OFDMA Suitability for mobile applications

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For discussion

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OFDMA suitability for mobile applications

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Mobile vs. Fixed wireless channel

- The mobile unit uses low-height antenna
- The mobile unit uses omni-directional antenna
- The mobile unit is sometimes in places where the path loss is excessive
- The mobile unit moves, and therefore the channel is not static

Path loss

- Typically use modified **Okumura-Hata model**
- **Formula is**

$$PL = A + 10\gamma \log_{10}(d/d_0) + S$$

- **Where**
  - **A is attenuation at distance d_0**
  - **S is the shadow fading variation (typically about 10dB)**
  - γ **is the fading exponent (typically 2 to 4)**
- **Path loss variance may cause excessive inter-cell interference**

Delay spread

- Extensive measurements exist in the **900MHz and 1900MHz area**
- **Delay spread range is anywhere between several hundreds of nanoseconds to several tens of microseconds**
- **Delay spread exists for both vehicular and pedestrian mobility – It does not depend on velocity**
- **See references in C802.16-SGM-02/23 for measurements results**

Doppler and fast fading

- **Doppler power spectrum is used to characterize the fast fading can be estimated as**
  - **Flat spectrum**
  - **Jakes model**
- **Doppler frequency can be estimated by**

$$F_{carrier} * V / c$$

- Doppler frequency for 100Km/H
  - For MMDS about 230Hz
  - For UNII about 540Hz

Effects of mobile channel on OFDMA

- Path loss
  - Handled by OFDMA concentration gain and by FEC
  - Inter-cell interference handled by permutations
- Delay spread
  - Handled by OFDMA large cyclic prefix
- Fast fading
  - Handled by synchronization mechanisms
  - Handled by channel estimation mechanism

OFDMA timing synchronization

- **Based primarily on the strong auto-correlation properties of the OFDMA waveform attributed to the CP**
- **Passage of the OFDMA waveform through the wireless channel smears the autocorrelation**
- **The longer the CP relative to the channel delay spread, the less the autocorrelation is smeared**
- **For OFDMA, CP even for a fairly broad 14MHz channel can be up to 32usec**

OFDMA frequency synchronization

- **Frequency synchronization is based on**
  - **A pre-FFT stage that handles the fractional frequency offset (i.e. the part that is not an integer multiple of sub-carrier spacing)**
  - **A pre/post-FFT stage that handles the integer frequency offset**
- **The pre-FFT stage will usually utilize the OFDMA waveform strong autocorrelation**
- **The post-FFT stage will usually utilize the pilot tones to correct the integer frequency offset**
  - **In OFDMA 166 out of the 1702 used carriers are pilots**
  - **This provides a processing gain in excess of ~22dB for the pilots PN series autocorrelation peak**

OFDMA frequency synchronization

- **Frequency synchronization in a mobile environment is more challenging due to the**
  - **Doppler frequency shift fast fading effects that tend introduce inter-carrier-interference**
- **OFDMA symbols are short enough relative to the highest Doppler spectral component**
  - **A typical value would be 300usec in a 6MHz MMDS channel**
  - **The channel response can be assumed fairly stable across one symbol**
- **With the help of the carrier frequency synchronization techniques used, even one OFDMA symbol is enough to extract accurate carrier frequency estimation**

