Proposal for IEEE 802.16m Preamble

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Venue:
IEEE 802.16m-08/016r1, Call for SDD Comments and Contributions on Preamble (2008-03-20)

Base Contribution:
C802.16m-08/371r2

Purpose:

To be discussed and adopted by TGm for use in 802.16m SDD

Requirements

- Simple/Reliable Timing/Carrier synchronization
  - Uniqueness of Preamble reduces the MSE
  - Small MSE & wide detection range
  - Fast convergence
- Simple detection (less power consumption)
  - Fast cell search
  - Avoid exhaustive cross correlations in time domain
- Required SNR @1% PER using [1] preambles< Required SNR for data transmission
  - <[-7] dB @AWGN
  - <[-5] dB @ fading channel (highly freq. selective channel) :how efficient in achieving freq. diversity gain?
  - No overdesign
- Smaller peak power and PAPR than data
- Same or lower overhead than 16e : <[1/48]
- More number of codes than 16e
  - Femto cell and Relay station : >[8] bits
- Support multicarrier/multi-bandwith operation
  - Scalable design
- Pathloss/ Noise power estimation
- Other Features
  - MIMO support
  - Serve as Common pilot
  - Immune to long delay spread and large Doppler frequency channel

WiMax 1 preamble

- One preamble @every 5 msec
  - Not differentially orthogonal
  - But, between sectors it is orthogonal owing to frequency reuse of 3
- Every third subcarrier is active
  - Time domain periodicity=T/3
- Frequency reuse of 3
  - Each uses 144 subcarriers
  - Total span is 144*3=432
- Send total 3*38=114 codes=6.8 bits
- Low PAPR < 5 dB @8x oversampling [see backup]
- Peak power<-0.6 dB @8x oversampling with 9 dB boosting [see backup]
  - Assuming average power@data subcarrier=1
- Very good frequency diversity gain (144 subcarriers are used)

WiMax 1 preamble (cont'd)

- In cell edge the property of repetition of 3 is destroyed
  - Can't use the Schmidl-Cox
- Using CP, detect OFDM symbol boundary and fractional frequency offset
  - UL and DL OFDM has timing offset due to TTG/RTG gap
    - Locked to which one?
  - If UL signal from proximity SS has larger power than DL, SS will be locked to the UL signal instead of DL
  - High MSE using CP only → Need refinement
- Once OFDM boundary is roughly known,
  - Repeat time and frequency domain processing

Features of Intel proposal

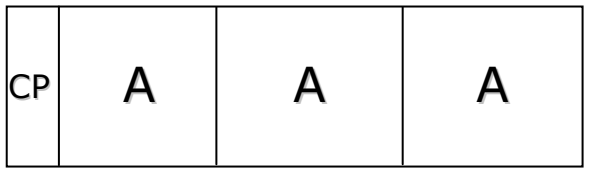
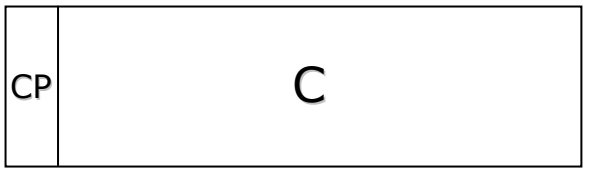
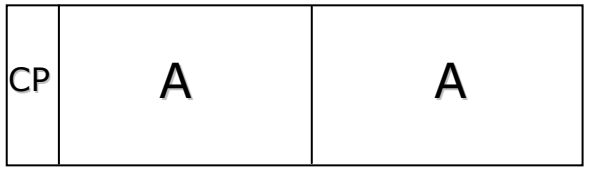
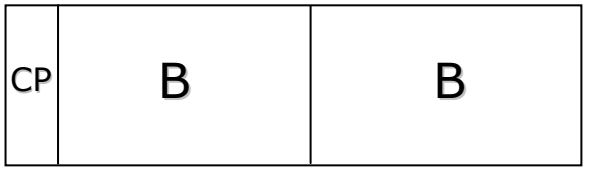
- Composed of multiple subblocks
- Non-coherent detection
  - One OFDM symbol
- Supplemental common pilot
  - Can be used as common pilot for MIMO channel estimation even at cell edge
- One preamble at every 5 msec
  - Time diversity
  - Less delay in timing/carrier synchronization
  - Same overhead as in WiMax1
  - Less overhead than LTE
- Accurate pathloss estimation
  - Orthogonal codes
  - Narrowband estimation possible
- Reuse pattern of 4
  - ex
    - Sector ID 1~3 for three sectors
    - Sector ID 4 for Femto/Relay Station indicator
- Different level of error protection
  - Sector ID(2bits): Stronger protection
- Simple detection (low power consumption)
  - Binary code
  - 3 sets of codes(2bits+3bits+3bits=8 bits)

