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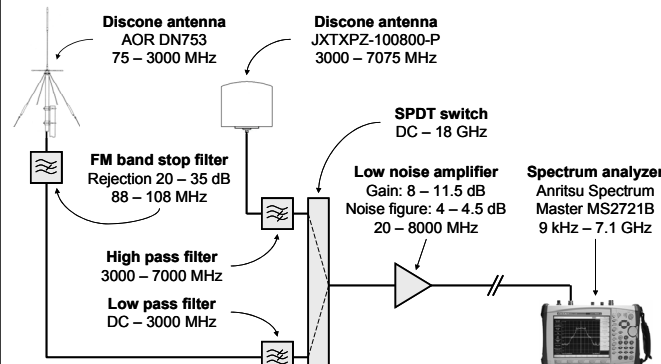
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Motivation and Objectives

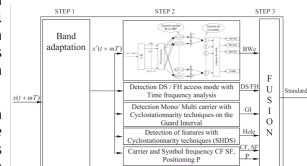
- Dynamic Spectrum Access (DSA) based on the Cognitive Radio (CR) concept has been identified as a promising solution to solve the so-called *spectrum scarcity problem*, i.e. the current conflicts between:
 - Spectrum demand growth.
 - Spectrum underutilisation.
- The basic underlying idea of DSA/CR:
 - To allow unlicensed users to access in an opportunistic and non-interfering manner some licensed bands temporarily unoccupied by licensed users, provided that no harmful interference is caused.
- Before investigating the technical issues of DSA/CR, it becomes necessary to determine the degree to which allocated spectrum bands are spatially and temporally unoccupied in real wireless communication systems.
- The measurement of real network activities:
 - Can provide valuable insights into current spectrum use.
 - Constitutes an important step towards a realistic understanding of dynamic spectrum utilisation.
 - Useful for policy makers to define adequate DSA policies.
 - Useful for the research community in general to identify the most suitable and interesting bands for the future deployment of DSA/CR networks.
- The objective of this study:
 - To perform an extensive, comprehensive and rigorous broadband spectrum measurement campaign.
 - Evaluate and analyse the availability of free spectral resources in terms of frequency, time and space.
 - Identify frequency bands suitable for DSA/CR.
- The campaign relies on a carefully designed measurement equipment and methodology, employed to cover a reasonably wide range of:
 - Frequencies: 75-7075 MHz.
 - Scenarios: urban, sub-urban and rural.
 - Locations: in various indoor and outdoor environments.

Measurement Setup



Blind Standard Recognition Sensor

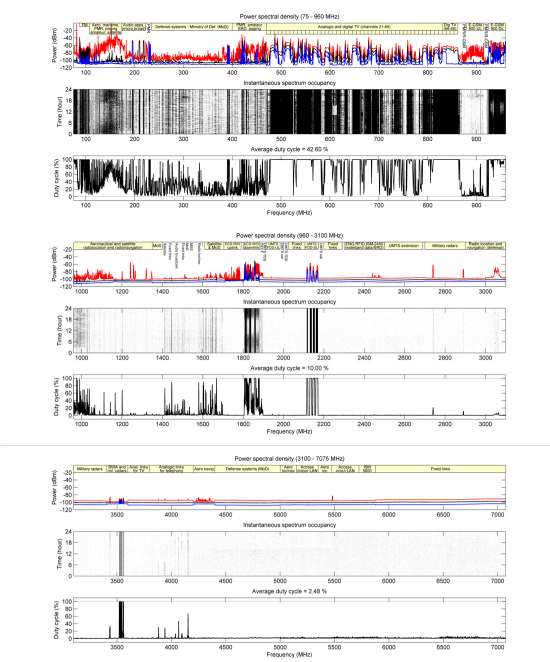
- Empirical measurements can find additional useful practical applications, e.g. evaluation of novel techniques such as the blind standard recognition sensor (BSRS).
- BSRS is a sensor embedded in a CR equipment to enable the identification of many wireless standards without the need to connect to any network.
- STEP 1: Reduction of the bandwidth to be analyzed to non-zero regions.
- STEP 2: Analysis of the signal characteristics with sensors:
 - Bandwidth recognition sensor.
 - Single/multi-carrier detection sensor.
 - Frequency hopping/direct sequence detection sensor.
- STEP 3: Fusion of information from all sensors to decide the actual standard.



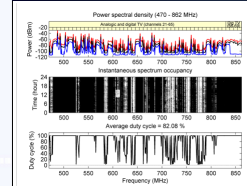
Spectrum Analyser Configuration

Parameter	Value	Parameter	Value
Frequency range	75 – 7075 MHz	Reference level	- 20 dBm
Frequency span	45 – 600 MHz (25 bands)	Scale	10 dB/division
Frequency bin	82 – 1091 kHz	Measurement period	24 hours
Resolution/video bandwidth (RBW/VBW)	10 kHz / 10 kHz	Sweep time	1.5 – 17.2 s
Detection type	Average (RMS)	Decision threshold	Probability of false alarm equal to 1%

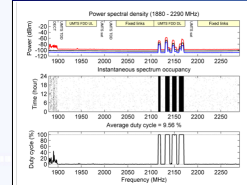
General Overview of Spectrum Occupancy



TV bands



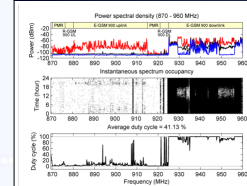
UMTS



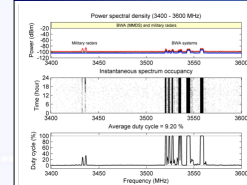
Occupancy Statistics

Freq (MHz)	Average duty cycle (%)	
75-1000	42.00	31.02
1000-2000	13.30	
2000-3000	3.73	
3000-4000	4.01	
4000-5000	1.63	2.75
5000-6000	1.98	
6000-7075	1.78	

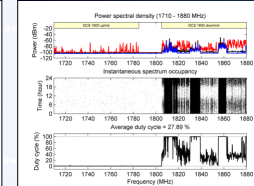
E-GSM 900



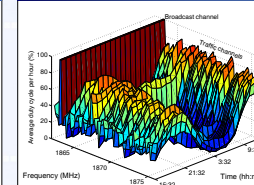
BWA



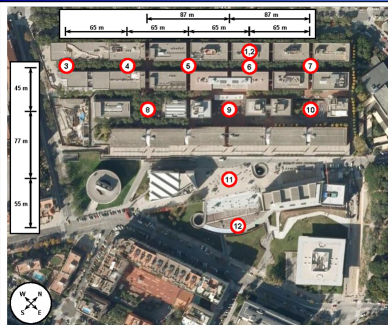
DCS 1800



DCS 1800



Measurement Locations



Location	Environment
1	Outdoor high point (building roof)
2	Indoor (building room)
3 - 7	Outdoor at ground level in narrow streets
8 - 10	Outdoor at ground level between buildings
11 - 12	Outdoor at ground level in open areas