Proposed Frame Structure for IEEE 802.16m

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Source:

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Re:

TGm Call for comments on SDD, IEEE 802.16m-07/047,
in the area of "Proposed 802.16m Frame Structure with special attention to legacy support"

Purpose:

Review and adopt

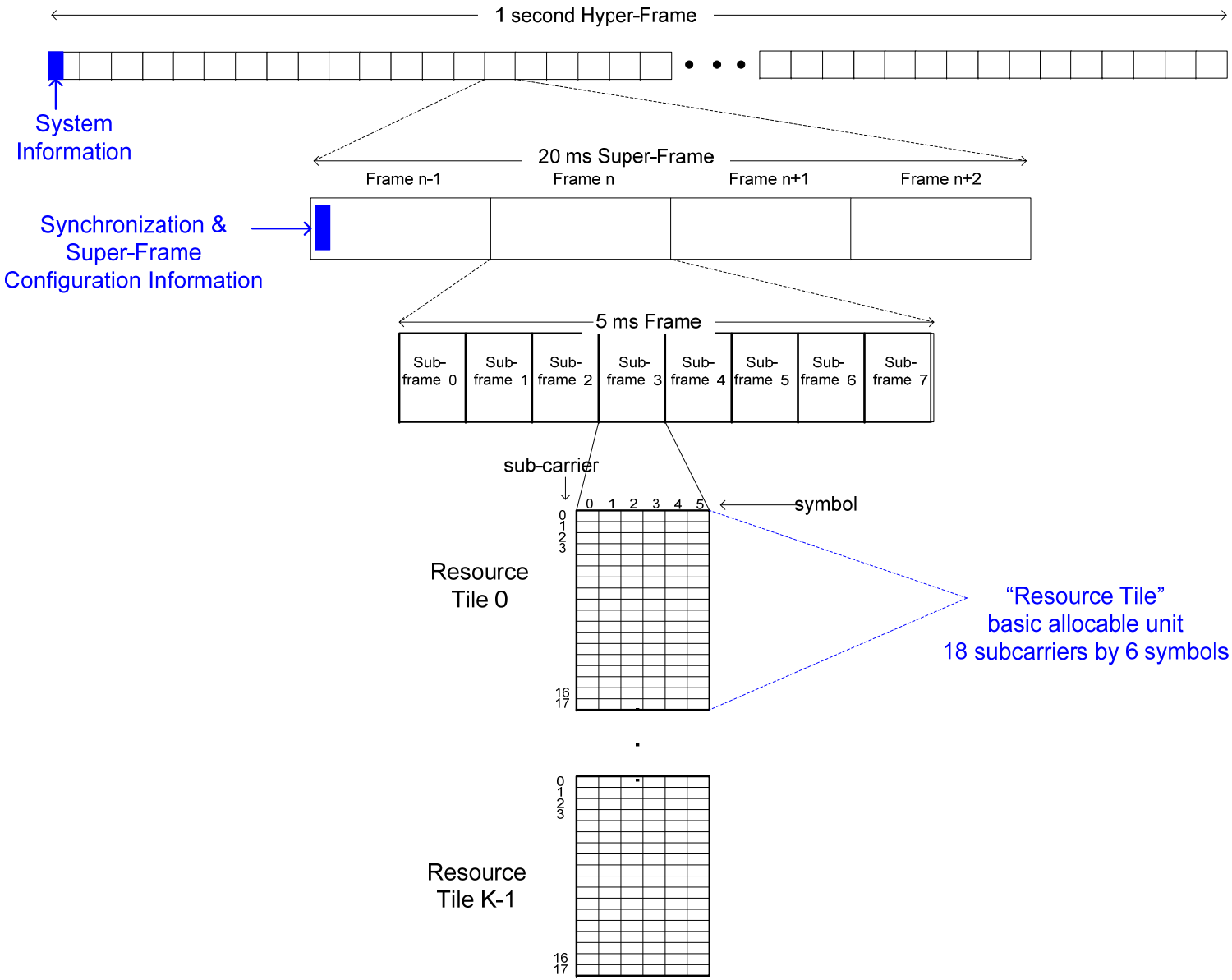
IEEE 802.16m Frame Structure Objectives

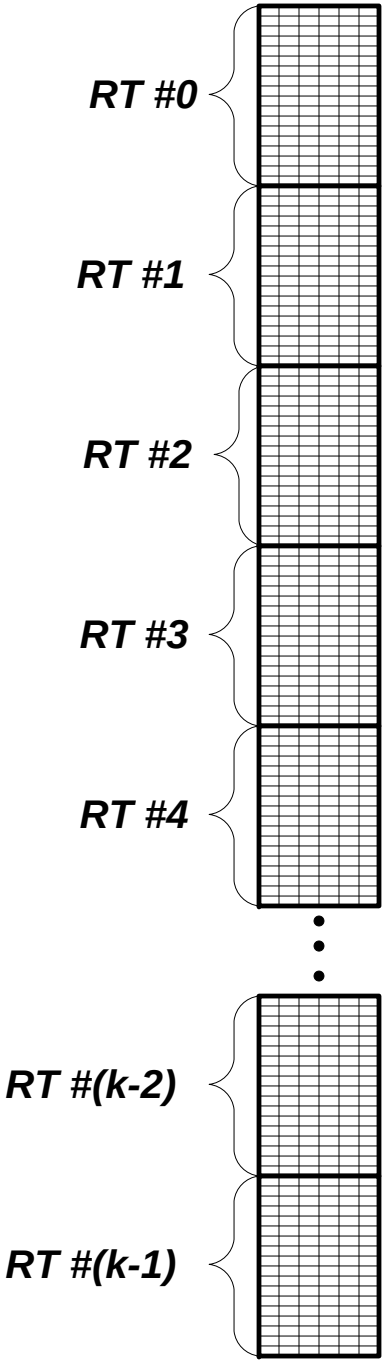
- Reduced system overhead through hierarchal structures (SRD Sec 6.10)
  - Hierarchal frame structure partitioning control between: ***hyper-frame, super-frame, frame and sub-frame***
    - Critical system information is communicated in well defined intervals
    - ***Per-frame (or sub-frame) control is reduced to essential information***
  - Hierarchal slot definition simplifying resource allocation
    - "Resource Tiles" are defined as fundamental building blocks
      - Resource tiles may be customized per link and application:
        - Full-Size Tiles: Downlink Tile (DLRT) and Uplink Tile (ULRT)
        - Mini-Tiles: Control Mini-Tile (CMT) and Feedback Mini-Tile (FMT)
      - Tile formats may vary to accommodate different transmission techniques
      - Time-Frequency dimensions of particular tile types are consistent
    - Resource allocation overhead is improved based on reduced signaling complexity
- Efficient implementation of multi-antenna techniques for both TDD, FDD (SRD Sec 5.7)
