Mobile WiMAX System Performance - Simulated Versus Experimental Results

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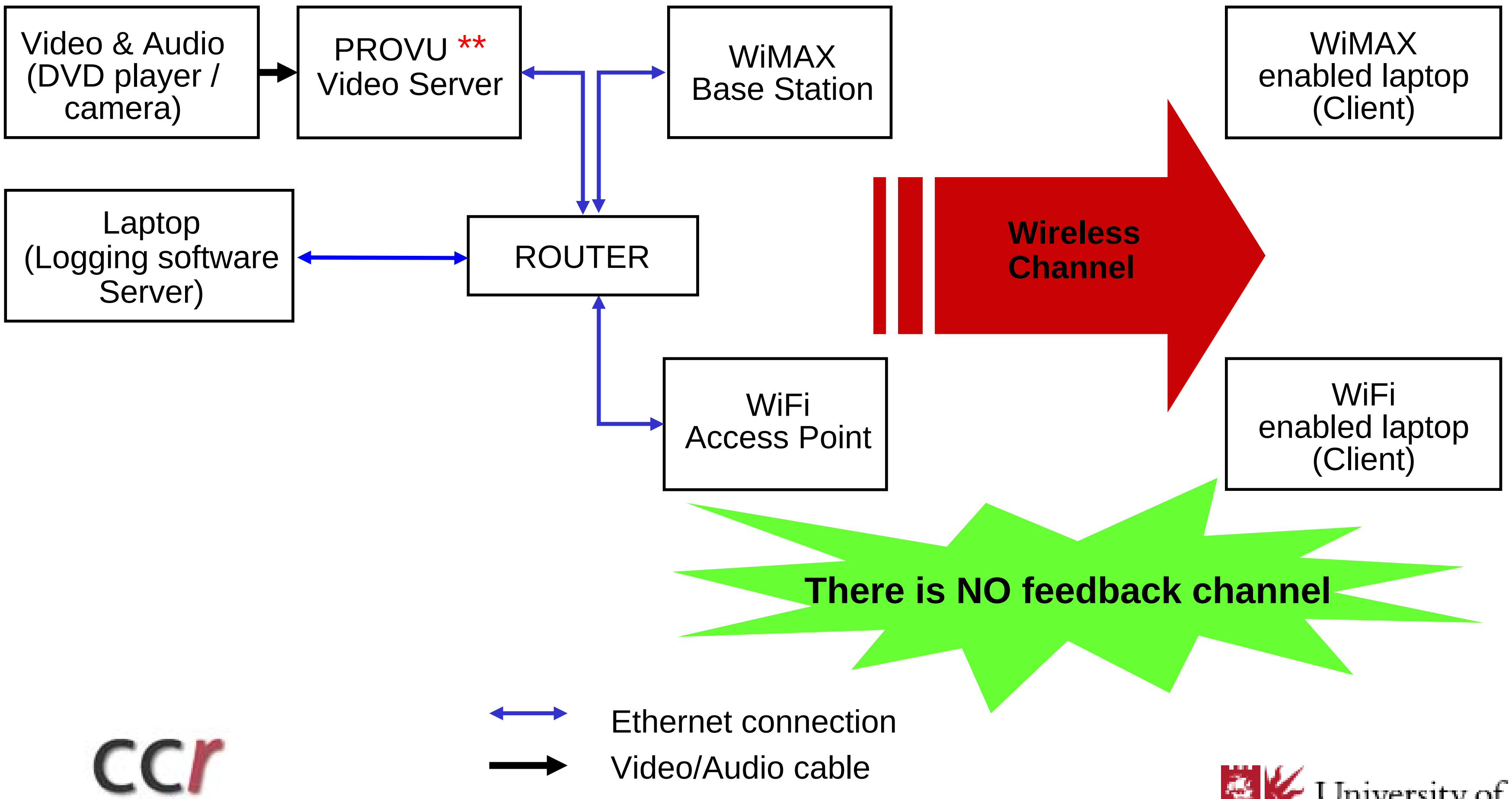
Presentation Outline

- What makes WiMAX better than WiFi ?
- Network architecture, measurements set-up and data collection procedure
- Measurements and Simulations Results and Recommendations
- Conclusions

What makes WiMAX better than WiFi ?