Features of Intel proposal (cont'd)

- Every other subcarrier is a null subcarrier
  - Better Timing/Carrier synchronization
    - Periodicity=T/2
    - Uniqueness (Very important for reliable synch especially at cell edge)
    - Co-channel preambles will increase SNR per sample, resulting in smaller MSE and more reliable synchronization (Macro-diversity)
  - Wider frequency offset detection range (+/- one subcarrier)
  - Simpler timing/carrier synchronization
    - Schmidl-Cox (delayed correlation)
    - No need of exhaustive cross correlations in time domain (less power consumption)
  - Null subcarriers can be used for noise power estimation
  - More immunity to larger delay spread and Doppler frequency
    - Large delay spread: Use only the last half of the symbol duration (half FFT size)
    - Large Doppler :apply twice of half sized FFT onto the first and last half symbol duration
    - Can maintain the synchronization in very high time/frequency selective channels

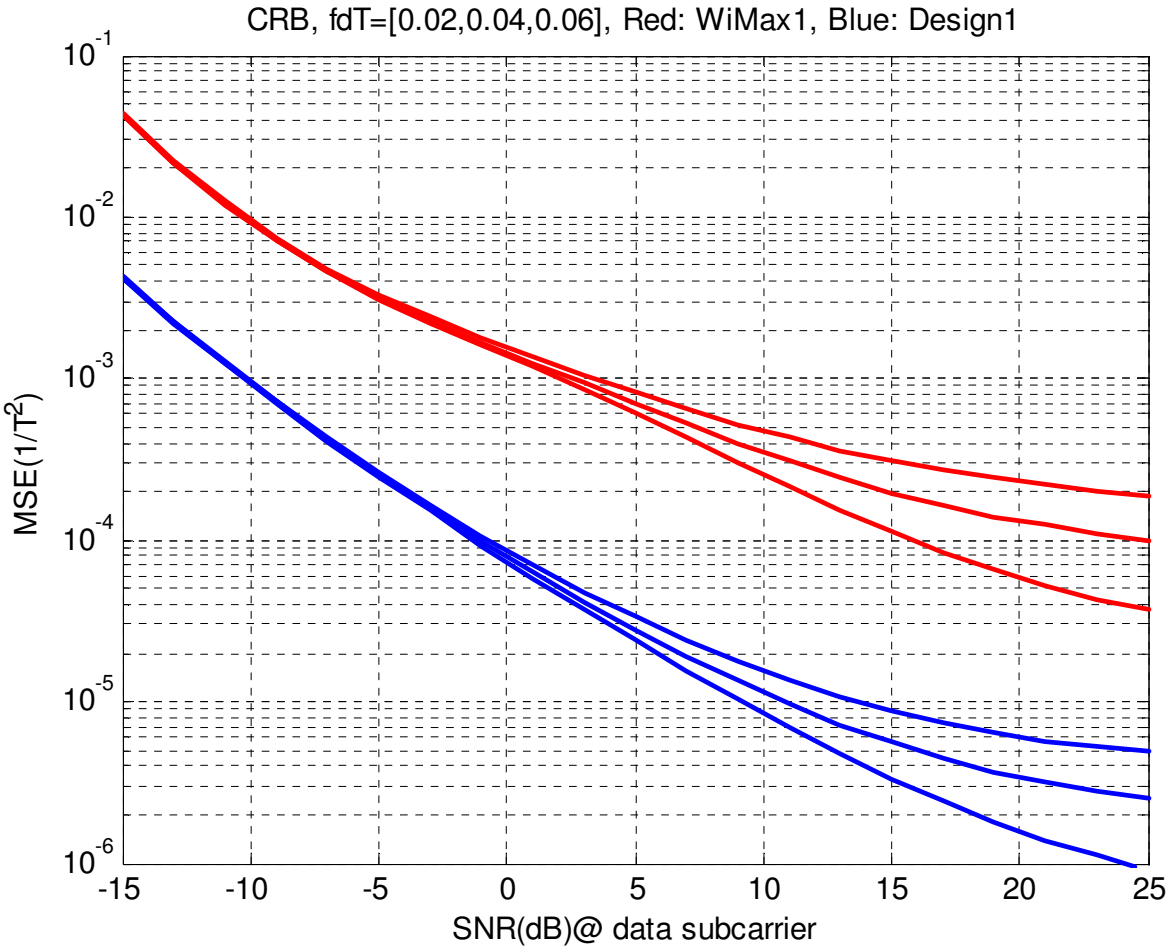
Features of Intel proposal (cont'd)