  - Support for 2 to 8 (or more) antennas at the base station
  - Support for 1 to 4 antennas at the mobile station
  - Enable beamforming, SDMA, SU-MIMO and MU-MIMO
  - Resource tiles optimized to meet all these techniques
- Lower latency (SRD Sec 6.2)
  - Shorter sub-frame allows for lower latency than IEEE 802.16e
- Efficient legacy support (SRD Sec 5.1)
  - Identical OFDMA numerology, same cyclic prefix and subcarrier spacing
- Improved Sector Throughput and VoIP Capacity (SRD Sec 7.2)
  - Combination of overhead reduction and multi-antenna techniques

Hierarchal Frame Structure

- Hyper-Frame: repeated every 0.5 to 2 s
  - Communicates system information similar to that currently found in the DCD/UCD
    - Neighbor lists, Security information, etc.
- Super-Frame: 20 ms duration
  - Synchronization
  - System Identification
  - Configuration of the multi-frame
- Frame: 5 ms duration
  - Consistent with legacy support
- Sub-Frame: 0.617 duration
  - 6 OFDMA symbols in duration ideal for legacy support
    - Supports 2 DL AMC slots, 3 DL PUSC slots or 2 UL slots
  - Fundamental allocation length for 16m
    - Full-size resource tiles span the duration of the sub-frame
- Resource Allocation Domain (RAD): N*0.617
  - One or more sub-frames may be grouped to form a *Resource Allocation Domain (RAD)*
  - One control channel (e.g. DL_MAP or UL_MAP) will be associated with a RAD and be used to allocate resources within the RAD
  - RADs will be defined for both the uplink and downlink intervals