OFDMA channel estimation

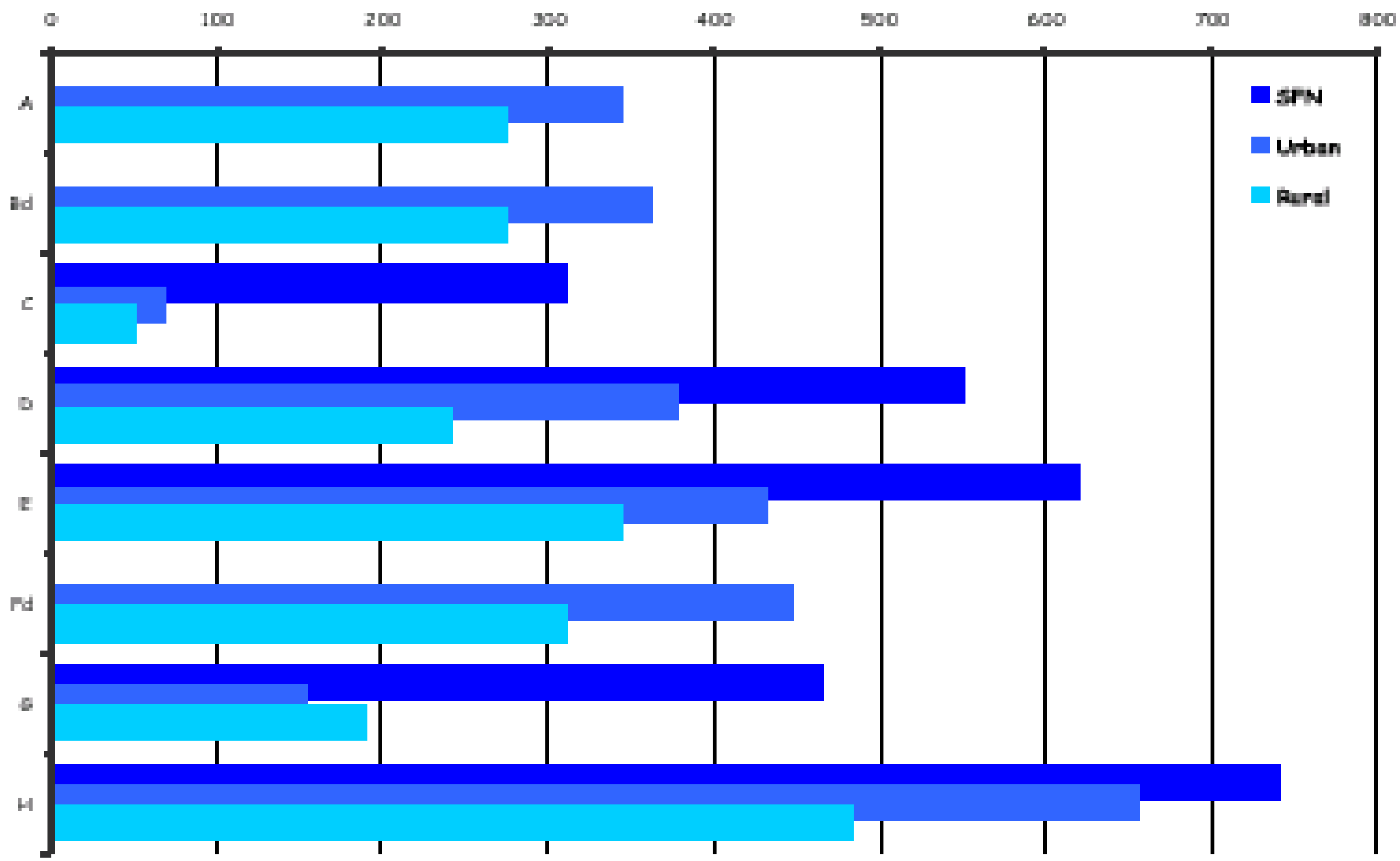
- **Channel estimation is based on pilot sub-carriers**
  - **constant location pilots**
  - **variable location pilots**
- **About 10% of the symbols are pilots**
  - **Even by using the pilots from one symbol, a channel estimate with length of up to about 1/10 of the symbol can be done**
  - **With two symbols, a channel estimate with length of up to about 1/10 of the symbol can be done**
  - **Fast, per symbol, estimation of the channel is possible**
- **OFDMA does not require a downlink**

OFDMA Ranging

- **In a mobile environment ranging has to be frequent because of the existence of fast fading effects in the channel**
- **CDMA ranging**
  - **BW efficient**
  - **Provides processing gain**
  - **Allows multiple SS to do ranging simultaneously**
- **OFDMA PHY supports a fast power control loop**
  - **Short frame duration, 2mS is the current minimum supported**
  - **The SS can do ranging frequently using CDMA code ranging**
  - **The downlink map contains a power control IE that provides a BW efficient means for controlling the SS transmitted power**