•

•	w/o interference	At cell edge
WiMax	•Unique 	•Not unique –Complicated detection (higher power consumption) –Potentially higher MSE 
16m	•Unique 	•Unique –Macro diversity (timing/carrier/frame synch) 

CRB of Carrier frequency offset

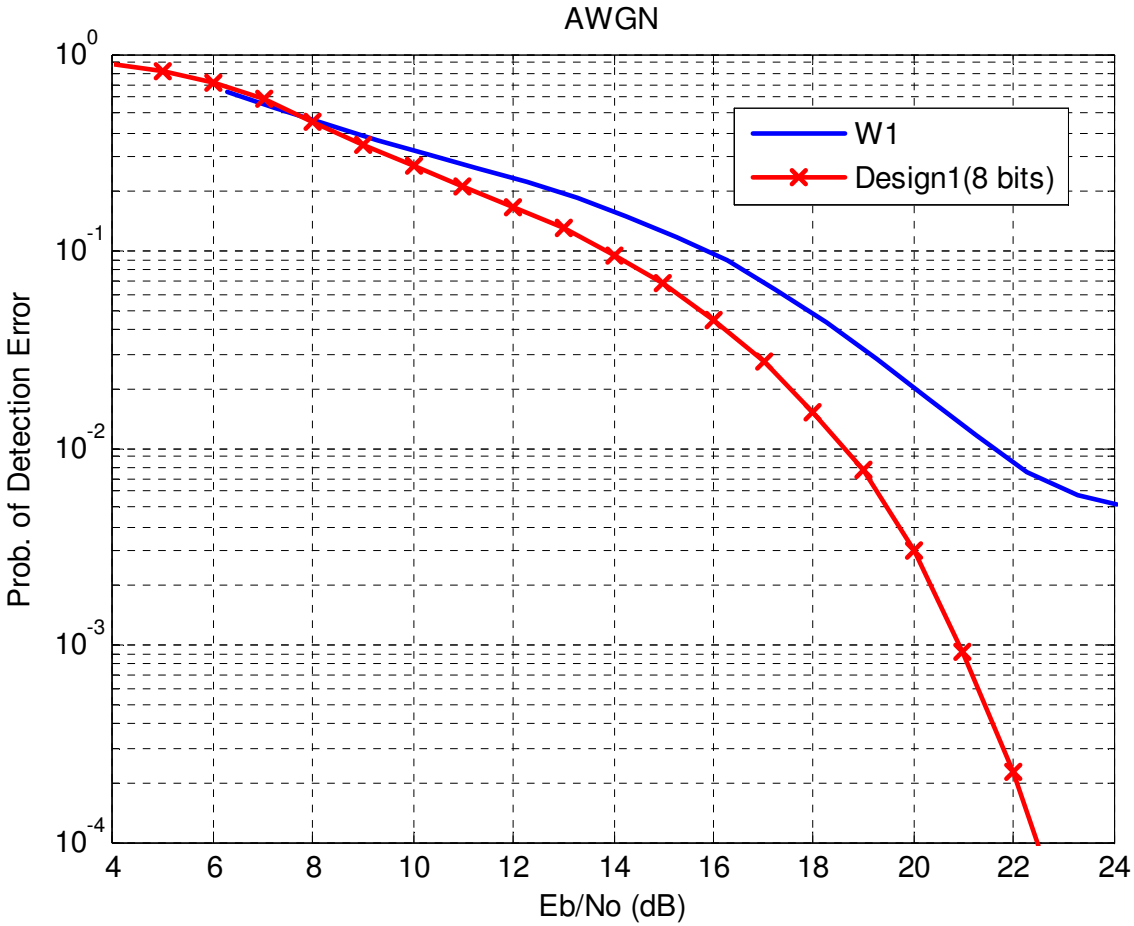
- Perfect Frame synch but unknown code index
  - Two co-channel preambles : SIR=[0 0]dB
  - Use 1 OFDM symbol excluding CP (CP size is unknown), Delay spread=CP



