WIMAX SYSTEM PERFORMANCE IN HIGHLY MOBILE SCENARIOS WITH DIRECTIONAL ANTENNAS

George Zaggoulos, Andrew Nix and Angela Doufexi

University of BRISTOL

ccr centre for communications research

Presentation Outline

- Wireless Communications and Mobility
- Challenges and Limitations
- Proposed Solution to Increase Mobility
- Conclusions

ccr centre for communications research

University of BRISTOL

Wireless Communications and Mobility

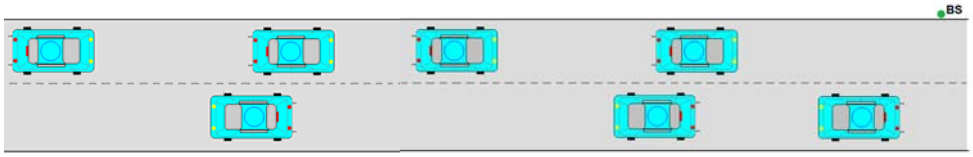
- Wireless Market Demands:
  - Faster Connections (Higher Transfer Rates)
  - Increased Availability of Service (Geographically)
  - Service that supports Highly Mobile users
- Wireless Services Available:
  - Mobile Telephony – 2G/3G
  - WiFi
  - WiMAX

ccr centre for communications research

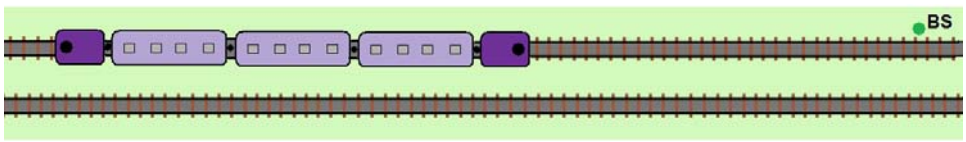
University of BRISTOL

High Mobility Users Include:

- Vehicles moving at high-speeds on motorways



- High-Speed Trains moving along fixed tracks



- Rally cars with rapid acceleration and braking

ccr centre for communications research

University of BRISTOL

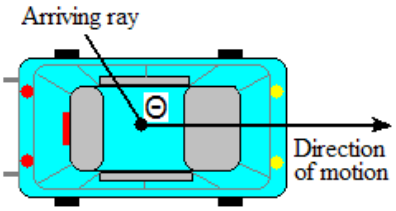
Mobility Limitation

- How can WiFi and WiMAX technologies support users travelling at high speeds without increased Signal Processing?

- Higher Doppler Shifts:
  - Increase Channel Fading
  - Reduce Coherence Time
  - Introduce Aging Problem

$$f_\theta = f_m * \cos(\theta)$$

$$f_m = u / \lambda$$

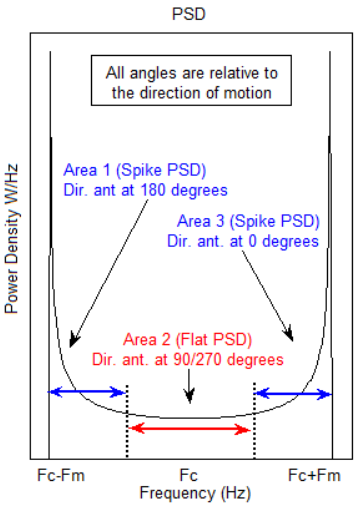


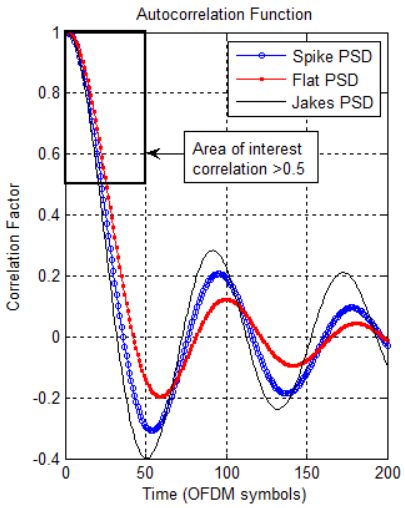
f_m: *Max. Doppler Shift*
u : *Mobile speed*
λ : *Carrier Wavelength*

centre for communications research

University of BRISTOL

Power Doppler Profile and Coherence Time





- Coherence Time

$$R(\tau) = FT^{-1}\{S(f)\}$$

$$T_c = \frac{\lambda / 2}{u} = \frac{0.5}{f_m}$$

- Coherence time is relatively insensitive to the shape of the Power Doppler Profile, but strongly related to the rms Doppler Spread.
- For antennas with a front-to-back ratio of 12 dB or higher, signals outside the main beam do not affect the coherence time.

