Comparison of WiMAX coverage at 450MHz and 3.5GHz

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Motivation

- The provision of Internet access and broadband multimedia services to residential users:
  - Urban areas ⇒ WiMAX at 3.5GHz
  - Rural areas ⇒ ? frequency band, ? technology
    - frequency band:
      - analogue mobile systems at 450MHz,
      - analogue broadcasting systems at 700-800MHz
    - technology:
      - WiMAX, wireless LAN (IEEE 802.11), DVB-S, DVB-S2, DVB-T, MVDS (multipoint video distribution system ETS 300 748), MMDS (microwave multipoint distribution service ETS 300 749)
      - **WiMAX** ???
  - Telsima d.d. (www.telsima.com) – radio coverage comparison for 3.5GHz and 450MHz

Outline

- Motivation
- WiMAX
- Channel models
- Simulation results
- Conclusion

WiMAX

- WiMAX subset of IEEE 802.16, planned for harsh multi-path environment (no line sight conditions)
  - 256 orthogonal frequency multiplex (OFDM)
    - information: 192 sub-carriers,
    - frequency guard: 27upper and 29lower sub-carriers,
    - pilot tones: 8 sub-carriers
  - Modulation schemes:
    - BPSK, QPSK, 16-QAM, 64-QAM
  - Coding schemes:
    - concatenated Reed-Solomon (RS) and convolutional code
    - concatenated RS code and parity bit check code
    - turbo code
  - Maximum allowed guard time ratio of ¼
  - Cell size from 1km to 5km
  - The frequency bands allocated for WiMAX: 2.5GHz, 3.5GHz and 5.8MHz with EIRP around 30dBm

Radio wave propagation models

- The radio wave propagation model or path loss model plays a significant role in planning of the wireless communication systems.
- Classes of radio wave propagation models:
  - empirical
    - equations and parameters are derived based on the field measurements
  - deterministic
    - based on the fundamental mechanisms of radio wave propagation: refraction, diffraction, scattering, etc.
  - semi – deterministic
    - combine good properties of both models

WiMAX Path Loss model (1)

- Based on Erceg path loss model (1.9GHz, suburban area)
- Adaptation of the Erceg model for WiMAX
- Path loss: $$L = A + 10\gamma \log_{10}(\frac{d}{d_0}) + s$$
- Free space path loss: $$A = 20\log_{10}\left(\frac{4\pi d_0}{\lambda}\right)$$
- Path loss exponent: $$\gamma = a - bh_b + \frac{c}{h_b}$$

WiMAX path loss model (2)

- Terrain types (a,b,c):
  - A: a hilly terrain with moderate-to-heavy tree density (the highest path loss)
  - C: a flat terrain with light tree densities (the lowest path loss)
  - B: either a mostly flat terrain with moderate-to-heavy tree densities or a hilly terrain with light tree densities

- Path loss with correction factors: $L_{\text{mod}} = L + L_f + L_h$
- Frequency correction: $L_f = 6.0 \log_{10}\left(\frac{f}{2000}\right)$
- Terrain A and B: $L_h = -10.6 \log\left(\frac{h_r}{2000}\right)$
- Terrain C: $L_h = -10.6 \log\left(\frac{h_r}{2000}\right)$

Path Loss models at 450MHz (1)

- Rural areas: digital elevation model play an important role at 450MHz
- Longley-Rice channel model
  - general propose model valid from 20MHz-40GHz
  - path length between 1km to 2000km
  - use digital elevation model (calculates the terrain roughness)
  - other parameters used in model
    - average climate conditions, soil conductivity, etc.