For std=1% of subcarrier spacing, MSE=1e-4

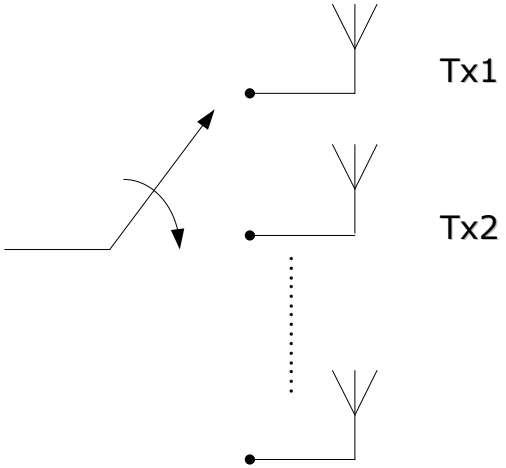
Performance

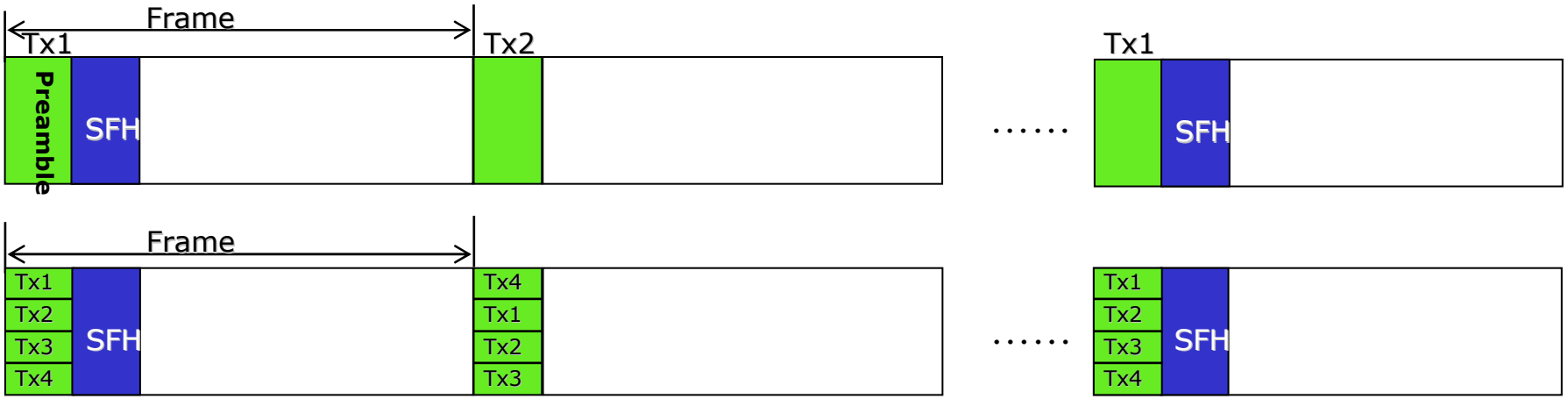
- 3 Co-channel preambles :SIR=[3 2 1]dB, SISO
  - Design1
    - Accurate pathloss estimation possible even using 1 preamble
    - No error floor observed