Proposed 16m Frame Structure

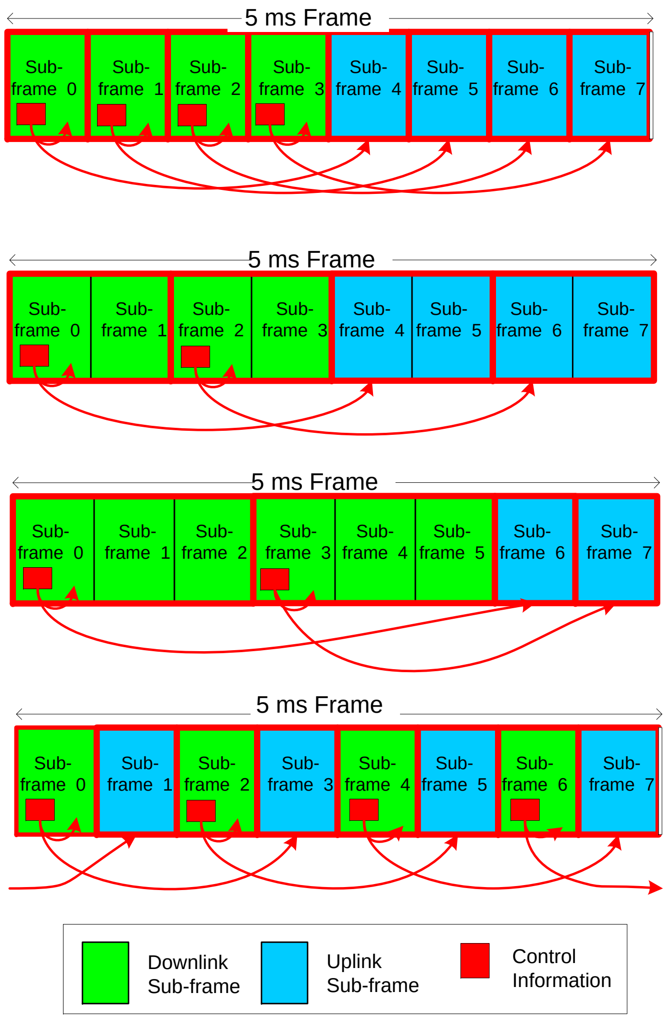




Sub-frame Structure

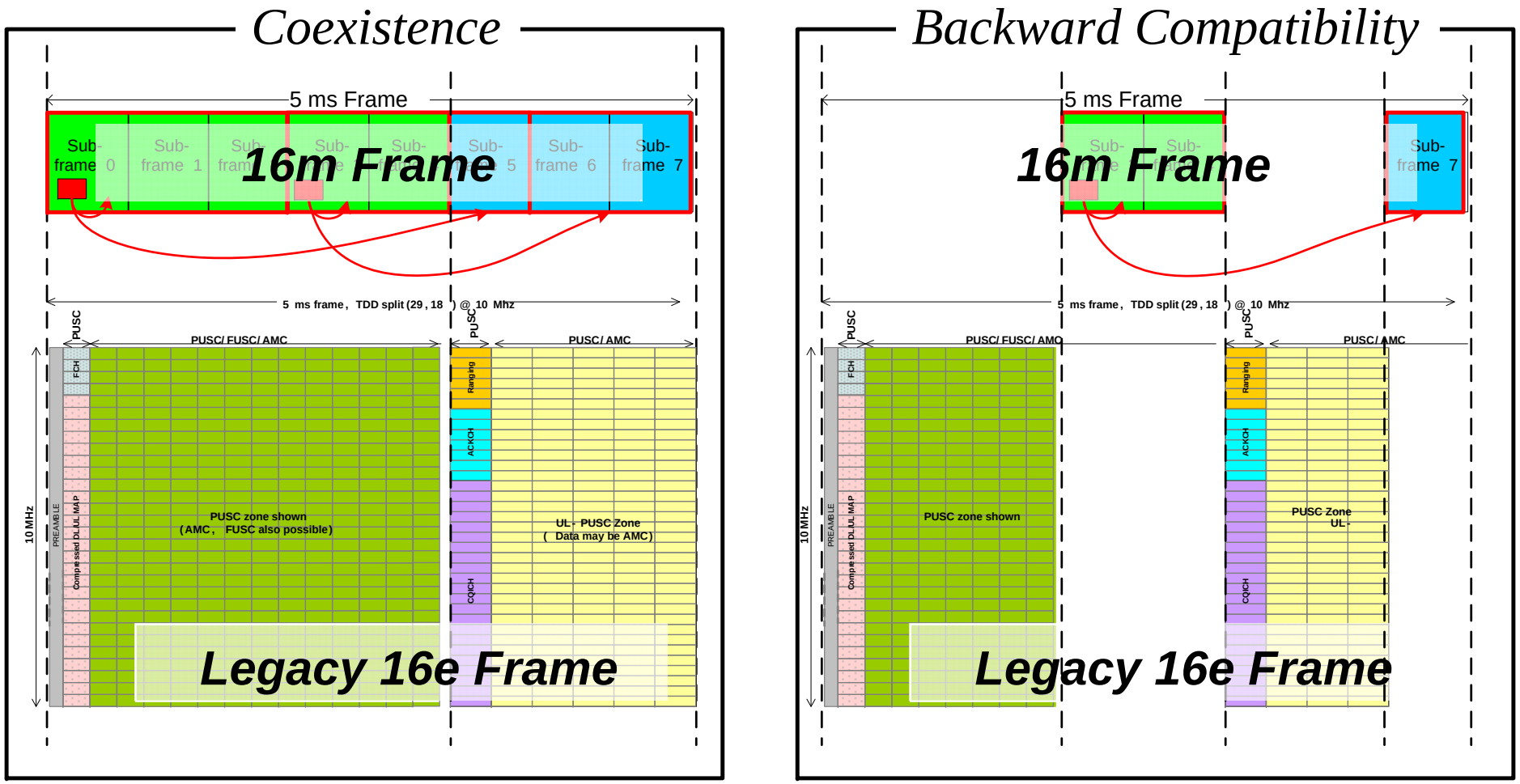
- Each sub-frame is divided into fixed sized Resource Tiles (RTs)
  - 18 subcarriers in frequency
    - 24 per sub-frame @ 5 MHz system bandwidth
    - 48 per sub-frame @ 10 MHz system bandwidth
    - 96 per sub-frame @ 20 MHz system bandwidth
  - Tile bandwidth equivalent to band AMC sub channel
    - 2x3 band AMC is exactly 18 subcarriers
    - Provides 200 kHz bandwidth for frequency selective allocation
- Application of diversity or frequency selectivity is a function of the scheduling
  - Adjacent tiles allocated for frequency selective transmission
