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# WIMAX SYSTEM PERFORMANCE IN HIGHLY MOBILE SCENARIOS WITH DIRECTIONAL ANTENNAS

George Zaggoulos, Andrew Nix and Angela Doufexi



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## Presentation Outline

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

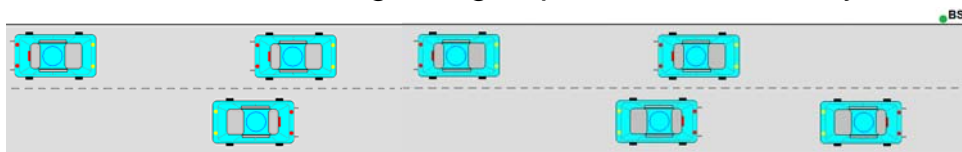


## Wireless Communications and Mobility

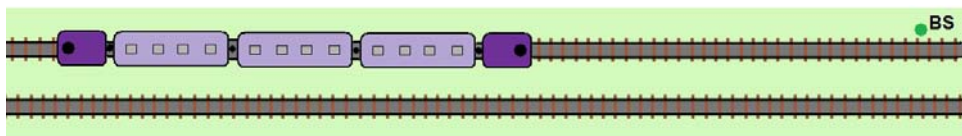
- ❖ **Wireless Market Demands:**
  - Faster Connections (Higher Transfer Rates)
  - Increased Availability of Service (Geographically)
  - Service that supports Highly Mobile users
  
- ❖ **Wireless Services Available:**
  - Mobile Telephony – 2G/3G
  - WiFi
  - WiMAX