MIMO support

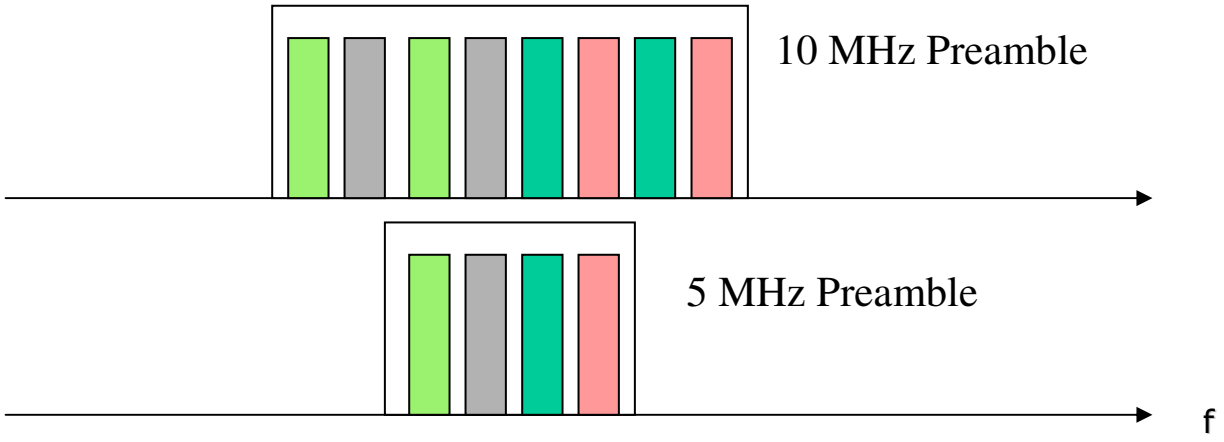
- MIMO support
  - Round robin
    - Tx Ant. diversity
    - common pilot : per Tx antenna
  - Interlace subcarriers or subblocks over antennas
    - Efficient use of PA's
    - Smaller Peak power/PAPR
    - common pilot per subband
  - CDD
    - Large cyclic delay (~3T/8) allows channel estimation for multiple Tx antennas
      - Large delay degrades detection performance
    - CDD creates **directional beam** different from subcarrier to subcarrier
      - cause **coverage hole**
      - SCH transmission should have omni-directional coverage





