Initial PHY Proposal for 802.16e + Coexistence of Fixed and Mobile Services

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PHY and Framing modifications for support of combined Fixed and Mobile operation in 802.16e

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Presentation Overview

- Differences between Fixed and Mobile
- Implication on PHY design
  - training, subchannelization, coding
- Framing issues for .16a+.16e functionality

What has changed? (1)

- The subscribers use smaller, less directional, lower gain antennas
  - The base station transmit power will be increased to compensate
  - The multipath delay spread will increase
- Some of the subscribers will work on batteries
  - Subscriber transmit power will decrease

What has changed? (2)

- The channel is time varying
  - The assumption that the channel estimate acquired at beginning of transmission will be valid till its end no longer holds
- The traffic will be more asymmetric than in fixed only case
  - Shift from businesses to individuals, more downloading than uploading

Intermediate conclusions

- OFDM 256, as is, is inadequate to support mobility
- Some redesign of the PHY is mandatory!
- A framework is needed to support both "legacy 802.16a" and the 802.16e-capable devices
  - See separate submission on framing

PHY modifications for 802.16e

Tal Kaitz et al.

PHY requirements

- Support of high delay spreads
  - At least as high as 802.16a OFDM mode.
  - Preferably more.
- Support of high Doppler spreads.
  - Optimize for 200 Hz (60Km/h @ 3.5GHz)
  - Support up to 400Hz (120Km/h @ 3.5GHz)
- High UL sub-channelization gain.
  - > 15dB ⇔ > 32 subchannels

Impact on UL subchannelization

- The 802.16a OFDM subchannelization was optimized for more balanced UL-DL scenarios → 4 subchannels were adequate
- Subchanelization should be commensurate with BS-SS power ratio
  - BST is likely to be 33-36 dBm, up to 40 dBm
  - PCMCIA card is likely to be 13-17 dBm
- Calls for 15+ dB of subchannelization gain

PHY requirements, cntd.

- Co-existence with 802.16a OFDM
  - Media is shared between *Fix* and *Mobile* Users.
- High alignment with 802.16a OFDM
  - Same basic parameters:
    - Bandwidth and Numbers of subcarriers
    - Sampling rate
  - Will simplify a dual design (fix and mobile capabilities on same SU)

Basic OFDM parameters

- 256 points FFT
- 200 active subcarriers
- 8/7 and 7/6 sampling rates
  - 8/7 for bands which are multiple of 1.25MHz and 1.75MHz
  - 7/6 for all other bands

Proposed PHY Highlights

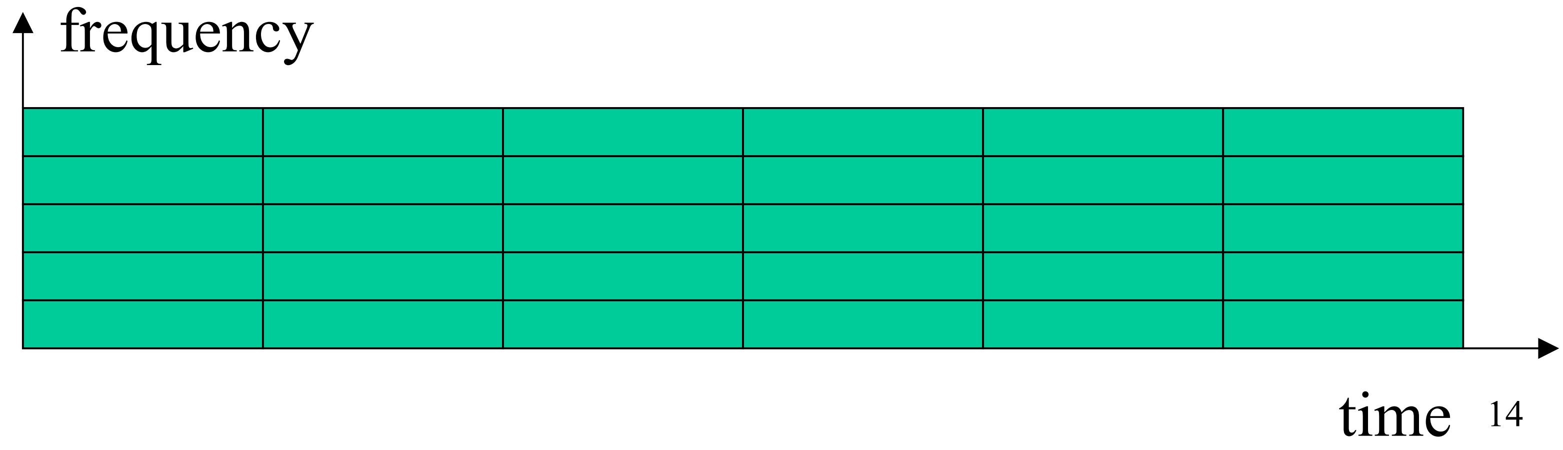
- OFDM modulation
- 256 points FFT
- UL OFDMA as mandatory mode
- 40 or 50 subchannels
  - Two alternatives presented, one to be chosen
- DL OFDM as mandatory mode.