## 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

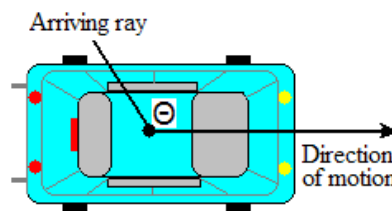


## Mobility Limitation

- ❖ 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

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

$$f_m = u / \lambda$$

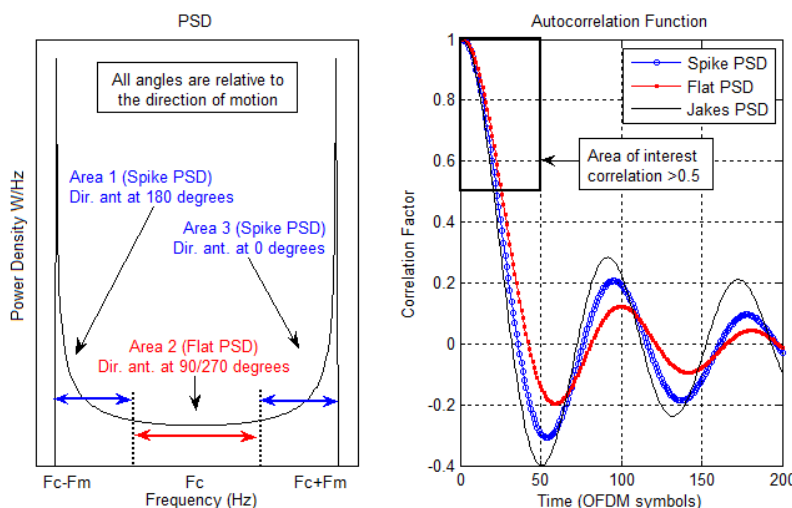


$f_m$ : Max. Doppler Shift

$u$  : Mobile speed

$\lambda$  : Carrier Wavelength

## Power Doppler Profile and Coherence Time



### ❖ Coherence Time

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

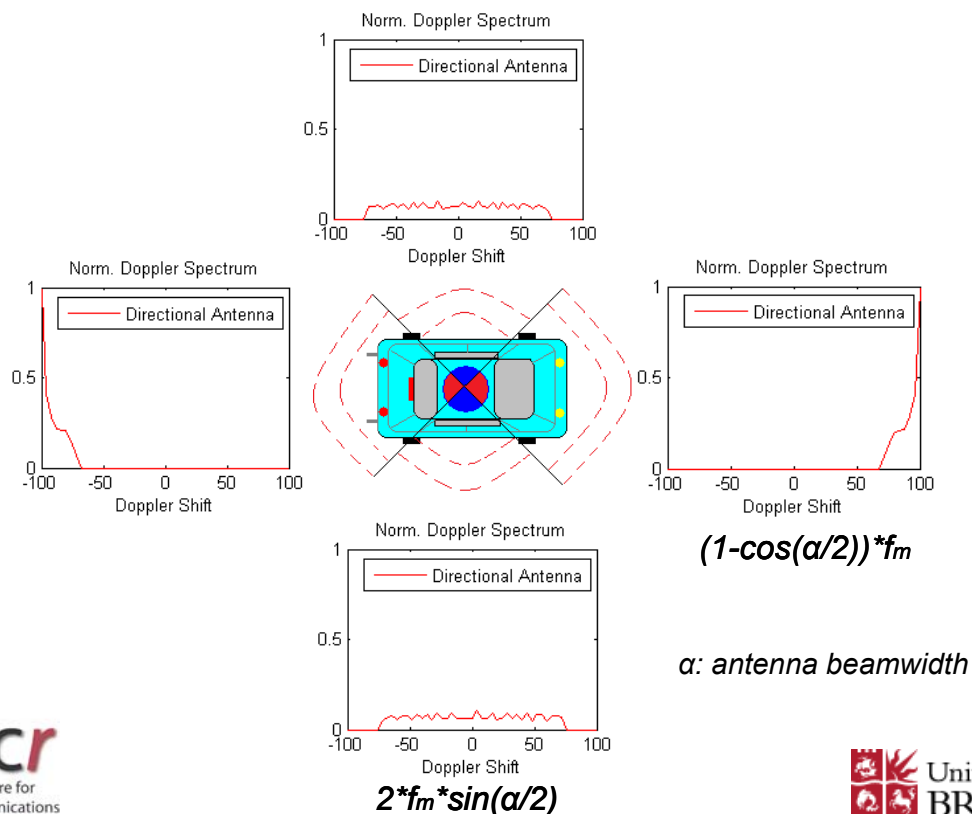
$$T_c = \frac{\lambda/2}{u} = \frac{0.5}{f_m}$$

- 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.

# Can Directional Antennas Increase Mobility?

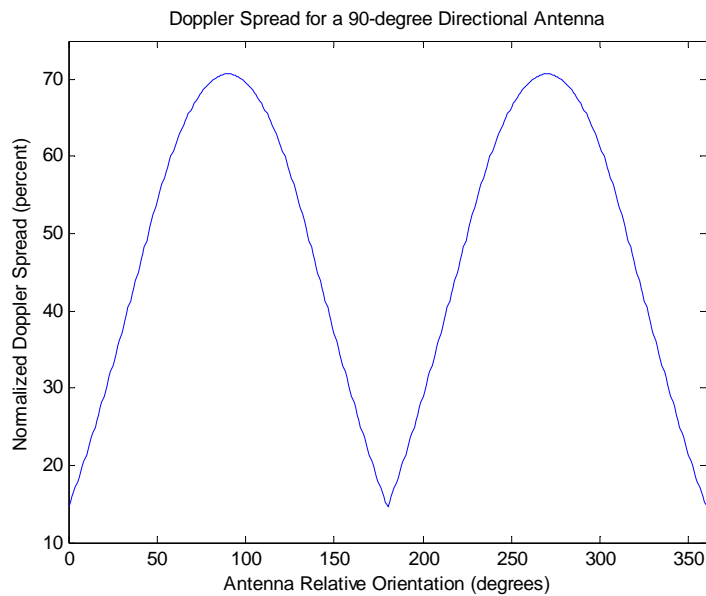
- ❖ Directional Antennas are used as Spatial Filters
- ❖ When correctly aligned, Directional Antennas offer:
  - Enhanced Signal Levels,
  - Reduced Doppler Spread,
  - Reduced Delay Spread,
  - Reduced Co and Adjacent Channel Interference.