- WiMAX specifications allow for EIRP of 61 dBm in a 10 MHz channel (about 40 dB more than in WiFi specs)
- MIMO antenna techniques along with flexible sub-channelization schemes, Advanced Coding and Modulation all enable the Mobile WiMAX technology to support up to 63 Mbps on the DL and up to 28 Mbps on the UL in a 10 MHz channel (per sector).
- 802.16e supports optimized handover schemes with latencies less than 50ms
- The fundamental premise of the IEEE 802.16 MAC architecture is QoS. It enables end-to-end IP based QoS. Additionally, sub-channelization and MAP-based signalling schemes provide a flexible mechanism for optimal scheduling of space, frequency and time resources on a frame-by-frame basis.

Trials' Network Architecture



** developed and supplied by ProVision Communications Ltd

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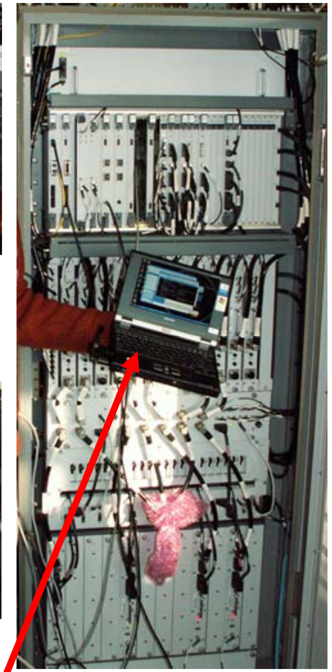
WiMAX Measurements Set-up

DVD player

H264 AVC and packetisation unit (Server 1)

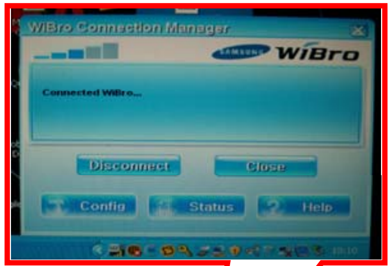


Mobile WiMAX Base Station

WiMAX Antenna (2dBi Omni)

WiFi Access point (7dBi Omni)

Laptop running Logging software (Server 2)