Performance – Maximum velocity

FFT size = 2K

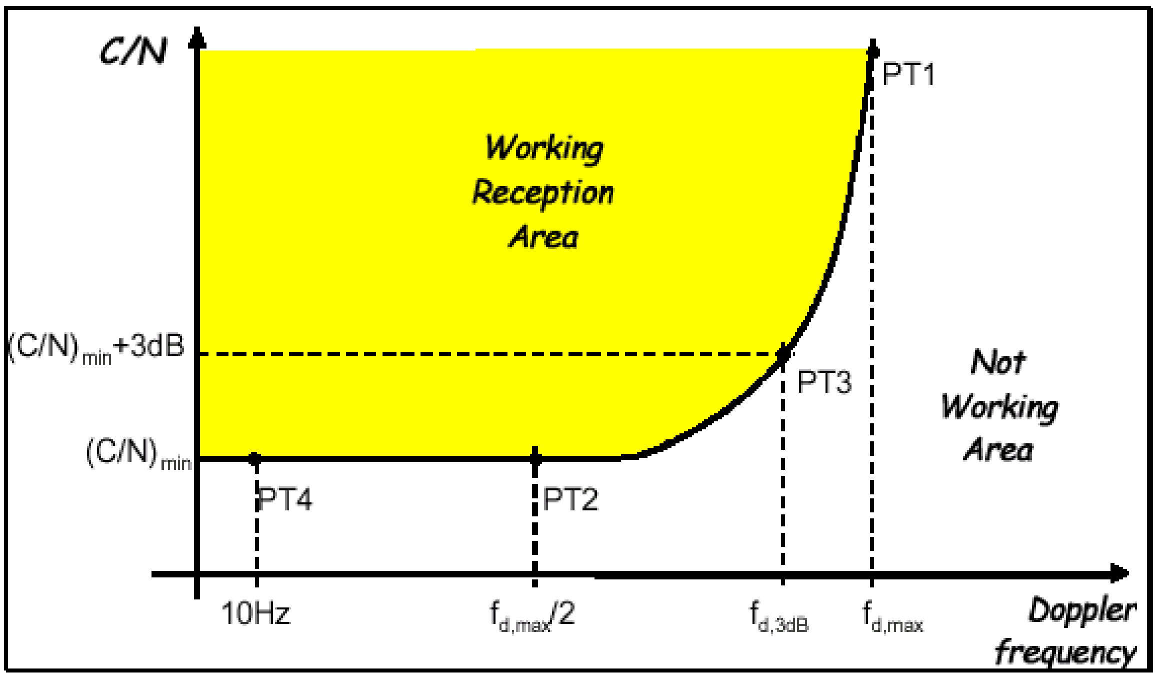


Performance estimates

- **In May 1998, a consortium of 17 broadcasters, network operators, manufacturers of professional and domestic equipment and research centers, lead by T-NOVA (formerly Deutsche Telekom Berkom), launched the MOTIVATE project**
- **Funded by the European Commission in the ACTS Program (Advanced CommunicationsTechnologies and Services)**
- **The purpose was to investigate the practical and theoretical performance limits of DVB-T for mobile reception**