Uplink

- Two schemes proposed (only one should be selected)
  - Fast hopping clustered scheme
    - Transmissions occur in clusters
    - Cluster hop in frequency
  - Scattered scheme
    - Transmission in sub carriers scattered over the band.

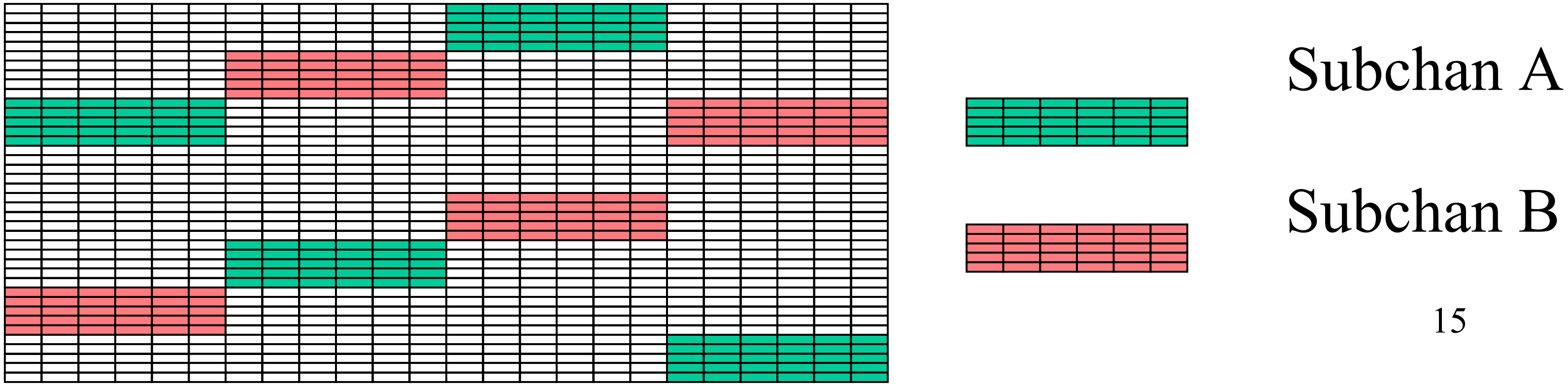
Clustered Approach

- Cluster: A group of contiguous clusters in time and frequency.
  - 5 contiguous subcarriers
  - 6 OFDM symbols
  - ICI robustness



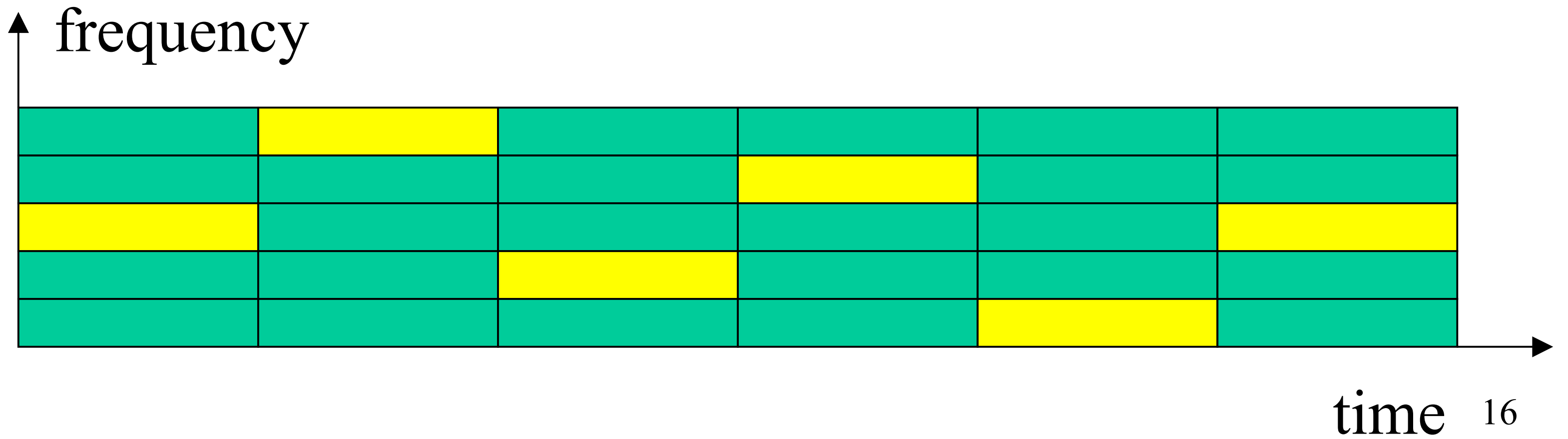
Clustered approach, cntd.