802.16e enabled laptop

802.11g enabled laptop

WiMAX EIRP: 32 dBm, WiFi EIRP: 21 dBm

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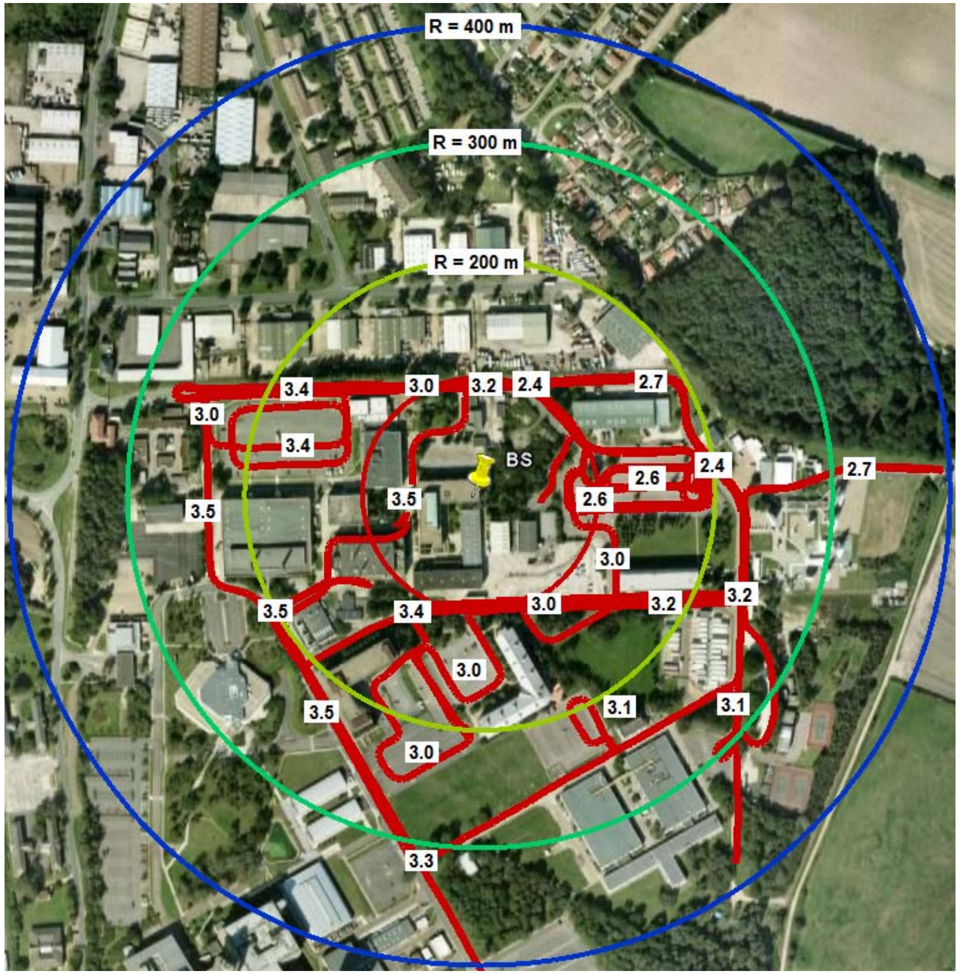
Measurement Environment: Routes and Pathloss exponent



- Pathloss is calculated based on a WiFi network at 2.4GHz operating in parallel to a WiMAX.
- Pathloss exponent (*n*) is extracted from Erceg's empirical model assuming (d_o = 1m)

