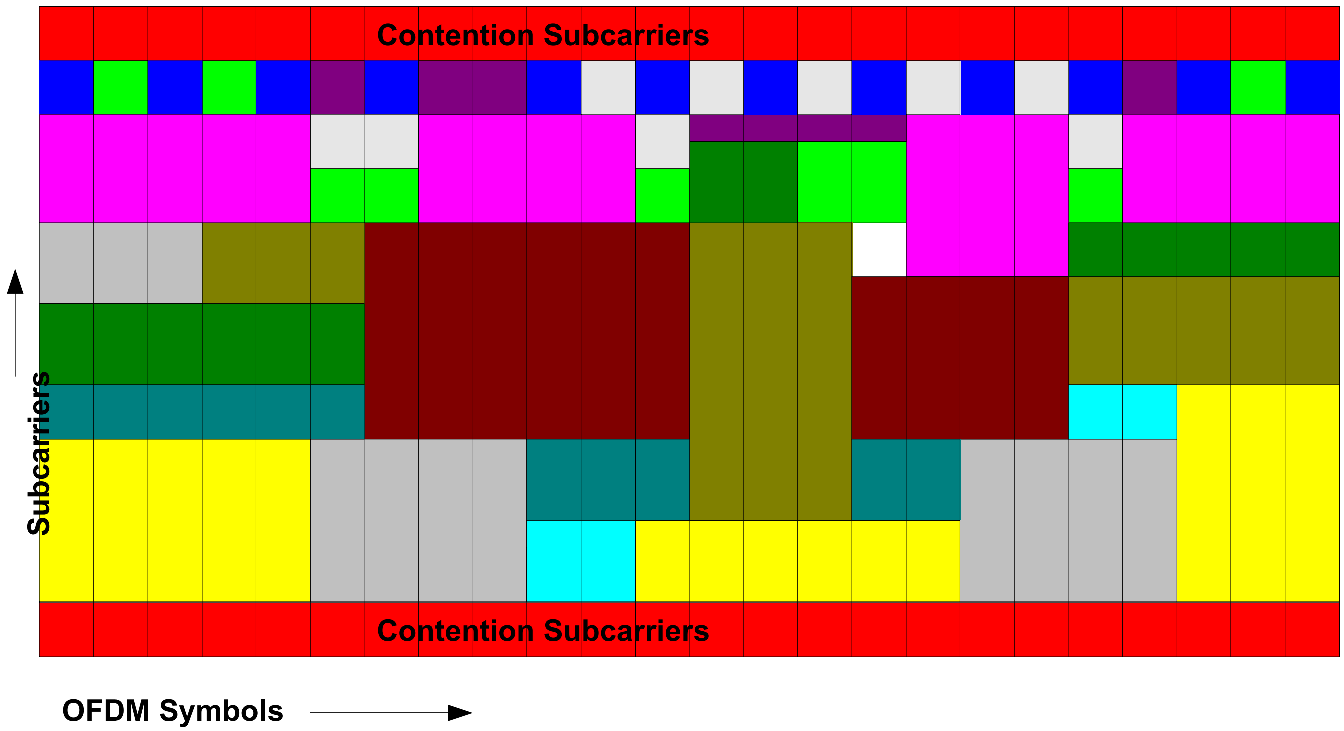
OFDMA



Pilot Tones
Data Subcarriers
...
Contention
User #1
User #2
User #N-1
User #N
Contention

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...