- A sub-channel is composed of a single cluster at a time.
  - 200:5= 40 sub-channels
  - Subchannels can be aggregated.
- Frequency hop every cluster.
  - Frequency diversity
  - Interference averaging



Clustered Approach, cntd.

- Clusters contain all training information
- 6 pilot subcarriers
- 24 data subcarriers

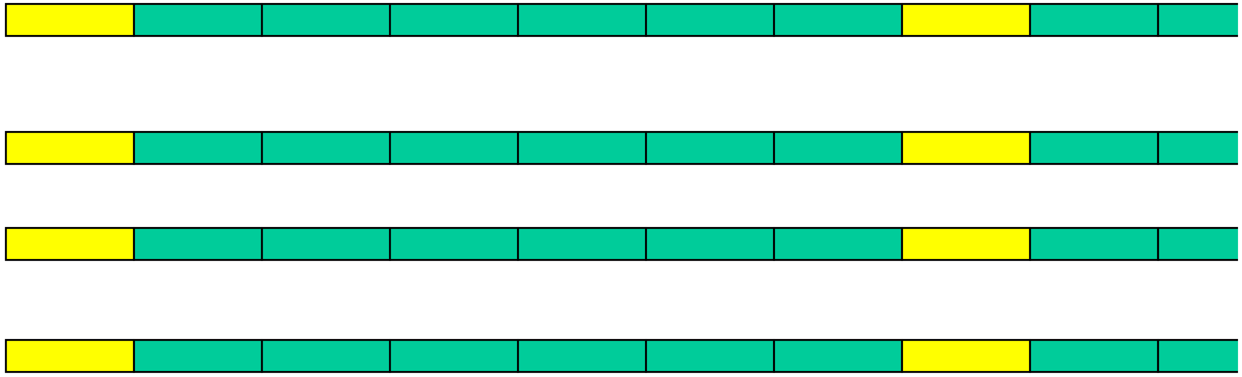


Scattered approach

- 4 subcarriers constitute a subchannel.
- Scattered across the band
  - Maximize frequency diversity.
  - No regular grid for interference averaging.
- Maximizes frequency diversity
- More sensitive to ICI.
- Similar to *Burst Structure 2* in DVB-RCT

Scattered approach, cntd.

- Pilot inserted after every 6 data subcarriers
  - Minimum allocation 8 symbols== 32 subcarriers.



Overhead – a discussion

- The proposed pilot arrangement has 1 pilot per 4 data subcarriers
    - Looks bad relatively to the 2 per 48 overhead in 802.16a, BUT:
- There is no preamble in the proposed scheme
- For short packets, the overhead is actually lower
    - Breakeven at 30-135 bytes relative to 1 subchannel
        - QPSK-1/2 – 64QAM-3/4
    - Breakeven at 120-540 bytes relative full bandwidth

Coding implications

- In both proposed schemes the allocations are always a multiple of 24 data subcarriers
- This allows coding approach similar to 802.16a, with somewhat improved granularity
- Interleaving composed of bit interleaving over groups of 24 subcarriers, followed bu subcarrier interleaving

Low PAPR mode

- Both schemes can employ low-PAPR modes, at the expense of data-rate.
- Needed for increased cell range, and reduced power consumption.