$$L_p = A + 10nLog_{10}(d/d_o) + s \qquad d \geq d_o$$

$$A = 20Log_{10}(4\pi d_o/\lambda)$$

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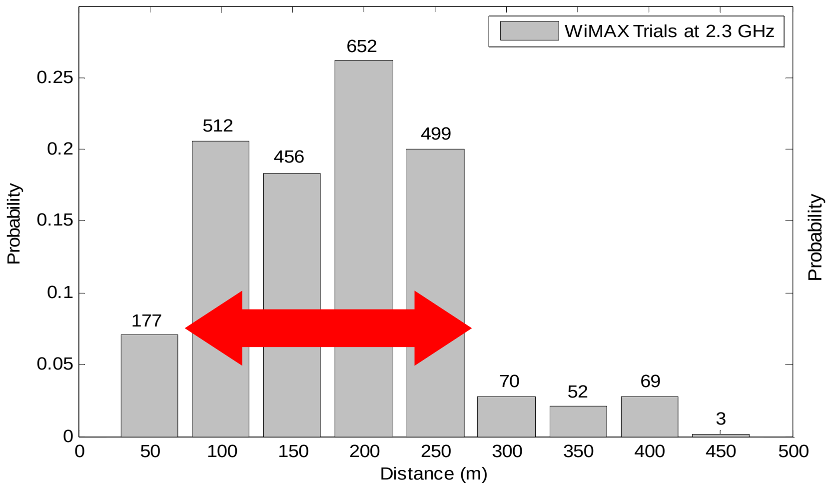
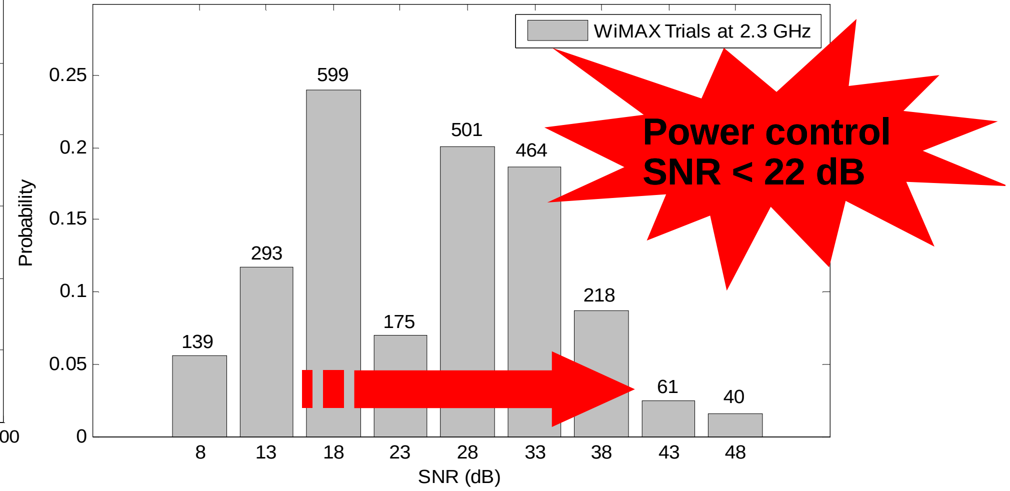
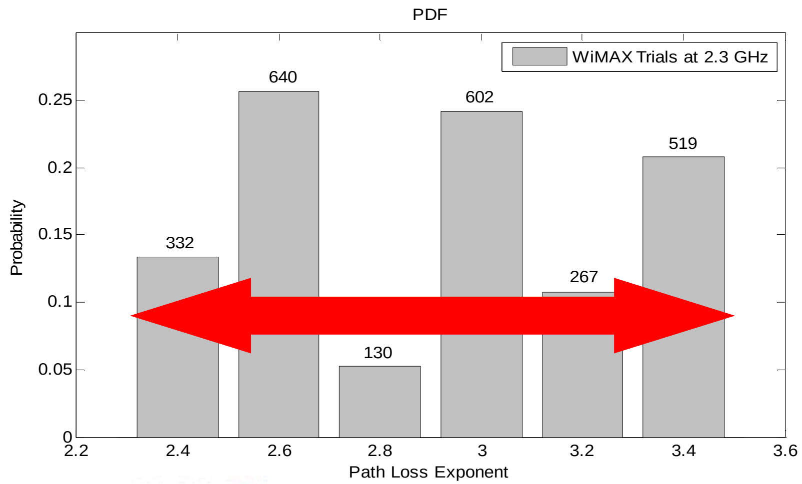
Statistics from 2500 sec. of data logging







Most data are collected with:

- Tx-Rx distance 75 to 275 m
- SNR values above 15.5 dB
- Path loss exponent being between 2.3 and 3.5

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Channel model and Simulation parameters

- 3GPP-SCM (urban-micro)
- MT velocity is set to 40 km/h
- No retransmission of packets is allowed

Tap	1	2	3	4	5	**6**
Delay (ns)	0	210	470	760	845	910
Power (dB)	0	-1.8	-1.5	-7.2	-10	-13
K factor	0	0	0	0	0	0
Delay spread	279 ns					

Parameter	**Value**
Operating Frequency	2.3 GHz
Channel Bandwidth	5 MHz
Sampling Frequency	5.6 MHz
FFT Size	512
Number of Used Sub-carriers	421
Sub-carrier Spacing	10.94 kHz
Sampling Period	0.18 μs
Useful symbol duration	91.4 μs
Guard Interval	11.4 μs
OFDMA symbol duration	102.9 μs
Number of Sub-channels	15
Number of Users	3
Number of Sub-channels/User	5
Number of Data Sub-carriers	360

