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WIMAX SYSTEM PERFORMANCE IN HIGHLY MOBILE SCENARIOS WITH DIRECTIONAL ANTENNAS

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Presentation Outline

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



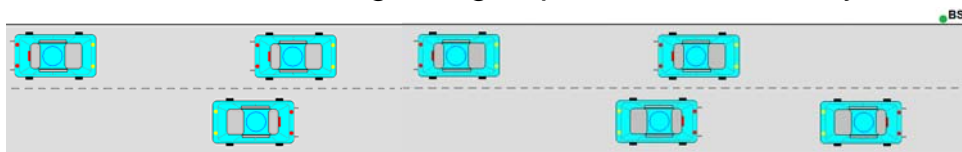
Wireless Communications and Mobility

- ❖ **Wireless Market Demands:**
 - Faster Connections (Higher Transfer Rates)
 - Increased Availability of Service (Geographically)
 - Service that supports Highly Mobile users

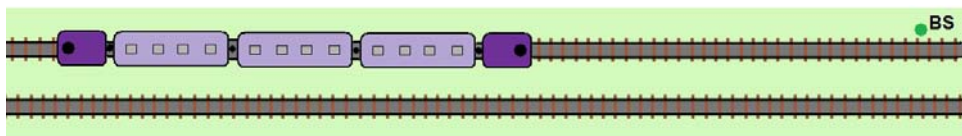
- ❖ **Wireless Services Available:**
 - Mobile Telephony – 2G/3G
 - WiFi
 - WiMAX

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

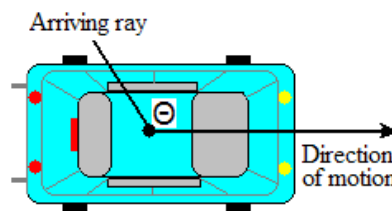


Mobility Limitation

- ❖ 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

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

$$f_m = u / \lambda$$

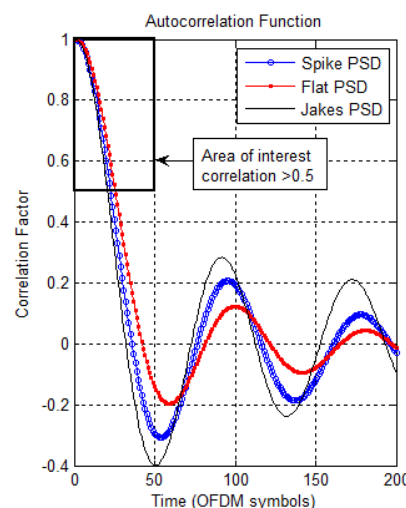
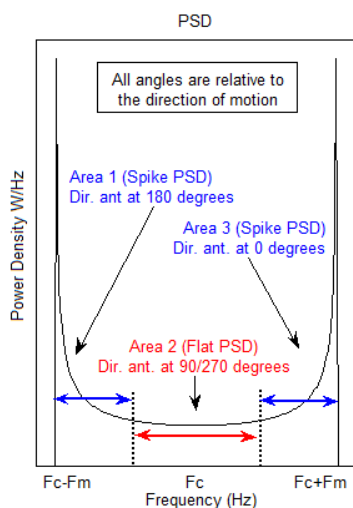