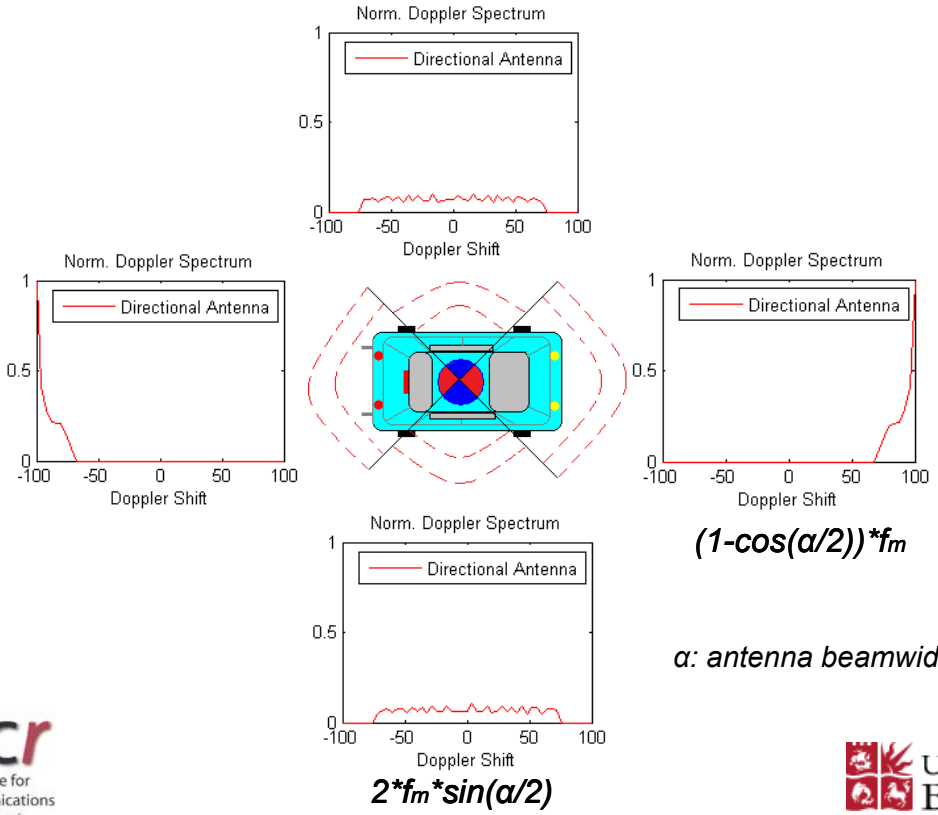
centre for communications research

University of BRISTOL

Can Directional Antennas Increase Mobility?

- Directional Antennas are used as Spatial Filters
- When correctly aligned, Directional Antennas offer:
  - Enhanced Signal Levels,
  - Reduced Doppler Spread,
  - Reduced Delay Spread,
  - Reduced Co and Adjacent Channel Interference.

Proposed Solution



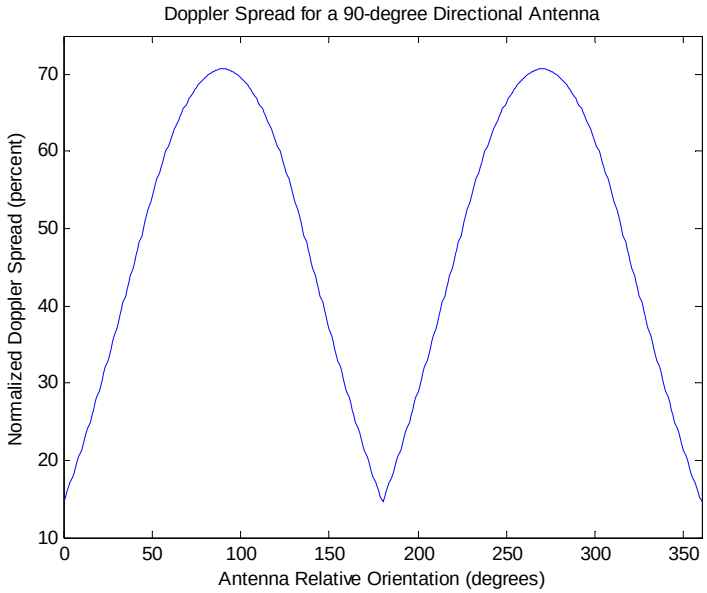
$(1-\cos(\alpha/2))*f_m$

α: antenna beamwidth

$2*f_m*\sin(\alpha/2)$

Proposed Solution

Doppler reduction with a 90 degree sector



ccr centre for communications research

University of BRISTOL

Simulation Parameters

802.16-2004 PHY-Layer simulator parameters:

Operating Frequency	3.5 GHz
Bandwidth	5 MHz
FFT Size	256
Useful Sub-carriers	192
Guard Interval Length	64
Sub-carrier Spacing	22.5 kHz
Useful Symbol Duration	44.4 μs
Total Symbol Duration	55.5 μs
Channel Coding	Punctured 1/2 rate convolutional code, constraint length 7, $\{133,171\}_{octal}$
Mode	BPSK ½

Channel Parameters

	Tap 1	Tap 2	Tap 3
K-factor	0	0	0
Delay (ns)	0	500	1000
Power (dB)	0	-10	-20
Max. Doppler Spread (Hz)	450	450	450
PSD	Jakes	Jakes	Jakes