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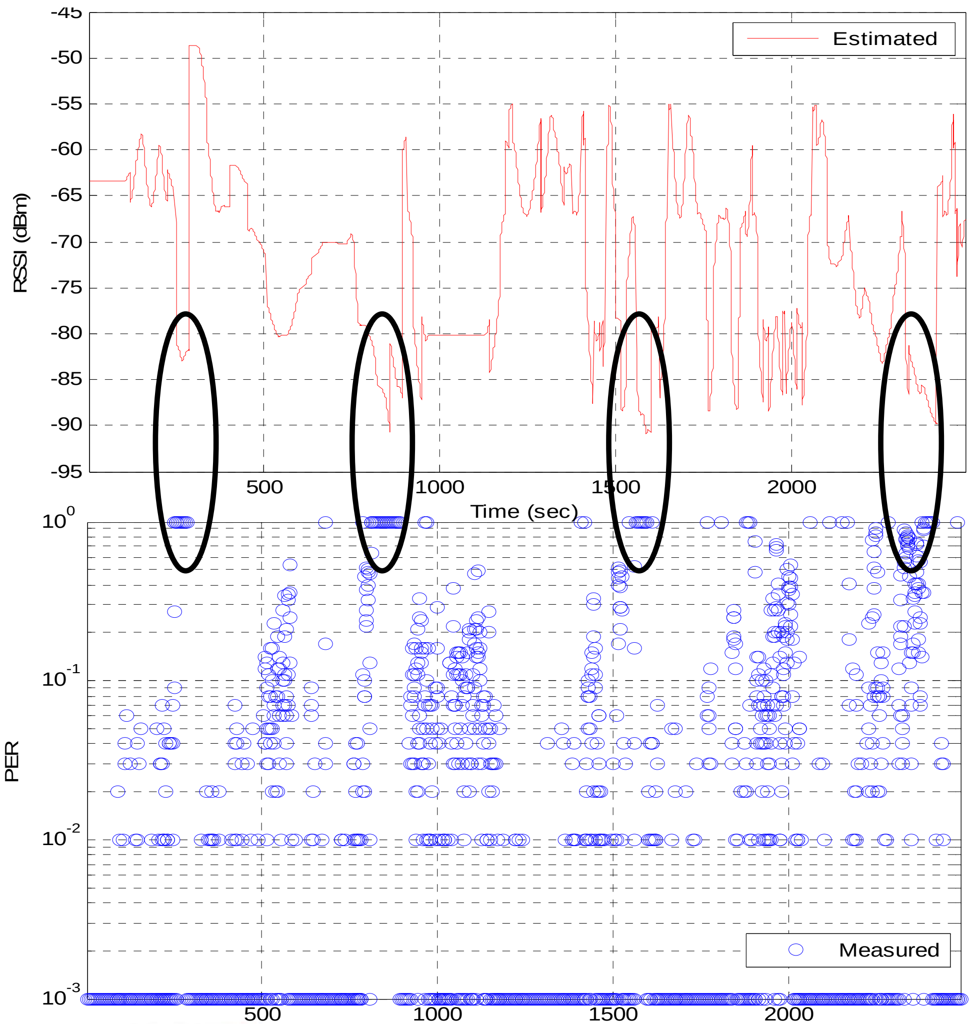
Measured WiMAX PER Performance



- The estimated RSSI appears to be very close to the real levels since high PER is seen when RSSI < -82 dBm
- The measured PER together with the estimated RSSI show that the system performance is power limited.
- It is expected that higher EIRP would lower significantly the PER.