f_m : Max. Doppler Shift

u : Mobile speed

λ : Carrier Wavelength

Power Doppler Profile and Coherence Time



❖ Coherence Time

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

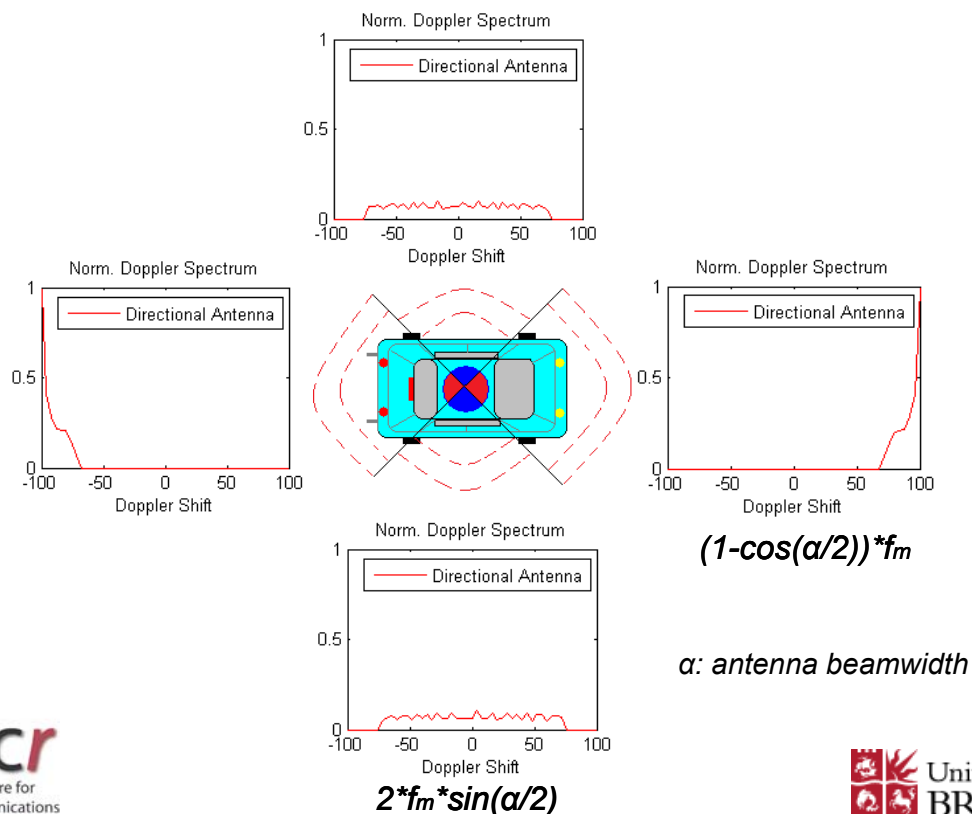
$$T_c = \frac{\lambda/2}{u} = \frac{0.5}{f_m}$$

- 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?

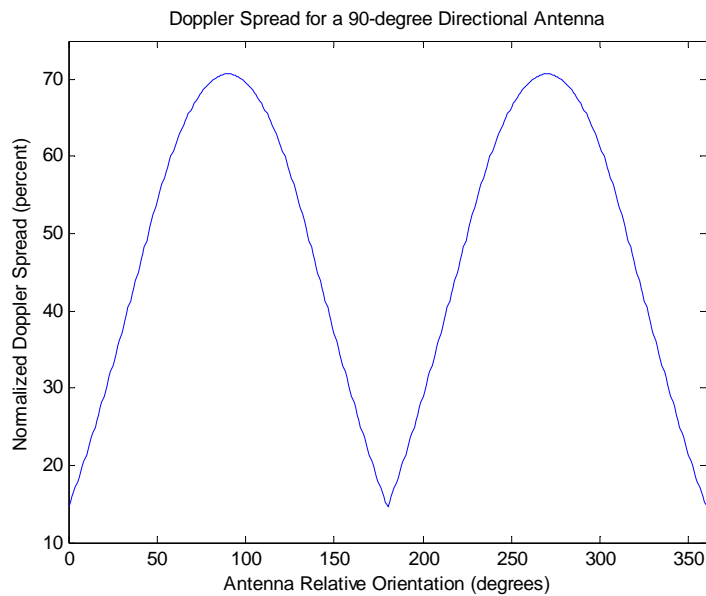
- ❖ Directional Antennas are used as Spatial Filters
- ❖ When correctly aligned, Directional Antennas offer:
 - Enhanced Signal Levels,
 - Reduced Doppler Spread,
 - Reduced Delay Spread,
 - Reduced Co and Adjacent Channel Interference.

