



Ofcom R&D Symposium

23rd November 2006

Polite Protocols



Headline Conclusions



A Polite Protocol is essential in avoiding catastrophic interference and providing fair access to Licence Exempt (LE) radio spectrum in congested areas

A Polite Protocol should be mandated in LE Bands for certain categories of application



Agenda



The Co-existence Problem

Categories of Polite Protocols

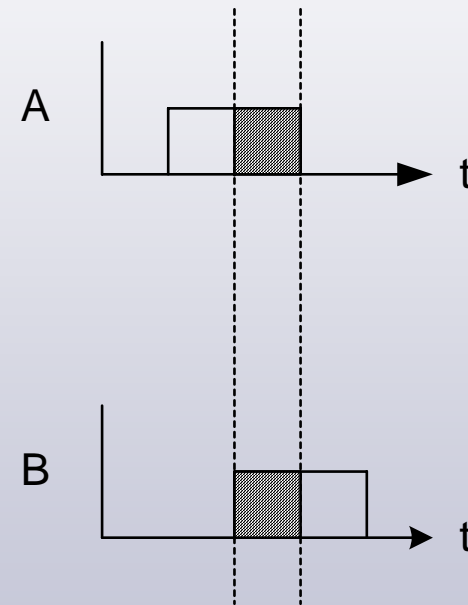
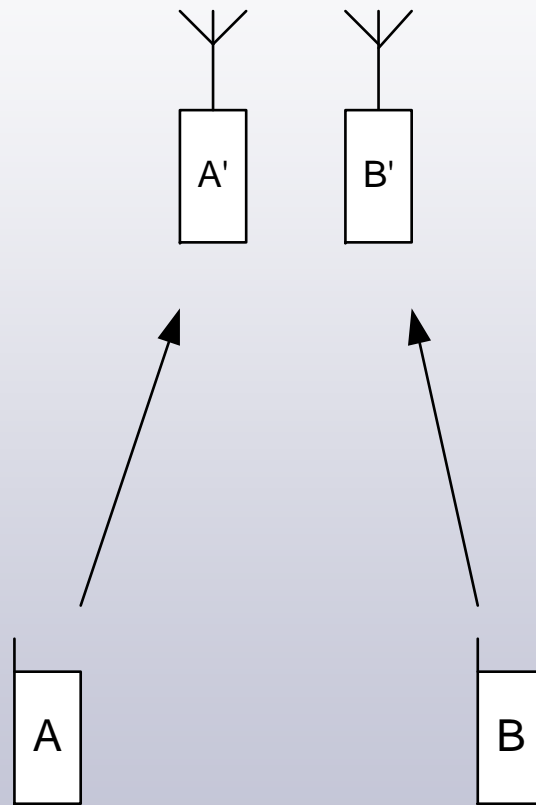
Results of our Polite Protocol Assessment

Options for Introducing PPC-spectrum

Conclusions



The Co-existence Problem



Categories of Polite Protocols



Frequency-based, e.g. Free Channel Search

Contention-Free, e.g. Polling

Contention-based, e.g. Listen Before Talk (CSMA)



Factors Contributing to Congestion



Isolation:- Low Isolation vs. High Isolation

Occupancy (including Link Density):- Low Occupancy vs. High Occupancy

Topology:- Single Link Access (Pt – Pt) vs. Multiple Link Access (Pt-MPt)

Isolation	Occupancy	Topology	Severity of Congestion	
High	Low	Pt-Pt	Low	(Garage Door Opener)
High	Low	Pt-MPt	Medium	(Telemetry System)
High	High	Pt-Pt	Low	Residential WiFi Scenario
High	High	Pt-MPt	High	Public Space WiFi Scenario
Low	Low	Pt-Pt	Medium	
Low	Low	Pt-MPt	Medium	
Low	High	Pt-Pt	Medium	(Wireless Headset)
Low	High	Pt-MPt	High	WiFi/WiMAX Scenarios