  - Multiple disjoint tiles allocated for frequency diverse allocations
- Resource Tiles are applicable to both the uplink and downlink sub-frames

Resource Allocation Domains



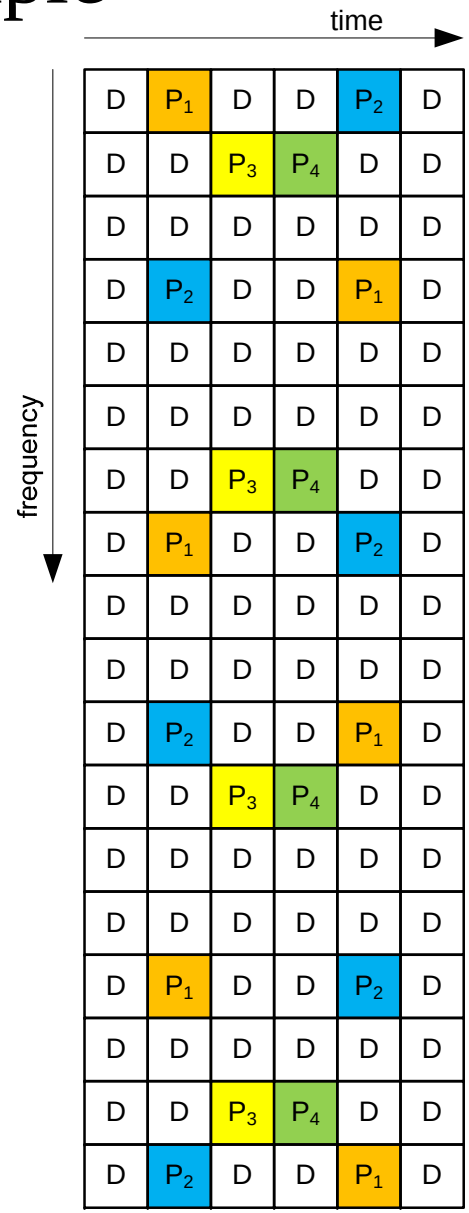
- Resource Allocation Domain (RAD) defines the domain of a particular control channel
  - At a minimum a RAD contains one sub-frame
  - Multiple subframes may concatenated to form an extended RAD
  - The configuration of RAD would be signaled in the super-frame
- Potential benefits
  - Reduced control overhead as the control channel appears less frequently
  - Improved subscriber battery life extending micro-sleep