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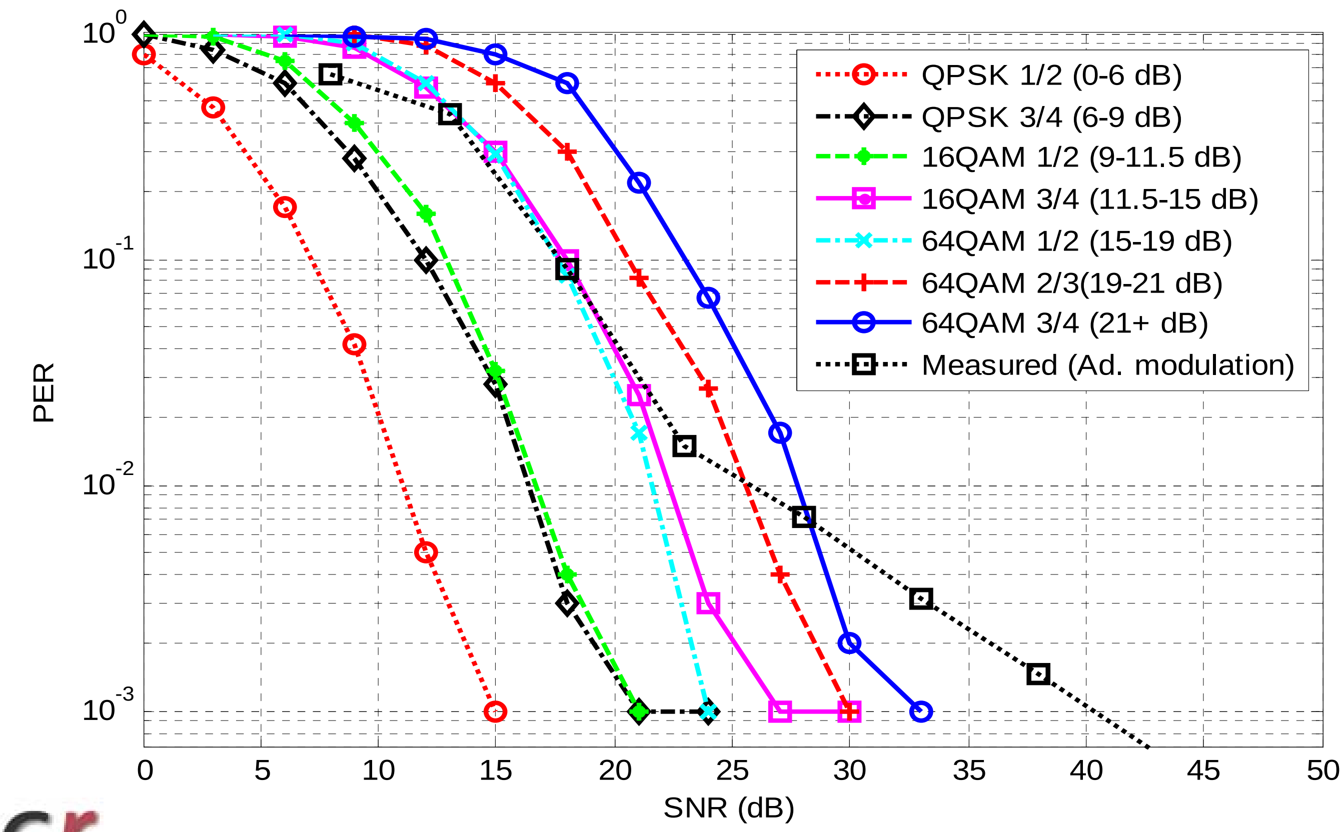
Measured versus Simulated PER

- Adaptive modulation and coding is supported at the BS
- In practice, Power Control at the BS limits the SNR at about 22 dB