Multi-bandwidth Support

- Multi-bandwidth
  - Reuse subblocks
  - Scalable design



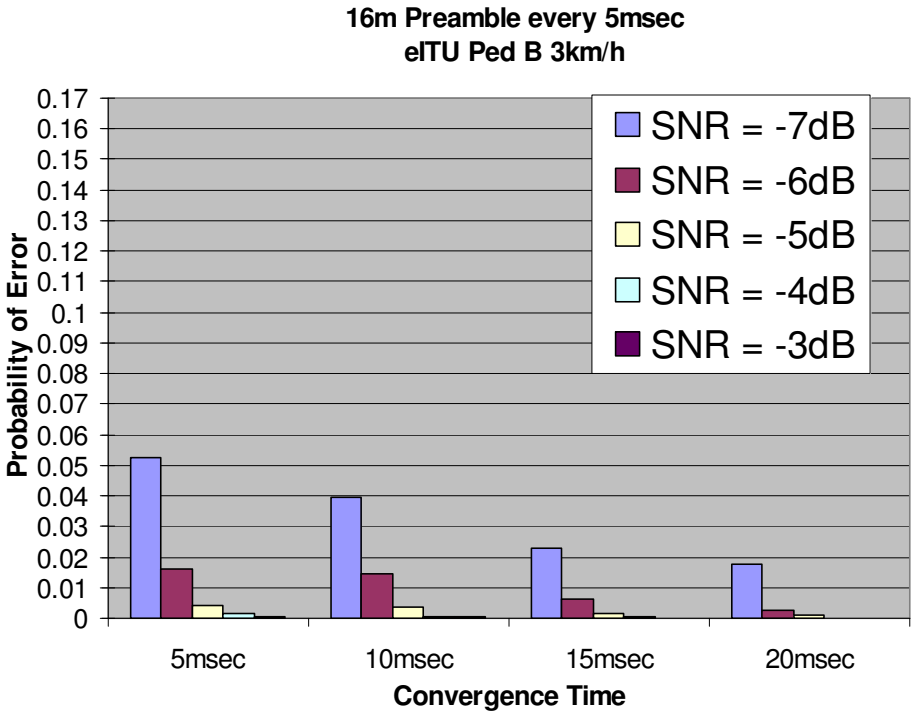
Super Frame Synch

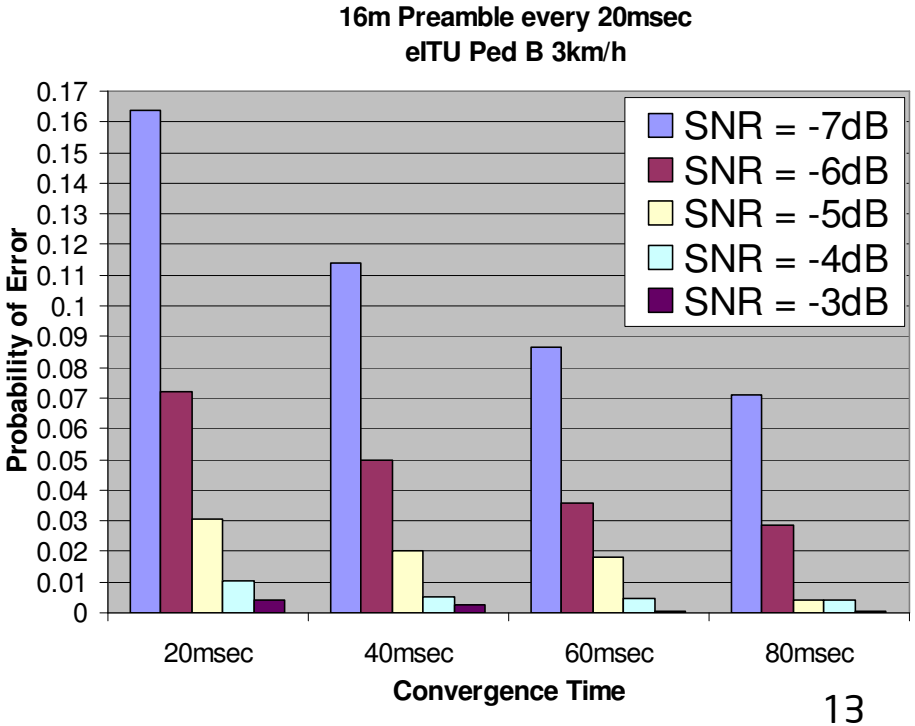
- Super Frame Synch
  - Indicator in MAC message

  or
  - All BS's use "reserved preamble index" at super frame

Tx Period : 5 msec vs 20 msec

- Tx period = 20 msec
  - Larger buffering size for averaging
  - +/- 10 msec maximum error
  - Large searching window : higher MSE in timing synchronization
- Simulations
  - Non-ideal timing synchronization (unknown OFDM/Frame boundary)
  - 100% loading, 100% DL, eITU Ped B 3km/hr, SISO
  - 5 msec Tx period outperforms