Coexistence & Backward Compatibility



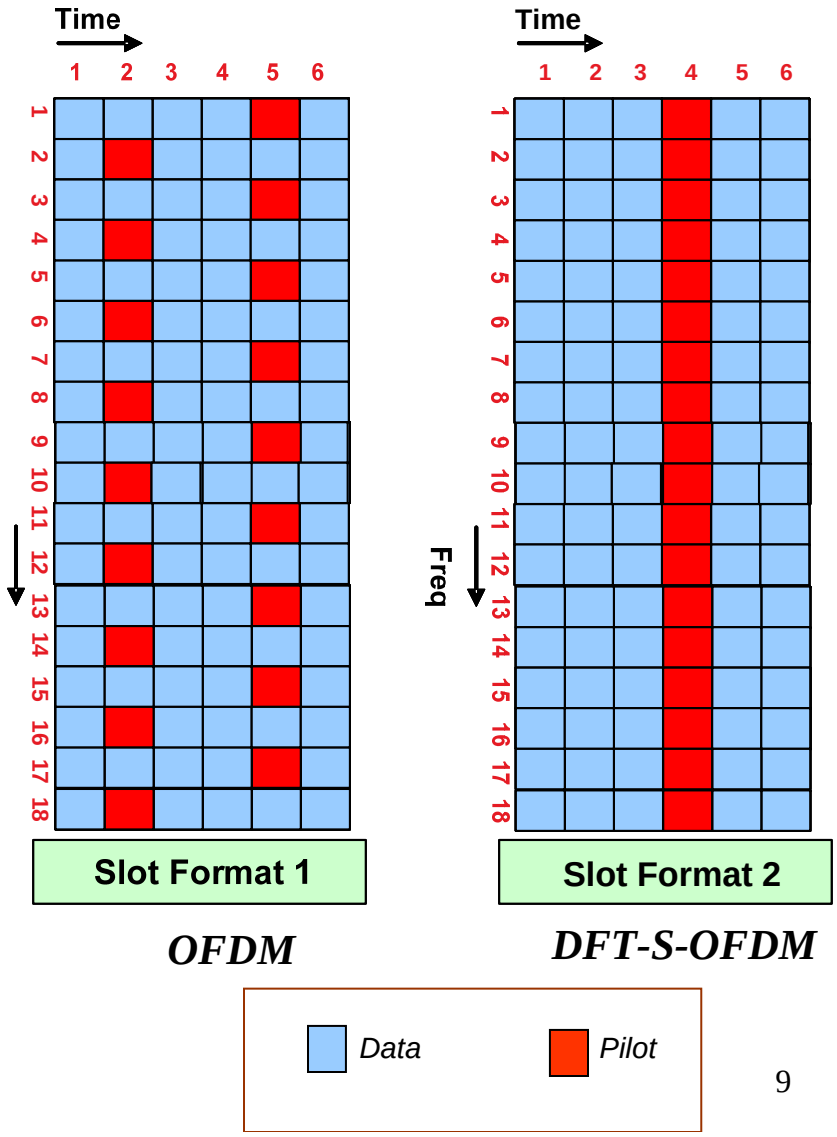
Downlink Resource Tile Example

- Supports arbitrary number of Tx antennas with up to 4 spatial streams
- Notation:
  - D=data symbol location
    - Spatial streams represent the third dimension in the diagram to the right
  - Pn=pilot transmitted by antenna/stream m.
    - Other spatial streams are null in those positions
    - When number of streams is n, then positions p_{n+1} to p_4 are replaced with data.
      - FEC rate matching is assumed
- Overhead:
  - Pilot overhead depends on the transmission rank:
    - 5.56% overhead for one data stream
    - 11.11% overhead for two data streams
    - 18.52% overhead for four data streams
  - Very small overhead for transmitting a single data stream (when using 4 Tx antennas) compared to broadcast pilots
- Channel Estimation:
  - Some simple channel estimators possible
  - Rays up to 13.1 usec can be estimated using only a single OFDM symbol
  - Pilots available at band edges (for streams 1 and 2) to improve channel estimation performance
  - Streams 3 and 4 best used for lower speeds (if streams 3 and 4 are weaker then higher speeds may be supported)
  - Time interpolation limited to linear interpolation/extrapolation (unless adjacent RTs are also available)
- ***See contribution IEEE C802.16m-07/014 for further details***

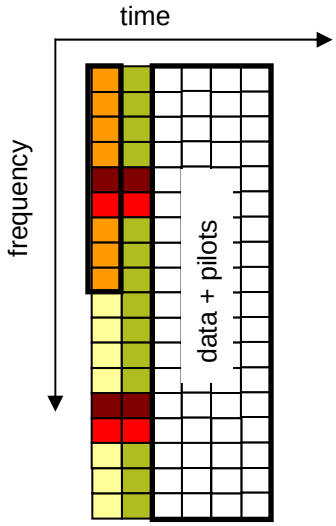


Uplink Resource Tile Example for OFDMA Hybrid: UL OFDM & DFT-S-OFDM

- 6 symbols x 18 consecutive tones
  - 0.617 msec duration
  - Primary pilot overhead = 18/108 ~ 17%
  - Auxillary pilots for MIMO/SDMA
  - Sounding Signal
- *See contribution IEEE C802.16m-07/012*