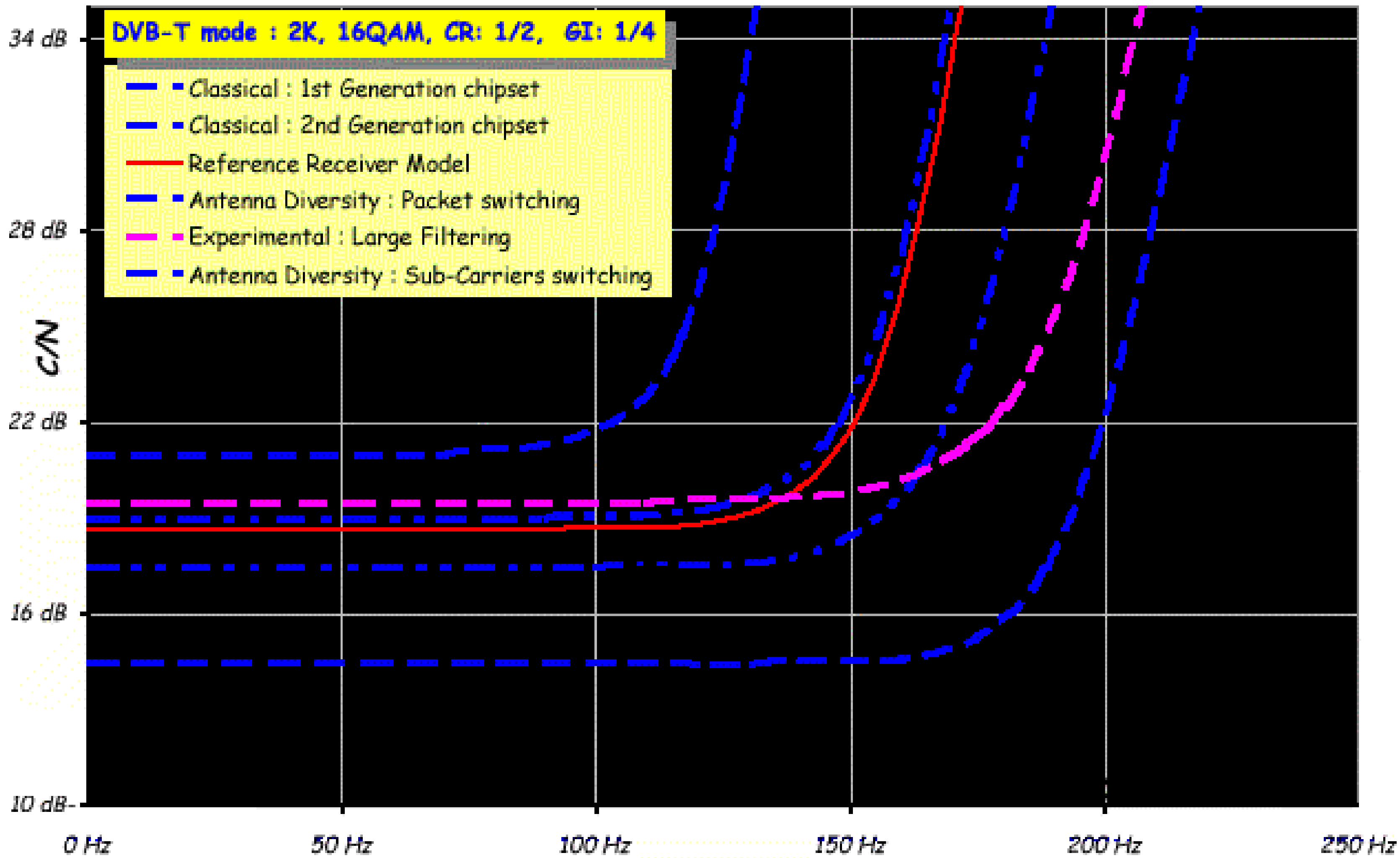
Performance estimates - Doppler

Theory



Performance estimates - Doppler

Measurements

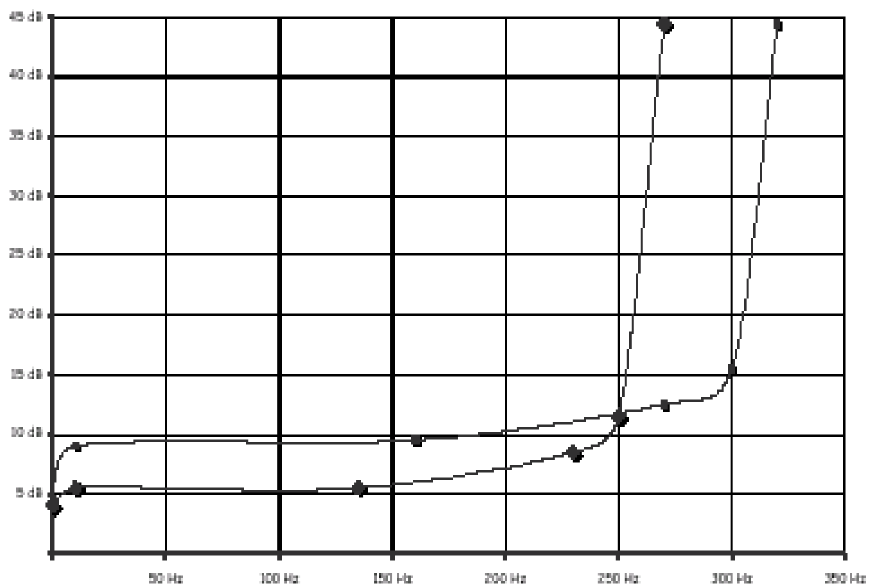


Types of receivers testes

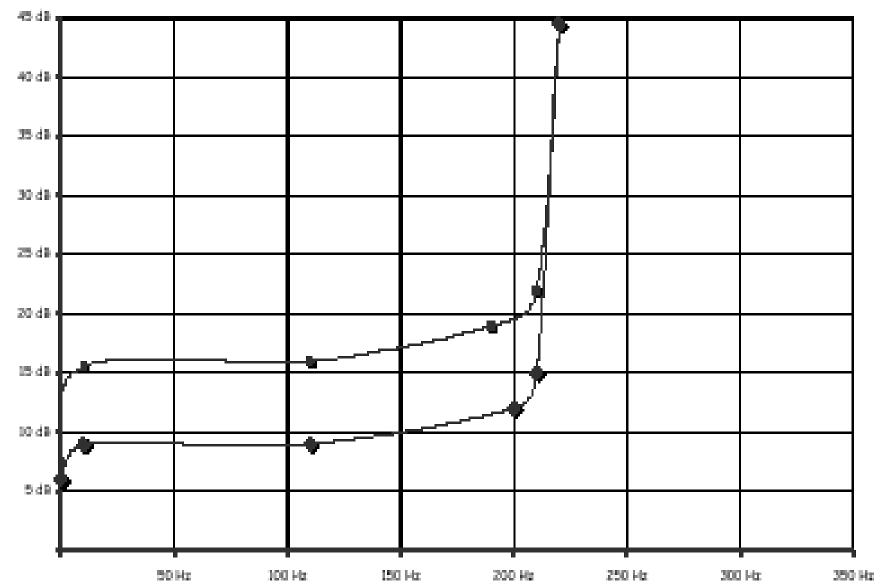
Id	Type	Technology	Architecture
A	Professional Receiver	Chipset 1st Generation	Standard demodulator
Bd	Experimental Receiver	Chipset 1st Generation	Antenna Diversity with sub-carriers switching
C	Professional Receiver	Chipset 1st Generation	Standard demodulator
D	Evaluation Board	Chipset 2nd Generation	Standard demodulator
E	Consumer setop box	Chipset 2nd Generation	Standard demodulator
Fd	Experimental Receiver	Chipset 2nd Generation	Antenna Diversity with packet switching
G	Professional Receiver	Discrete components	Standard demodulator
H	Experimental Receiver	Discrete components	Standard demodulator

Performance – Effect of code rate with different receivers

Code is CC-RS with Forney interleaver



Performance with CR : 1/2



Performance with CR : 2/3

Summary

- General guidelines for a mobile channel model have been presented
- OFDMA PHY, that is closely related to DVB-T/DVB-RCT seems to meet the mobile environment
- Performance of DVB-T standard in mobile channels has been presented
  - DVB-T receivers have NOT been designed for mobile reception