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 μ s
Total Symbol Duration	55.5 μ s
Channel Coding	Punctured 1/2 rate convolutional code, constraint length 7, {133,171} _{octal}
Mode	BPSK 1/2

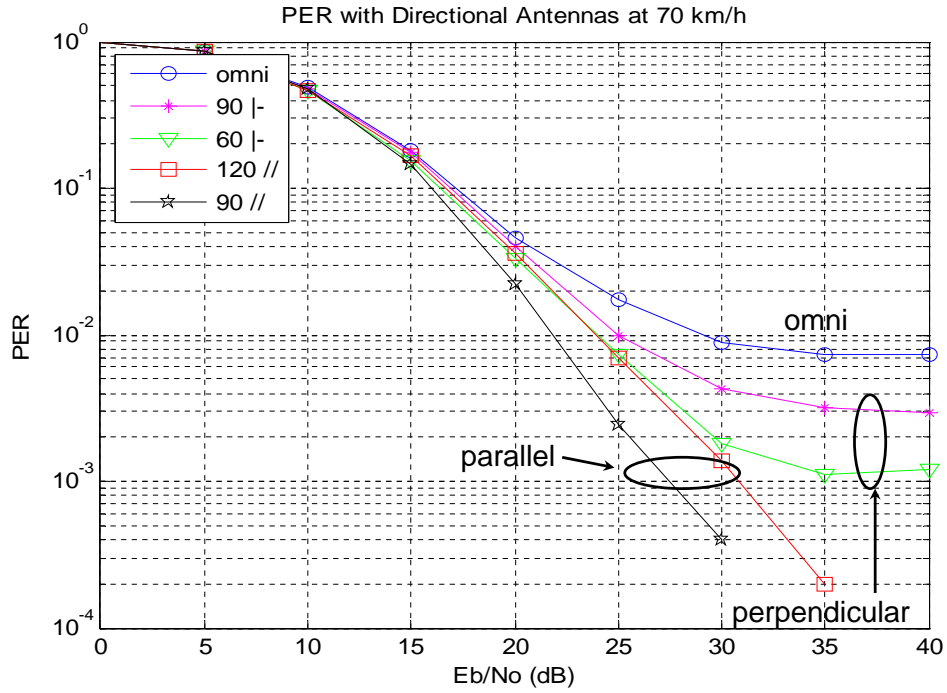
Channel Parameters

	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

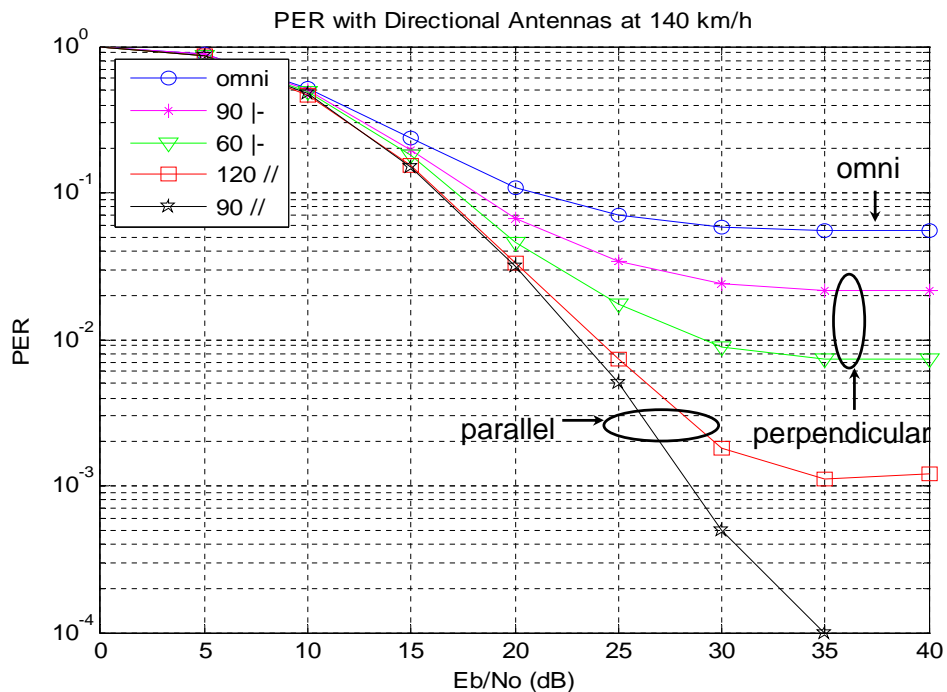
Frame Structure

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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