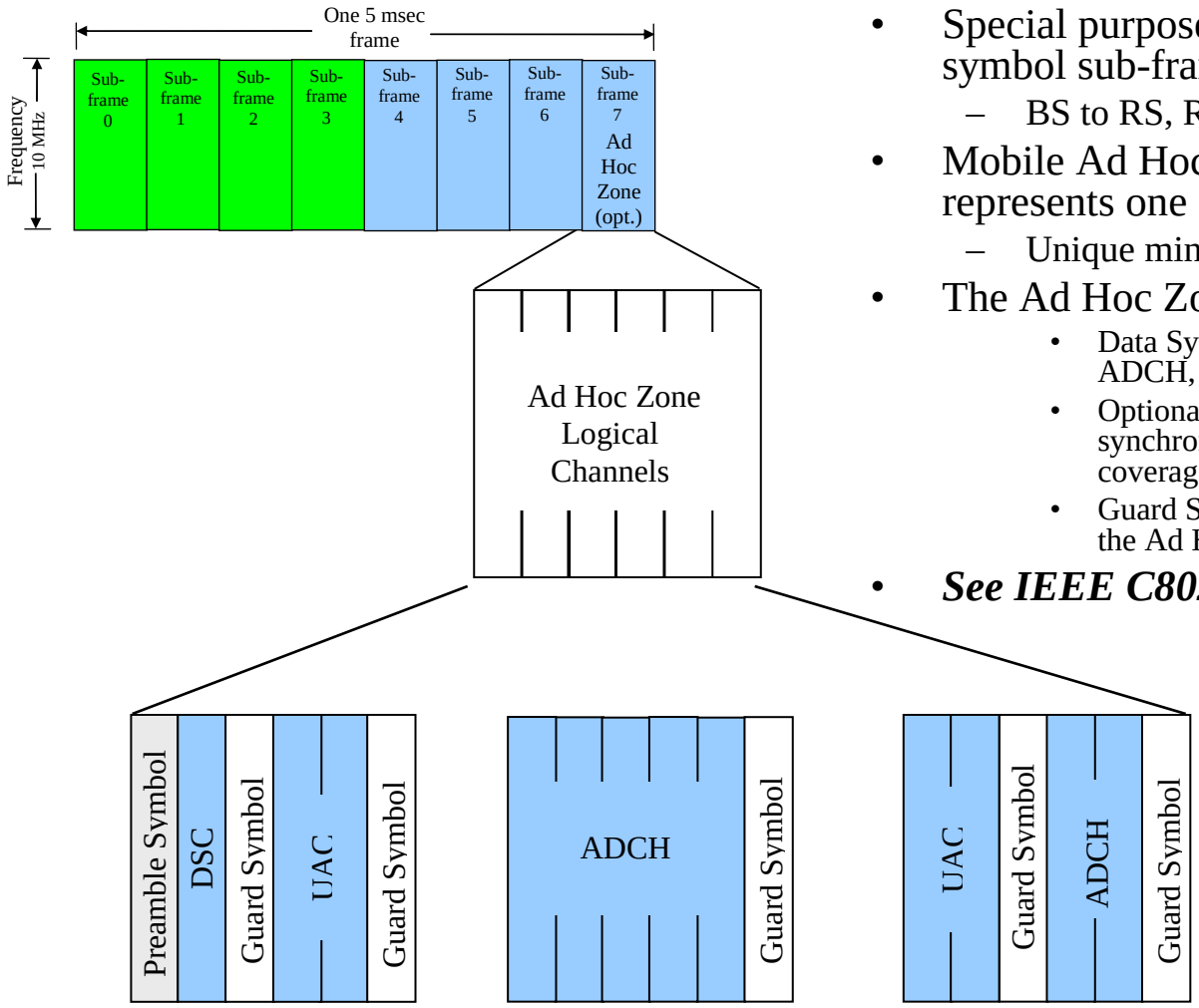
Mini-Tiles for Control and Feedback



- Downlink
  - Control Mini-Tile (CMT) provides as means for transmitting dedicated control
  - May be used for downlink resource allocations or uplink access grants
  - Multiple CMTs may be concatenated to achieve the desired reliability
  - ***See contribution IEEE C802.16m-007/013 for more details***

- Uplink
  - Feedback Mini-Tile (FMT) provided as means for transmitting feedback information in the uplink
  - May be used for HARQ acknowledgements, channel quality feedback, channel sounding, ranging, etc
  - Multiple tile formats may be required in the uplink to achieved the various objectives

Mobile Ad Hoc Relay Zone



- Special purpose zones may be defined within a six symbol sub-frame to support both
  - BS to RS, RS to MS or MS to MS
- Mobile Ad Hoc Relay zone (depicted on left) represents one of these specialized zones.
  - Unique mini-tile formats are defined for efficiency
- The Ad Hoc Zone utilizes 3 OFDM symbol types:
  - Data Symbol is a logical channel representing an UAC, ADCH, or DSC
  - Optional Preamble Symbol enables physical layer synchronization for MS peer nodes that are out of the coverage of the BS