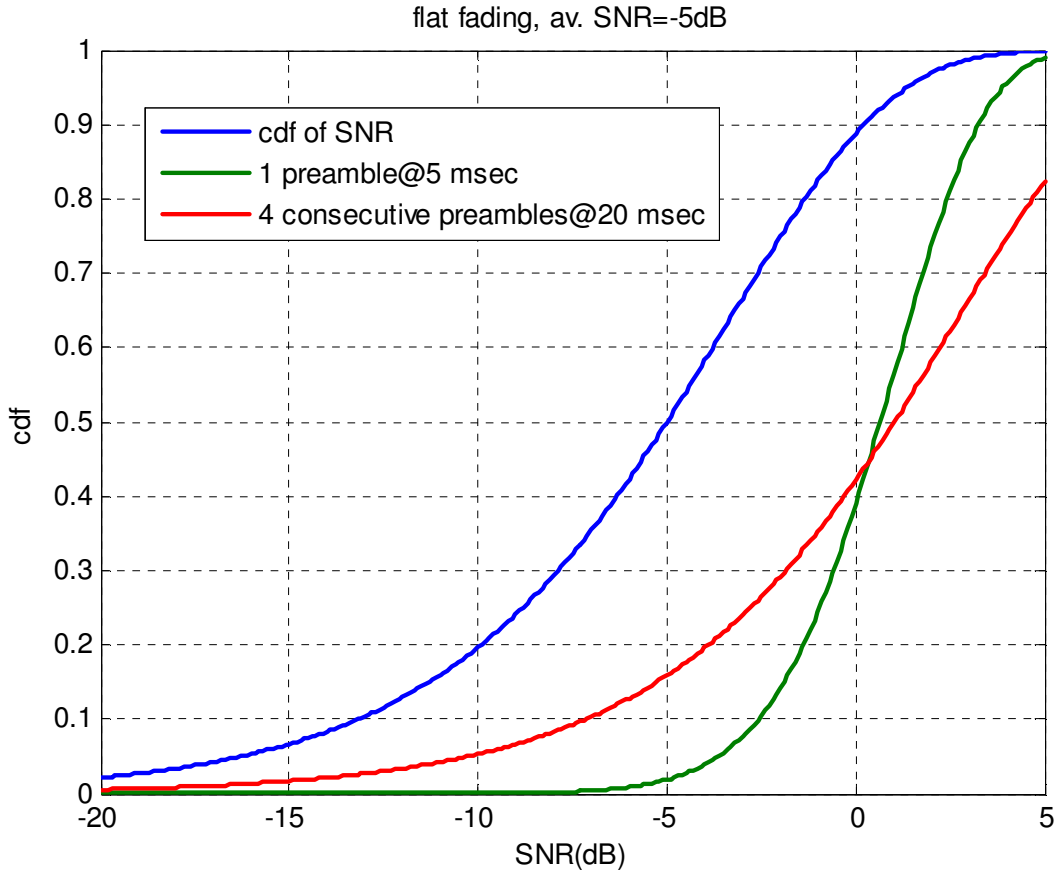




Tx Period : 5 msec vs 20 msec (cont'd)

- 120km/hr → Doppler frequency=278Hz → coherence time~3.6 msec
  - Assume independent fading between 5 msec frames
- 1 preamble at every 5 msec
  - Combine 4 preambles
  - Time diversity
- 4 consecutive preambles at every 20 msec
  - Combine 4 preambles

- Sending preamble at every 5msec
  - 16e and LTE
  - Smaller latency
  - Better time diversity
  - Smaller MSE
  - Better detection
  - Less memory



Summary

Preamble Features	**Intel**
Boosting	Yes, 10dB
Number of codes	256(=8 bits) [10,12 bits,… possible]
Legacy 16e Preamble used by 16m terminals in mixed mode deployment	No
Are Preambles used for common pilots?	Yes
5/10/20MHz BW for 16m preamble	Yes/Yes/Yes
Frequency of Preamble transmission	5ms
# of symbols used in 16m zone	1 symbol every 5ms (no P-SCH, S-SCH concept)
Subcarrier Mapping	▪ Every other subcarrier is null (time domain repetition period = T/2) ▪ No exhaustive cross correlations in time domain
Pathloss estimation	Yes, support narrow band & wideband measurement
Different level of error protection	Yes, Sector ID stronger protection
Fast cell search	Yes, binary codes, 3 sets of codes
Convergence time	Less than 2 frames in SISO
Type of detection	Non-coherent detection

Text Proposal to 802.16m SDD

Insert the following text into Physical Layer clause (Chapter 11 in [IEEE 802.16m-08/003r1])

---------- Text Start ----------

11.x.2 Synchronization Channel (SCH)