* PER < 0.001 is shown as 0.001

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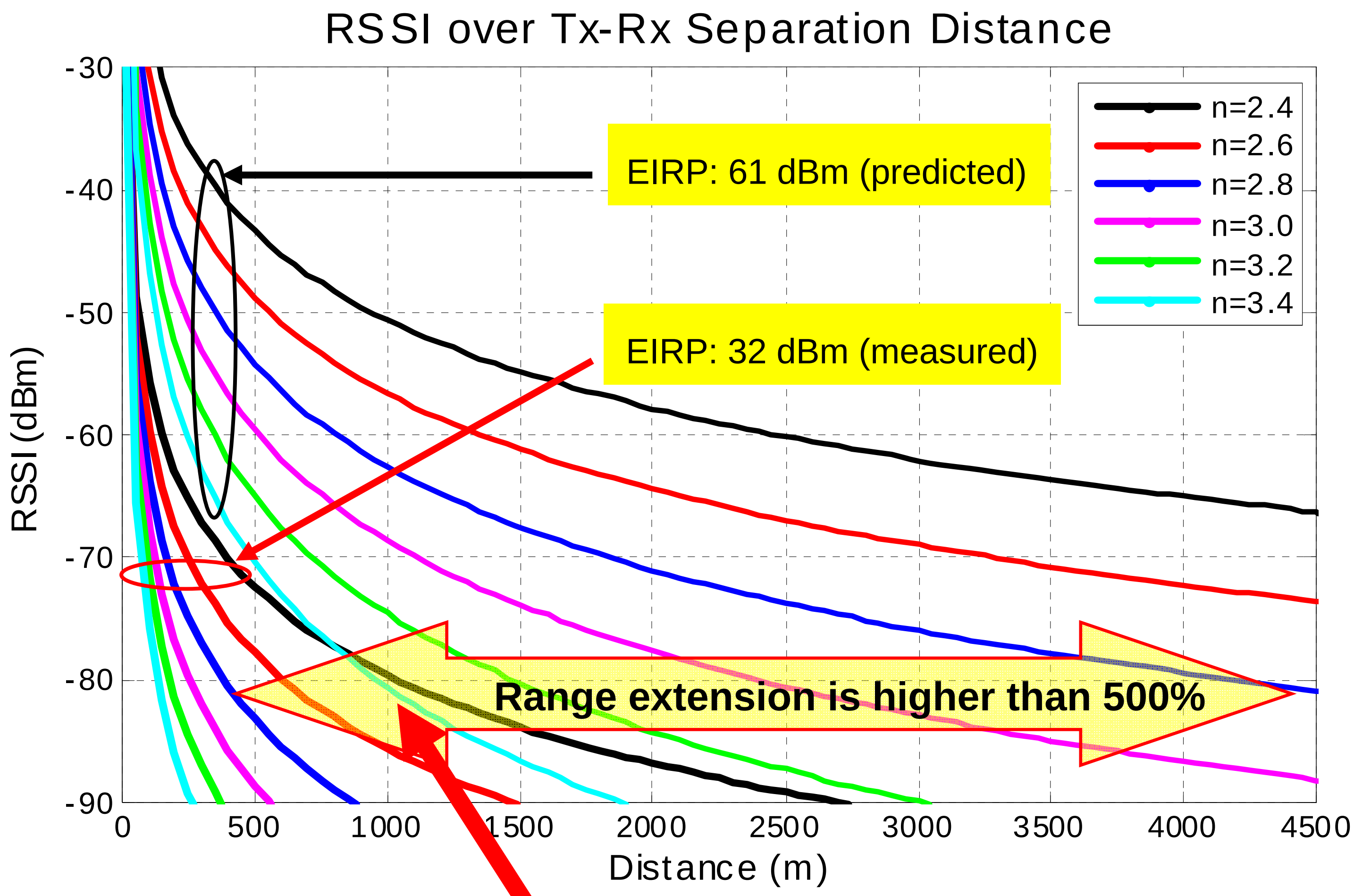
Range Prediction using the maximum EIRP



The range of mobile WiMAX in urban (NLoS) environments is expected to be about 1km !

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How can we achieve the maximum EIRP?

- Is a Power Amplifier the right solution?
- Directional Antennas do not only contribute to the EIRP (18 dB), but also increase mobility, range and throughput.
- Directional Antennas are used as Spatial Filters offering:
  - Enhanced Signal Levels
  - Reduced Doppler Spread
  - Reduced Delay Spread
  - Reduced Co and Adjacent Channel Interference

Conclusions

- As seen, it is reasonable to expect range and PER performance degradation with low BS height and EIRP.
- Good agreement between the PER performance of a carrier-class mobile WiMAX system and a simulator was demonstrated.
- By combining the measured path loss and the OFCOM regulations for the licensed 2.5GHz band, the expected performance of mobile WiMAX was shown to be about 4 km in sub-urban environments (n=2.8) and 1km in urban ones (n=3.4).

Questions?

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