  - Guard Symbol provides Tx/Rx turn around time within the Ad Hoc Zone
- ***See IEEE C802.16-08/003 for details***

Example Logical Definitions of a 6 symbol Ad Hoc Zone

Parameter Summary

Feature Description	Motorola
Duplex Mode	TDD, FDD, H-FDD
DL Multiple Access	OFDMA
UL Multiple Access	TBD: OFDMA or DFT-SOFDM
Channel Bandwidth (MHz)	5, 7, 10, 20 (larger BW TBD)
FFT Size	12, 1024, 2048 (4096 for larger BW TBD
Sampling Frequency (MHz)	5.6, 11.2, 22.4
Over-Sampling Factor	28/25
Sub-Carrier Spacing (kHz)	10.94
OFDM Useful Symbol Time (us)	91.4
Cyclic Prefix (us)	11.42
OFDM Symbol Duration (us)	102.82
Number of OFDM Symbols per Frame	48
Regular Sub-Frame Length (ms)	0.617
# of OFDMA Symbols per Subframe	6
Relay Support	Relay and Adhoc
Switching Point Alignment (TDD)	Tx/Rx interval allignment
Number of Switching Points (TDD)	2 or 4
New Subcarrier Permutations	Yes
Number of Sub-Carriers/Basic Resource Block	108 (18x6)
DL Modulation for Traffic	QPSK, 16QAM, 64QAM
DL Modulation for Control/Signaling	QPSK
UL Modulation for Traffic	QPSK, 16QAM, 64QAM
UL Modulation for Control	QPSK
DL Coding Rate	Rate adapted
UL Coding Rate	Rate adapted
DL Repetition Rate	Rate adapted
Channel Coding	Turbo codes
Number of Basic Resource Blocks/ Sub-Frame	24, 48, 96

