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The IET Seminar on Cognitive Radio and Software Defined Radios: Technologies and Techniques

Distributed Spectrum Detection Algorithms for Cognitive Radio

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University of BRISTOL

Background and Introduction

- For Cognitive Radio networks
  - There is a need to identify the White Space in the spectrum
  - The capabilities of the terminals could allow them to perform spectrum sensing to achieve this
  - The sensing task could be implemented more accurately/efficiently by teaming of terminals
- This technique introduced in this work
  - Decides whether a single channel is occupied
  - Shares results between CR nodes to improve performance

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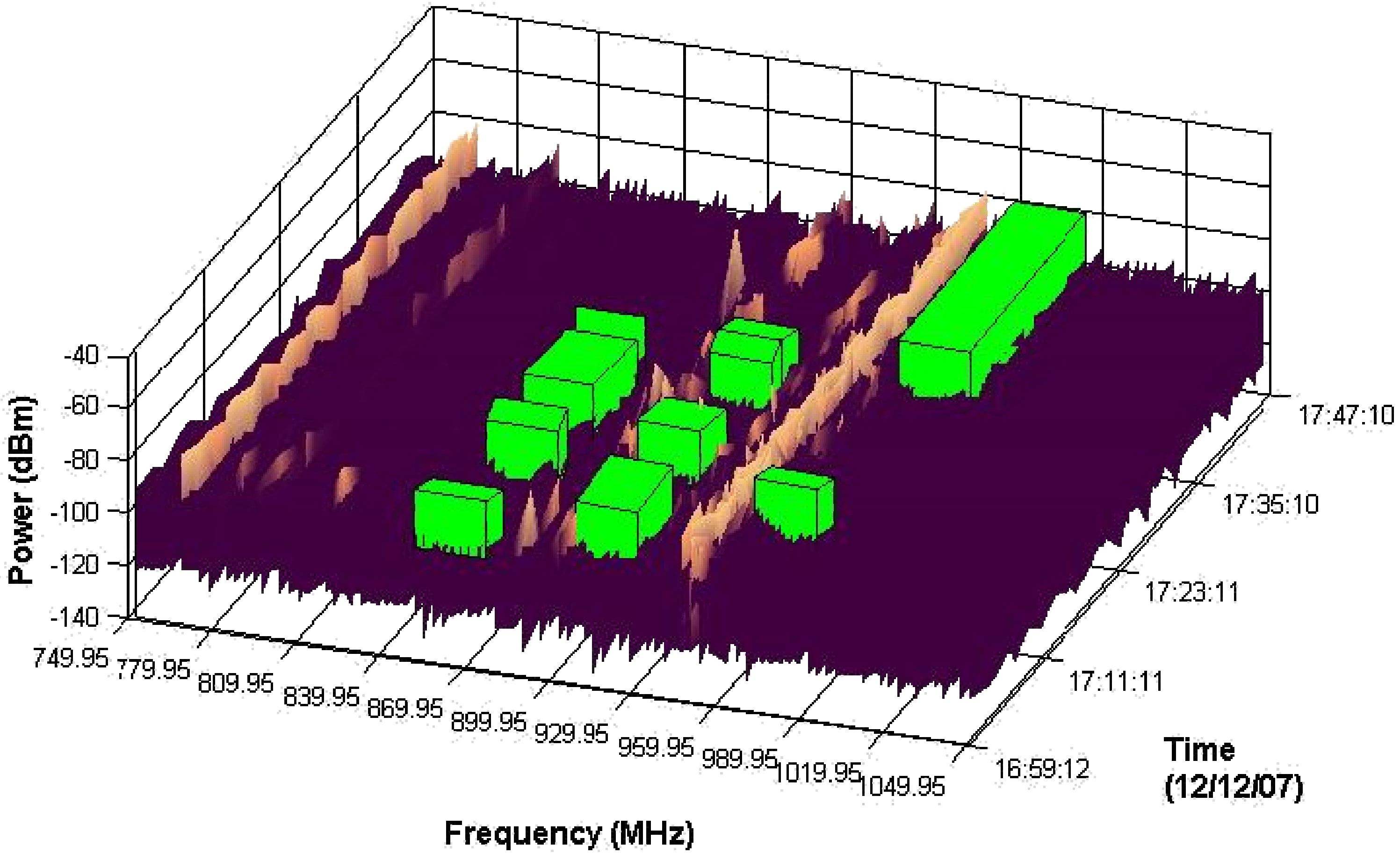
Background and Introduction