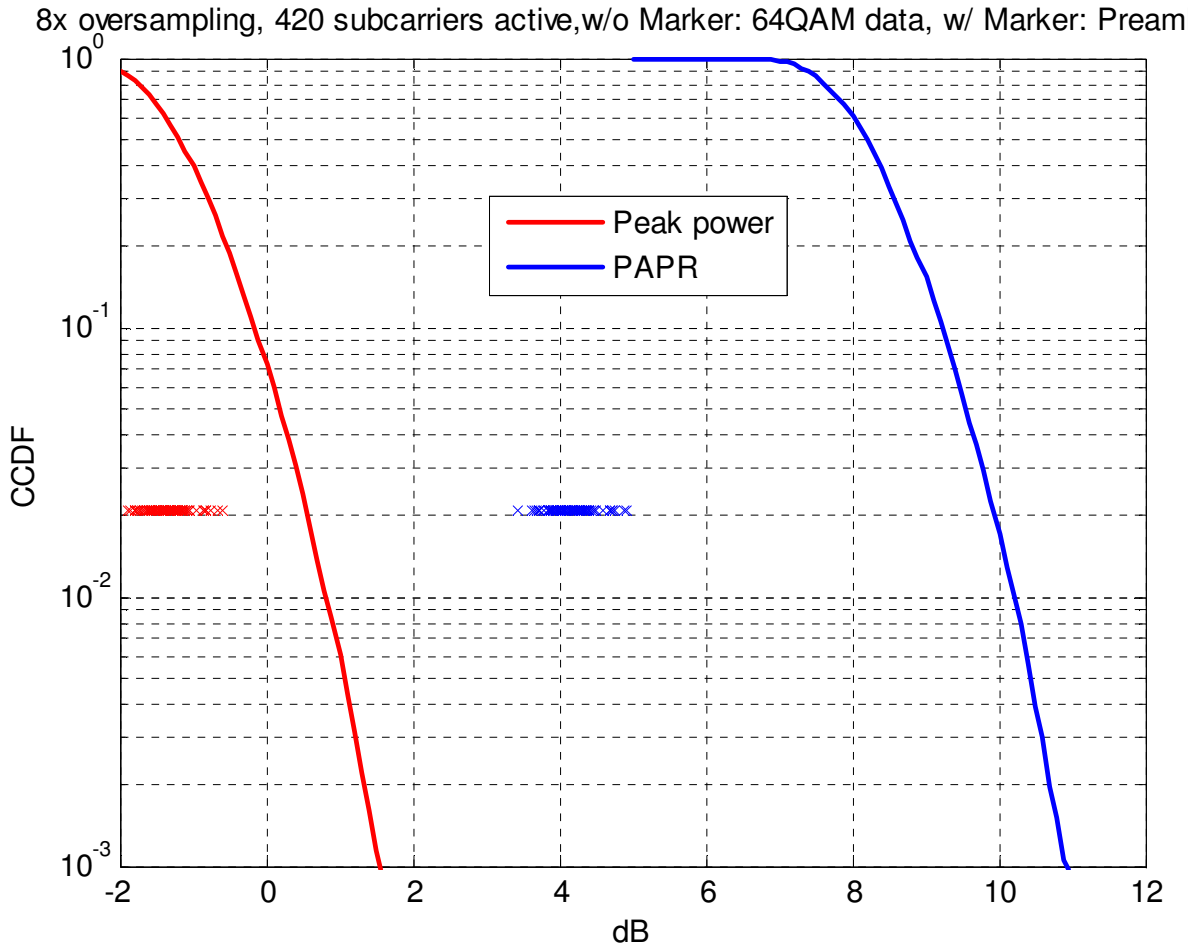
Preamble is used to perform initial acquisition on timing and carrier. The preamble further serves to carry cell ID information. The pathloss of each neighboring BS will be estimated using the preamble for BS selection and FFR. Null subcarrier at every other subcarrier (subcarrier 0,2,4,…) creates a time domain repetition of 2 for the resulting waveform which will enhance the timing and carrier synchronization. The preamble is transmitted at the beginning of every frame with a span of one OFDM symbol.

---------- Text End ----------

Back-up

WiMax 1 preamble

- PAPR & Peak power comparison of Data and WiMax 1 Preamble
  - With 9 dB boosting, maximum peak power is -0.6 dB



WiMax 1 preamble (cont'd)

- With 9 dB boosting, maximum peak power is -0.6 dB