Proposed text for the SDD

Add the following sub-section on frame structure under the physical layer description:

IEEE 802.16m frame structure will organized hierarchically with a hyper-frame, super-frame, frame and sub-frame. The hyper-frame will be used to communicate system information information necessary for hand-over and network access. The superframe will contain synchronization sequence and system information which describes the configuration of the frames and sub-frames contained within the superframe. The frame will be 5 ms and be backwards compatible with 16e. Each frame will be subdivided into 8 sub-frames for purposes of resource allocation and zoning. A diagram of this hierarchy is depicted in Figure XX.

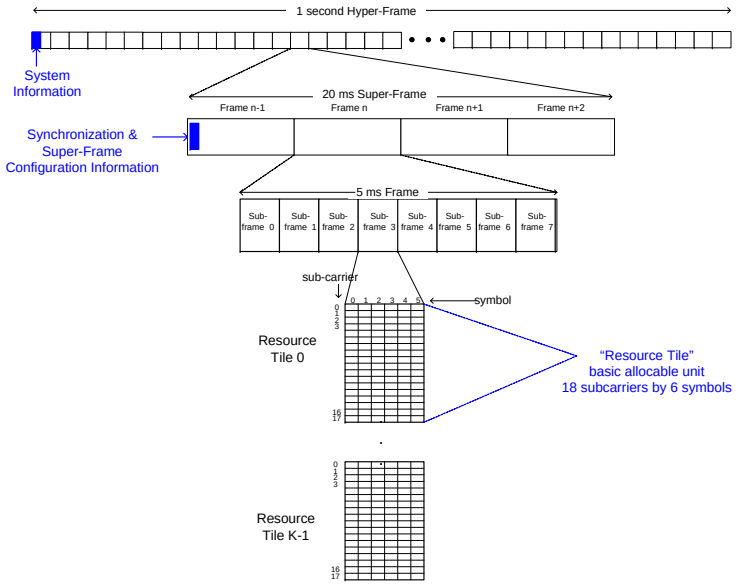


Figure 1 IEEE 802.16m Frame Structure Hierarchy

The key system parameters defining the IEEE 802.16m frame structure are captured in Table 1 below:

Table 1 IEEE 802.16m Frame Structure Key System Parameters

Feature Description	Value
Duplex Mode	**TDD, FDD, H-FDD**
DL Multiple Access	**OFDMA**
UL Multiple Access	**TBD: OFDMA or DFT-SOFDM**
Channel Bandwidth (MHz)	**5, 7, 10, 20 (larger BW TBD)**
FFT Size	**512, 1024, 2048 (4096 for larger BW TBD)**
Sampling Frequency (MHz)	**5.6, 11.2, 22.4**
Over-Sampling Factor	**28/25**
Sub-Carrier Spacing (kHz)	**10.94**
OFDM Useful Symbol Time (us)	**91.4**
Cyclic Prefix (us)	**11.42**
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Number of OFDM Symbols per Frame	**48**
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# of OFDMA Symbols per Subframe	**6**
Relay Support	**Relay and Adhoc**
Switching Point Alignment (TDD)	**Tx/Rx interval allignment**
Number of Switching Points (TDD)	**2 or 4**
New Subcarrier Permutations	**Yes**
Number of Sub-Carriers/Basic Resource Block	**108 (18x6)**
DL Modulation for Traffic	**QPSK, 16QAM, 64QAM**
DL Modulation for Control/Signaling	**QPSK**
UL Modulation for Traffic	**QPSK, 16QAM, 64QAM**
UL Modulation for Control	**QPSK**
DL Coding Rate	**Rate adapted**
UL Coding Rate	**Rate adapted**
DL Repetition Rate	**Rate adapted**
Channel Coding	**Turbo codes**
Number of Basic Resource Blocks/ Sub-Frame	**24, 48, 96**