Down Link

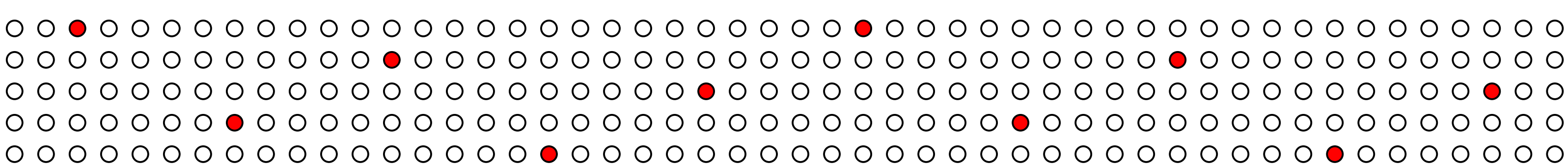
- OFDM as mandatory mode.
  - Optional OFDMA with a small number of subchannels may be considered
- Scattered pilot to improve channel estimation in time-varying channels.

Impact on Downlink pilots

- In fixed systems pilots were used purely for phase tracking – the channel was assumed static
- The multipath to support became larger
- With time varying channels we need to refresh the channel estimate
  - Either higher pilot density
  - Or, scattered (changing location) pilots

Example scattered pilot design

- In each OFDM frame the pilots are 1 pilot per 24 data
- Spread the pilots at regular interval of 25
- In each OFDM symbol, shift the locations by 10
- In 5 OFDM symbols 1:5 density is achieved



Downlink coding

- No changes are necessary for the downlink coding
- Same structure of 192 data subcarriers per OFDM symbol is retained

Framing for .16a+.16e operation

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Quotes from the 802.16e PAR

- Fixed 802.16a subscriber capabilities shall not be compromised
- Subscriber stations specified herein, when stationary, shall interoperate with base stations specified in IEEE Std 802.16a.
- Base stations specified herein shall interoperate with stationary subscriber stations specified in IEEE Std 802.16a.