Path Loss models at 450MHz (2)

- Urban area
- Okumura model:
  - which is based on a number of measurements at various frequencies (150, 450, 900, and 1500 MHz) in primarily urban areas in Japan
    - Frequency range 150 – 1500MHz,
    - Base station height 30 – 200m,
    - Mobile height 1 – 10m,
    - Distance range 1 – 20km

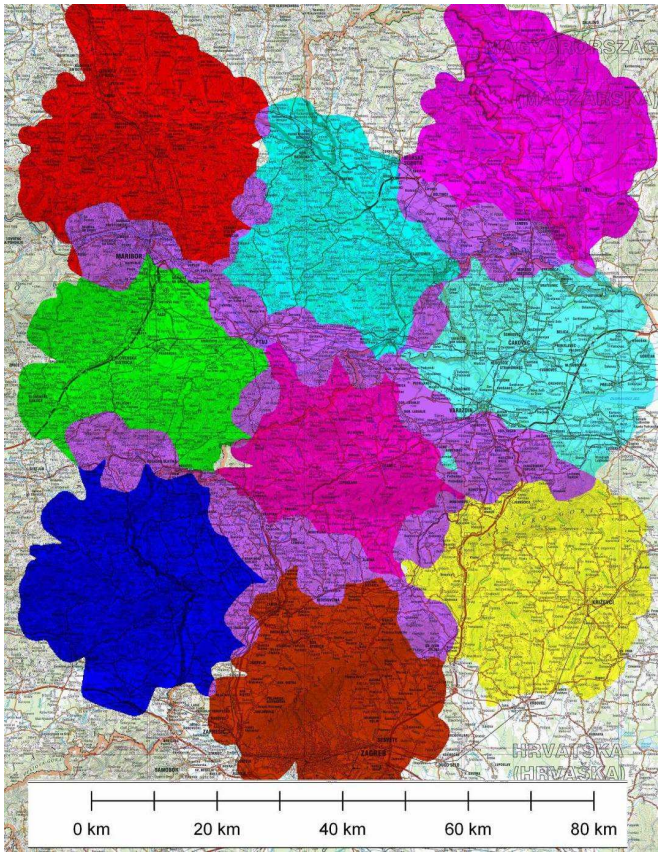
Radio Coverage calculation (1)

- The most important parameters for cell size calculation are:
  - transmitter: transmit power, transmission losses, antenna type and its location, etc.,
  - radio channel: the propagation environment and interference from neighboring radio systems, etc., and
  - receiver: static and dynamic receiver sensitivity, antenna type, antenna elevation, azimuth, altitude and receiver loss

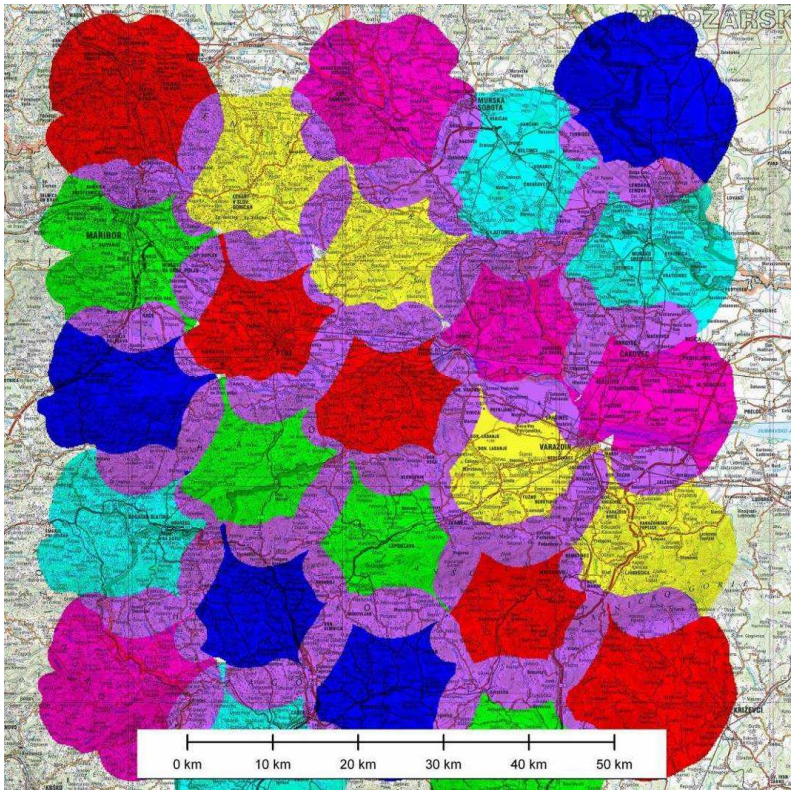
Radio Coverage calculation (2)

- We calculated the cell size using effective radiated power (ERP)
- Results are independent on transmission losses and transmitter antenna types
- The probability of terrain coverage is set to 95%.
- The typical values, which varies from 30dBμ to 15dBμ was calculated based on the off the shelves antennas for 3.5GHz and 450MHz.