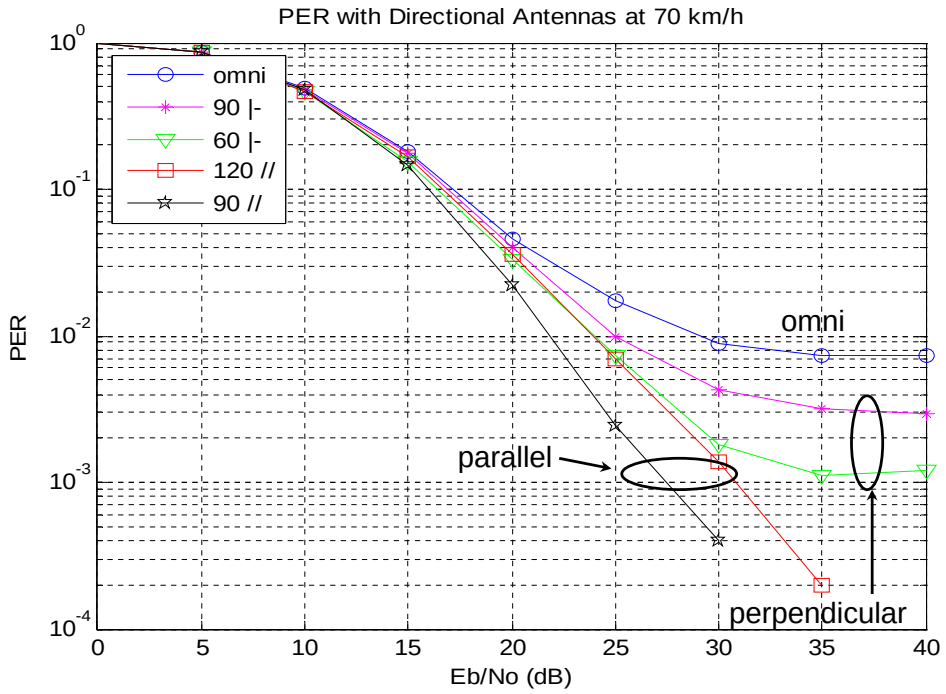
Frame Structure

Preamble	Data 1	Data 2	Data 3	Data 4

ccr centre for communications research

University of BRISTOL

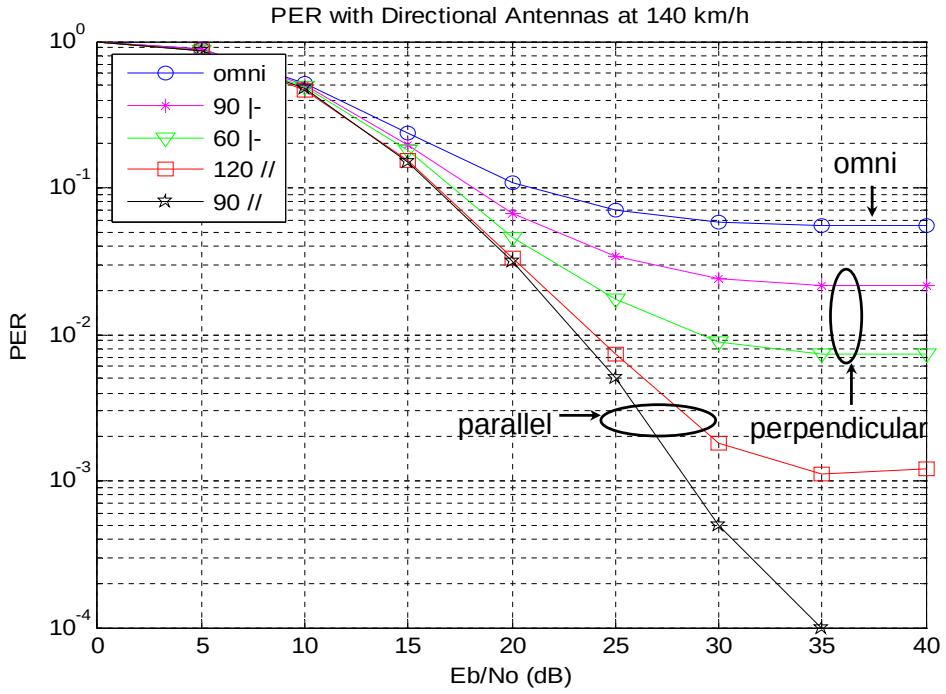
Simulation Results 70 km/h



centre for communications research

University of BRISTOL

Simulation Results 140 km/h



centre for communications research

University of BRISTOL

Conclusions

- Performance is relatively insensitive to the shape of the Power Doppler Profile, but strongly related to the value of the rms Doppler Spread.
- The use of directional antennas (aligned parallel to the direction of motion) improves performance without the need for increased digital signal processing.
- Antennas with at least a 12 dB front-to-back ratio result in a channel coherence time that is independent of the side lobe structure.

Acknowledgments: This work was partly funded by the Department of Trade and Industry, UK Technology Programme: Project VISUALISE.

ccr centre for communications research

University of BRISTOL

Questions?

G.Zaggoulos@bristol.ac.uk

Acknowledgments: This work was partly funded by the Department of Trade and Industry, UK Technology Programme: Project VISUALISE.

ccr centre for communications research

University of BRISTOL