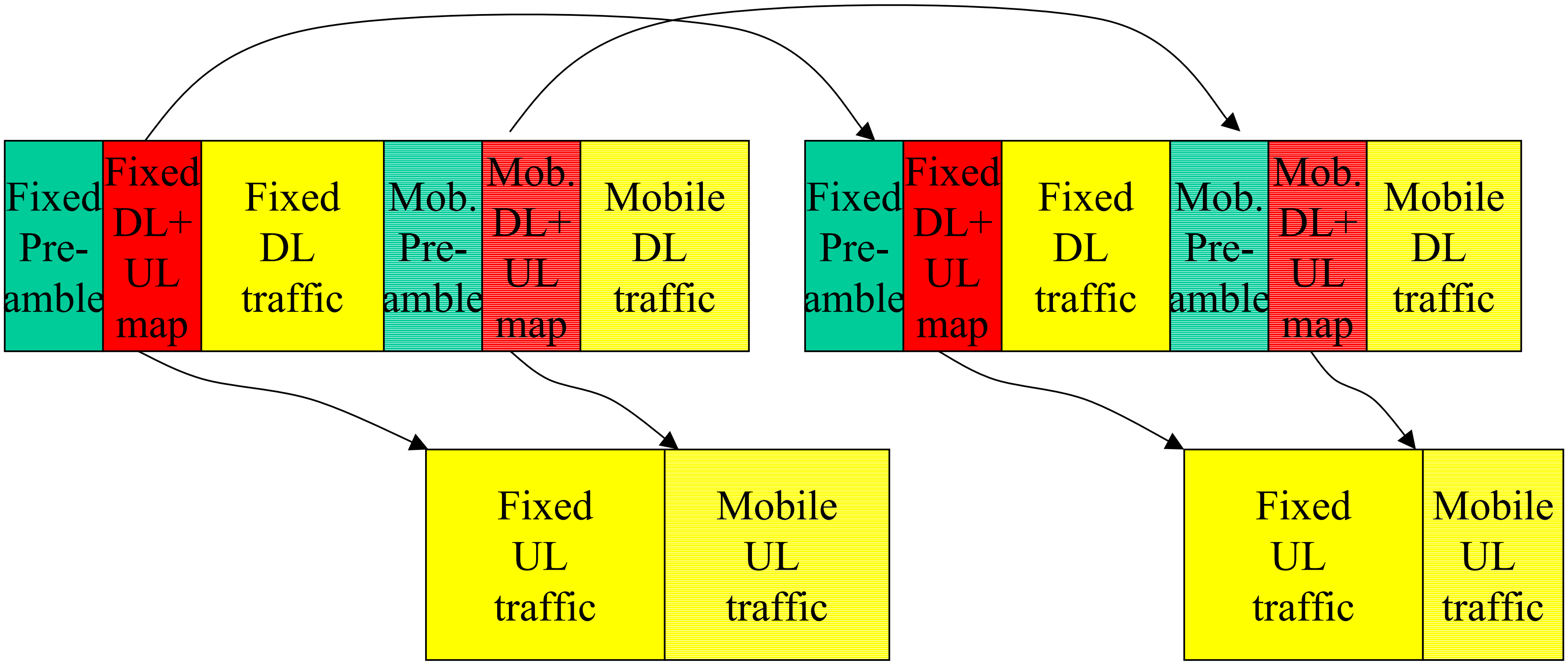
Possible approaches

- On UL there is no problem to allocate different PHY burst formats in disjoint time regions
- On Downlink, we need to assure that mobile station can receive its more robust mode
  - One approach: create interleaved mobile+fixed frames, each pointing to same kind only
  - Second approach: Use DL usage code "we're switching to the mobile format"
    - Similar to AAS, STC switchover

Interleaved framing option

- In interleaved framing the 802.16a users and 802.16e users listen to different DL frames and respond in disjoint UL regions
- The UL maps are conveyed in corresponding DL frame regions regions
- DL frames point to next frame of same type for synchronization and flexible boundaries

Interleaved 16a+e framing - FDD

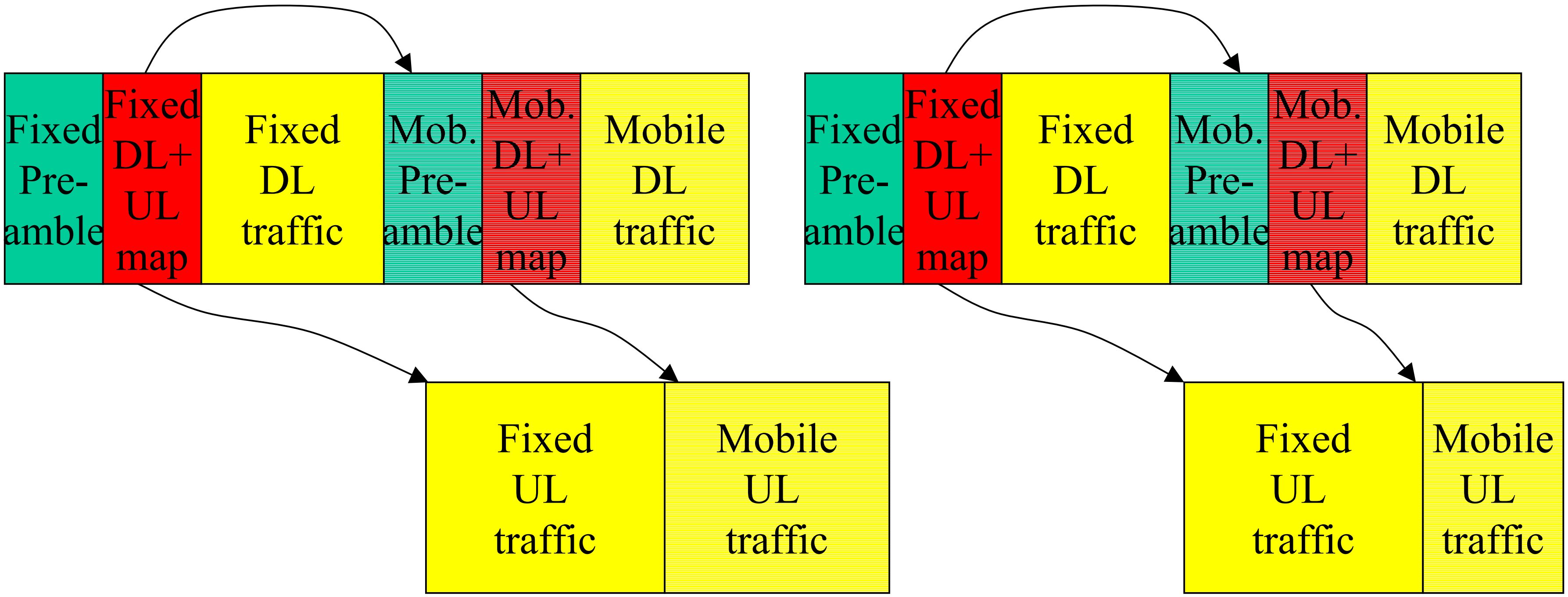


In TDD same idea is used, just the DL and UL are sequential

Extended DIUC option

- The extended DIUC signaling the switchover to “mobile mode” needs to occur early enough in the frame so that the reliability of it is not compromised by channel variation
- The .16e region needs to start with a preamble and continue with the improved pilot scheme