Cell sizes for flat rural area

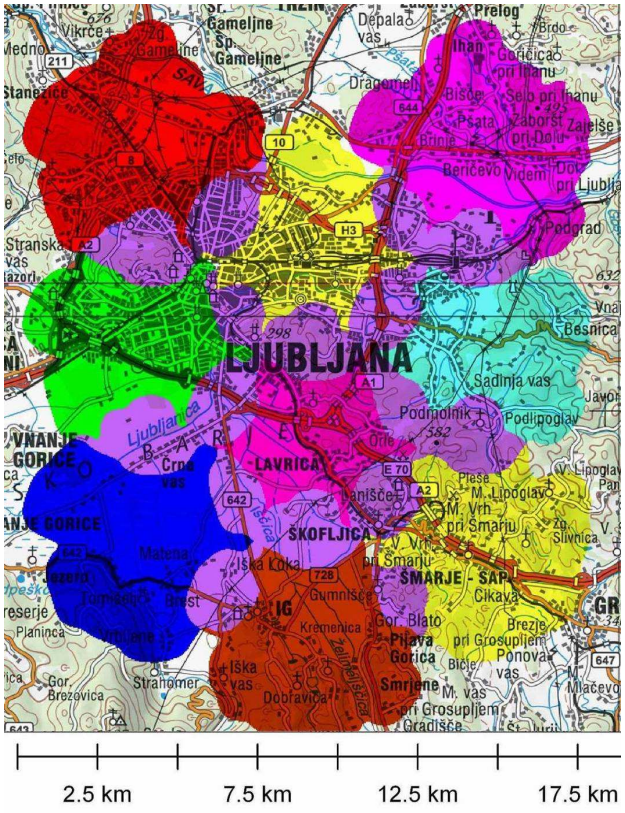


450MHz

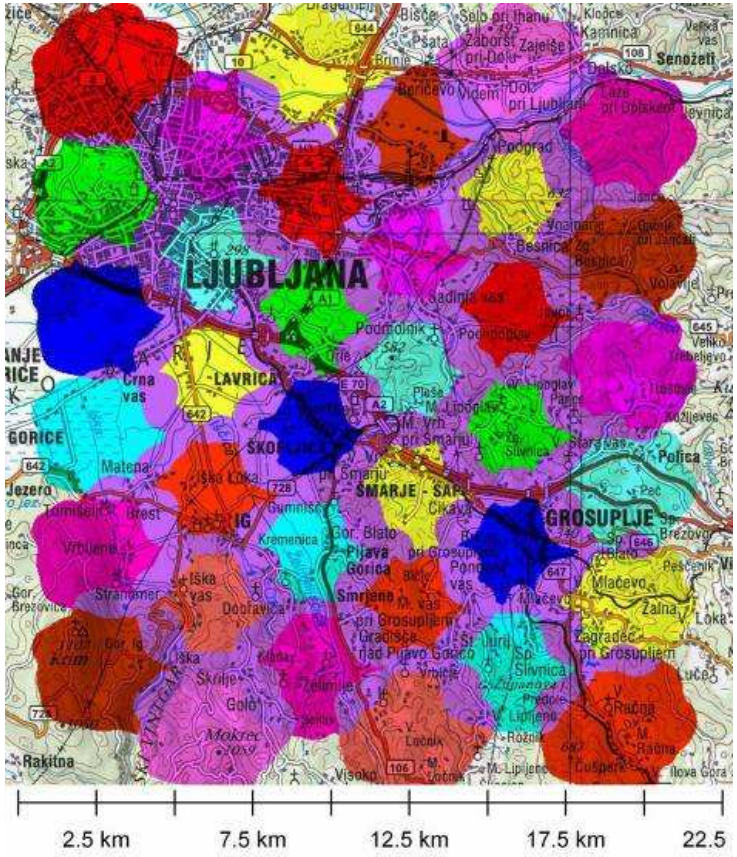


3.50GHz

Cell size for urban area

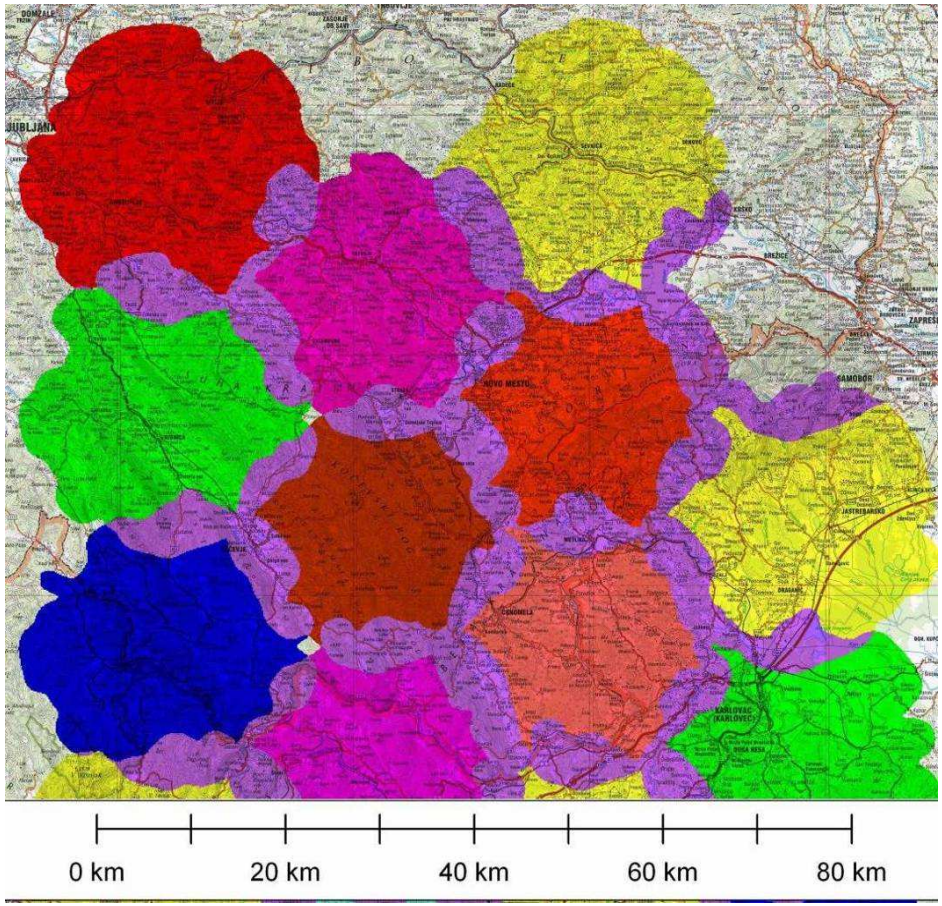


450MHz



3.5GHz

Cell size for hilly rural area at 450MHz



Conclusion (1)

- The cell size for two carrier frequency namely 450MHz and 3.5GHz is estimated for WiMAX system using path loss propagation models for flat rural, hilly rural and urban environment
- The estimated cell radius ratio for analyzed frequencies is much lower than expected from free space loss formula.
- In urban area and flat rural area the usable radio coverage can be provided at both frequencies with different cell sizes.
- In the hilly rural terrain the radio signal at 3.5GHz does not provide sufficient coverage.

Conclusion (2)

- Analaysis in terms of system capacity
  - WiMAX standard support adaptive coding and modulation
    - the coverage is determined by the most robust signal (BPSK)
    - the system capacity mostly depends on high efficient coding modulation schemes
  - Assuming the equal distribution of the coding modulation schemes inside the cells, the system capacity is lower for WiMAX system at 450MHz frequency, due to large cell size