Contention-based Protocols - Results

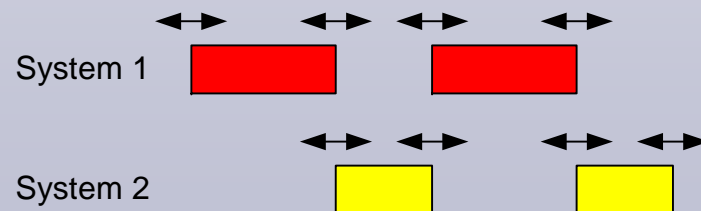


Polite Protocol	Residential WiFi Scenario	Public Space WiFi Scenario
Aloha (an Impolite Protocol)	<ul style="list-style-type: none">• Good performance• Most links work• Those that don't work, fail catastrophically	<ul style="list-style-type: none">• Performance dominated by unresolved contention
CSMA	<ul style="list-style-type: none">• Moderately good• Degrades rapidly with increasing level of penetration	<ul style="list-style-type: none">• Higher throughput than Aloha
TARB (A novel extension to CSMA)	<ul style="list-style-type: none">• Significantly better than CSMA• Degrades more slowly (in relative terms) than CSMA with increasing level of penetration	<ul style="list-style-type: none">• Useful improvement over CSMA

IDC Protocol - Results



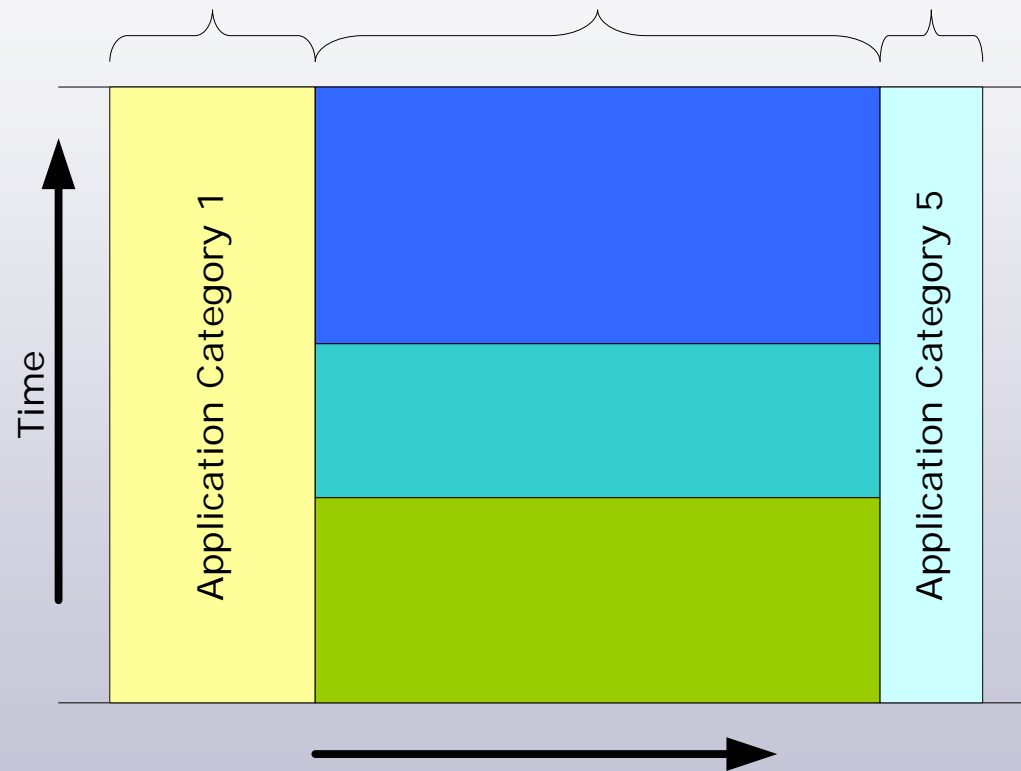
Polite Protocol	Residential WiFi Sharing with WiMAX	Two WiMAX Operators: BS Antennas Facing	Two WiMAX Operators: BS Antennas Aligned
None	With reasonable wall losses – small degradation	High isolation from customer premise's antennas	Low isolation – zero throughput
Intelligent Duty Cycle (IDC) (A novel protocol)	Tends to be unnecessary in this scenario	Tends to be unnecessary in this scenario	Allows time sharing of the radio channel (80-90% efficient)



IDC Principle of Operation



Options for Introducing PPC-spectrum



(IDC = Intelligent Duty Cycle)



LE
Commo

Conclusions



What benefits do Polite Protocols provide?

- Protection against catastrophic interference in areas of congestion
- 'Security of tenure' and incentives for innovation
- Increased spectrum efficiency

Should Polite Protocols be mandated in future LE bands (i.e. PPC-Spectrum)?

- Yes, but possibly only in some application category-specific bands and ideally in a technology neutral manner