## Proposed Solution



## Proposed Solution

Doppler reduction with a 90 degree sector



## 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 $\mu$ s
Total Symbol Duration	55.5 $\mu$ s
Channel Coding	Punctured 1/2 rate convolutional code, constraint length 7, {133,171} <sub>octal</sub>
Mode	BPSK 1/2

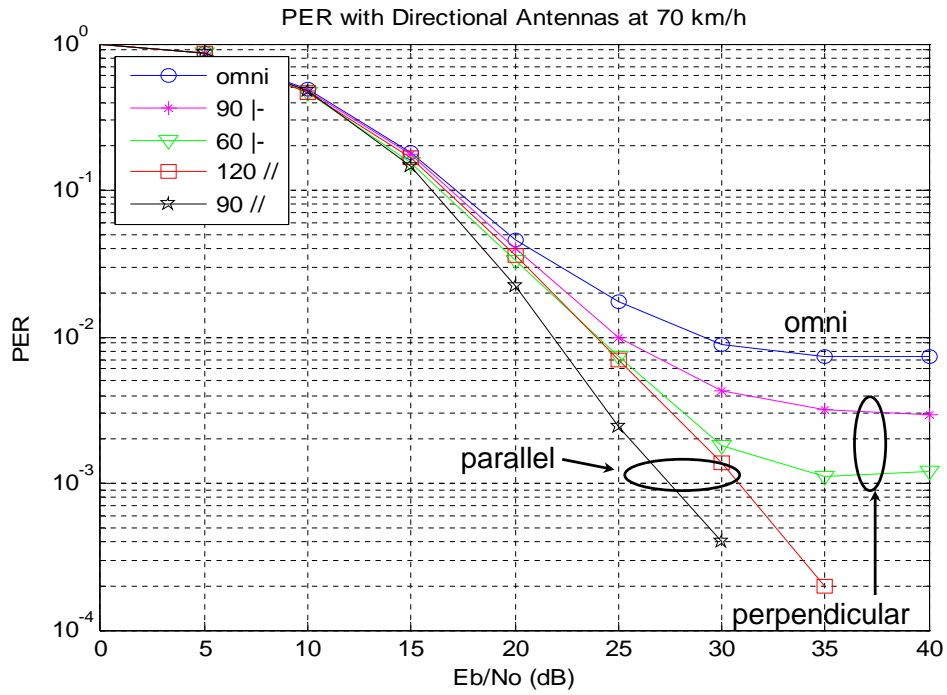
Channel Parameters

	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

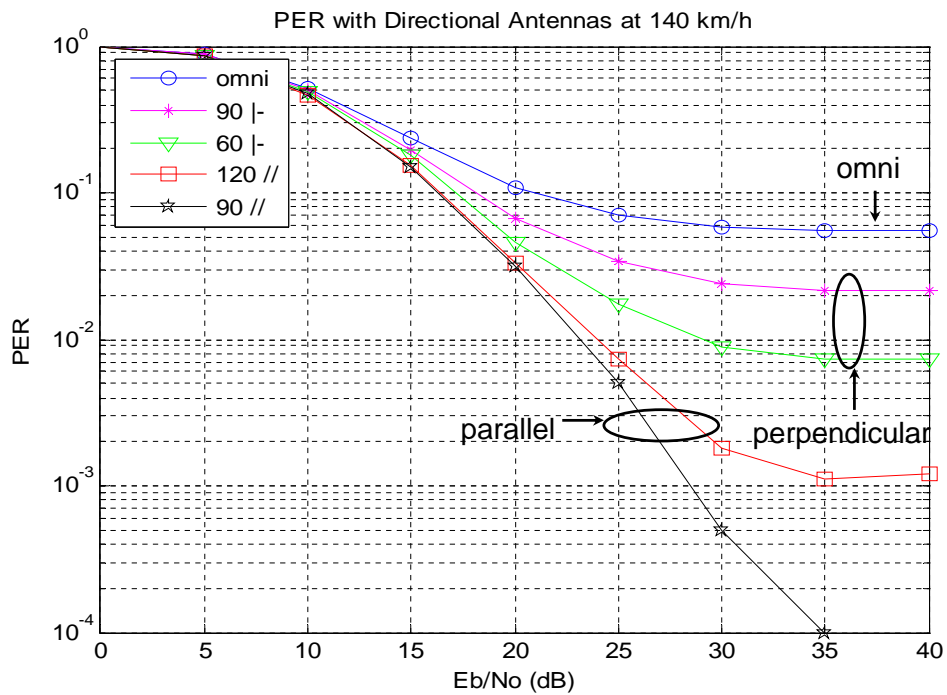
Frame Structure

Preamble	Data 1	Data 2	Data 3	Data 4
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# Simulation Results 70 km/h



# Simulation Results 140 km/h



## 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.

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## Questions?

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