Ext. DIUC 16a+e framing - FDD

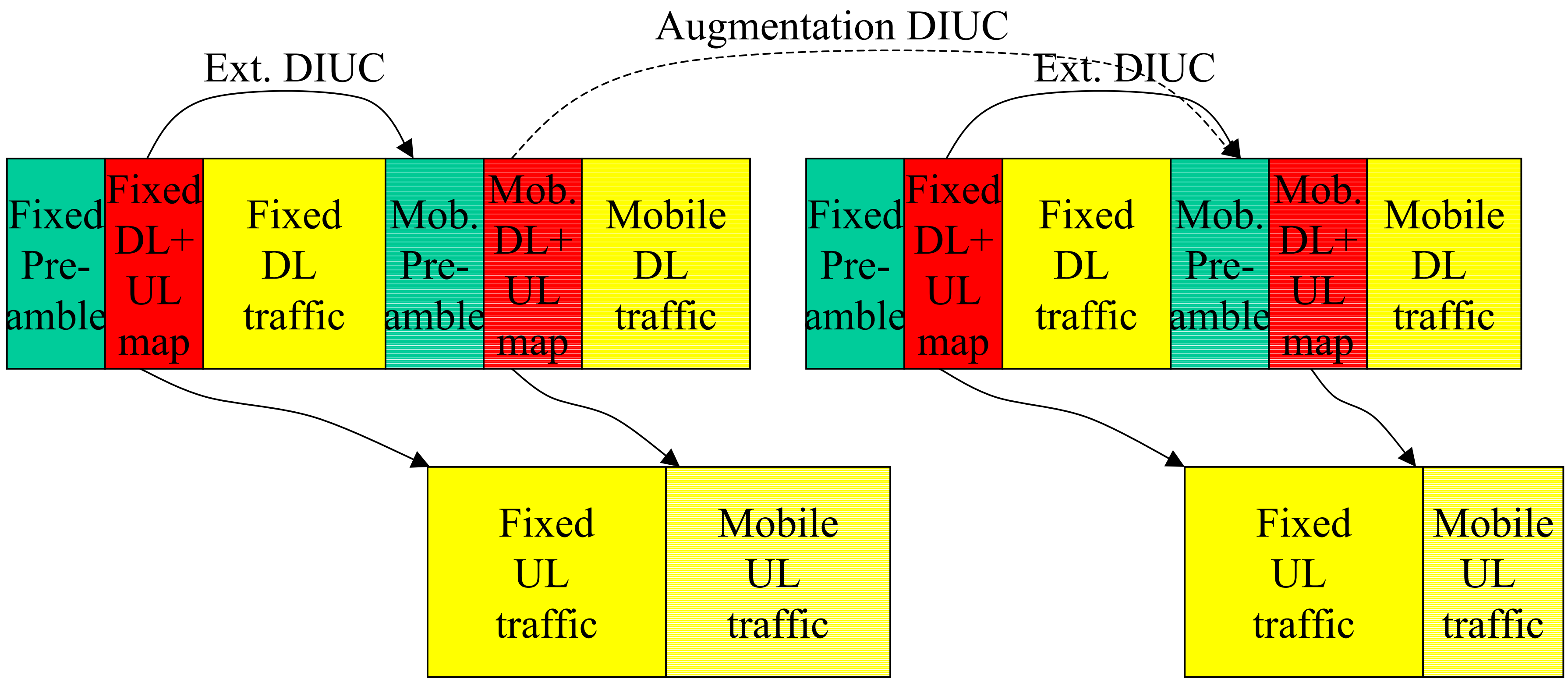


In TDD same idea is used, just the DL and UL are sequential

Comparing the extended DIUC and the interleaving approaches

- Interleaved frames:
  - Mobile subscribers do not depend on the robustness (or lack thereof) of the fixed part
- Extended DIUC:
  - Same approach as used in AAS, STC
    - Including preamble insertion
    - Including maps in the new region
  - Easier for 802.16a stations to skip the unsupported region.

Ext. DIUC with augmentation



In TDD same idea is used, just the DL and UL are sequential

Augmented extended DIUC approach - discussion

- Enjoys the regular mechanism familiar in 802.16a of mode switchover
- Enjoys the increased robustness of the mobile PHY mode to know the beginning of the mext mobile PHY frame
- Another possible form of augmentation is to seek the mobile PHY preamble to decide on switchover