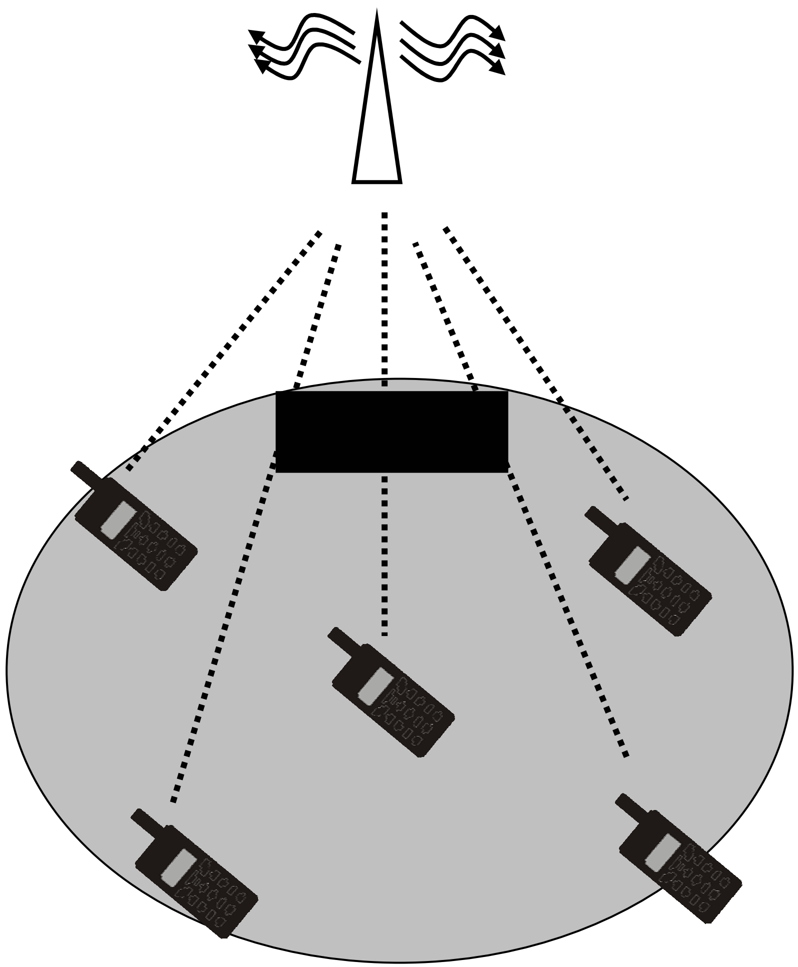


Spectrum Occupancy and White Space

Spectrum Sensing Challenges

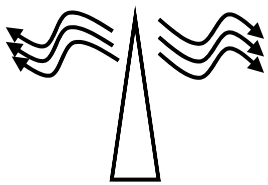
- Maintaining an up to date picture of spectrum occupancy is difficult
  - Transmitters may be agile
  - Path loss may suffer temporal changes between transmitter and sensor
  - Transmitter may be temporarily hidden due to shadowing
- Getting it wrong
  - False detection: lost re-use opportunity
  - Missed transmission: potential interference

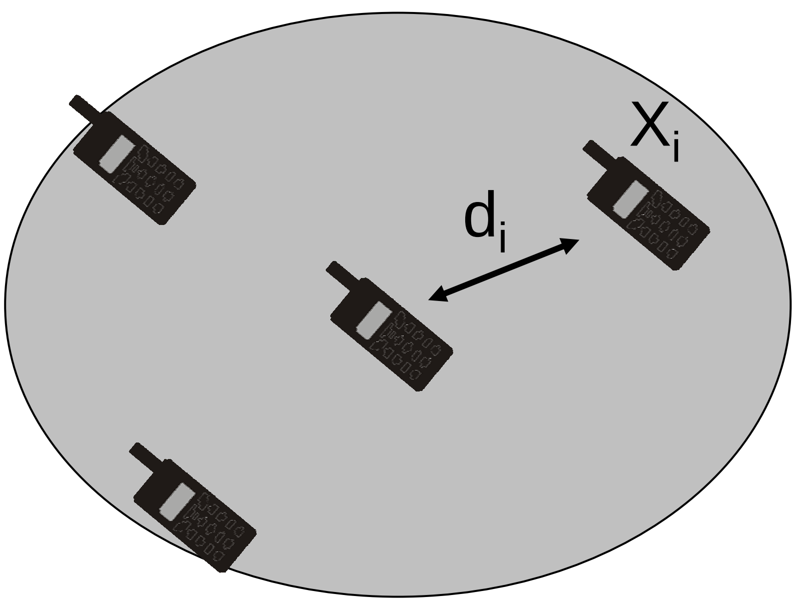
Distributed Sensing



Distributed Sensing

$$Q = \begin{bmatrix} X_1 & \dots & X_N \end{bmatrix} \begin{bmatrix} D_1 \\ \vdots \\ D_N \end{bmatrix} + \begin{bmatrix} Y_1 & \dots & Y_M \end{bmatrix} \begin{bmatrix} T_1 \\ \vdots \\ T_M \end{bmatrix} + S \times Z$$





M	Number of previous results/time-steps included
N	Number of neighbouring nodes included
X_n	Sensing result from neighbouring node *n* [+1,-1]
D_n	Weighting factor according to distance applied to neighbouring node *n*
Y_m	Result from *m* time-steps previously
T_m	Weighting applied to previous result *m*
S	Weighting applied to the node's own result
Z	Node's own result [+1,-1]
Q	Final result [positive, negative]

Eg. $D_i = 1000/d_i$ $D_i <= 1$

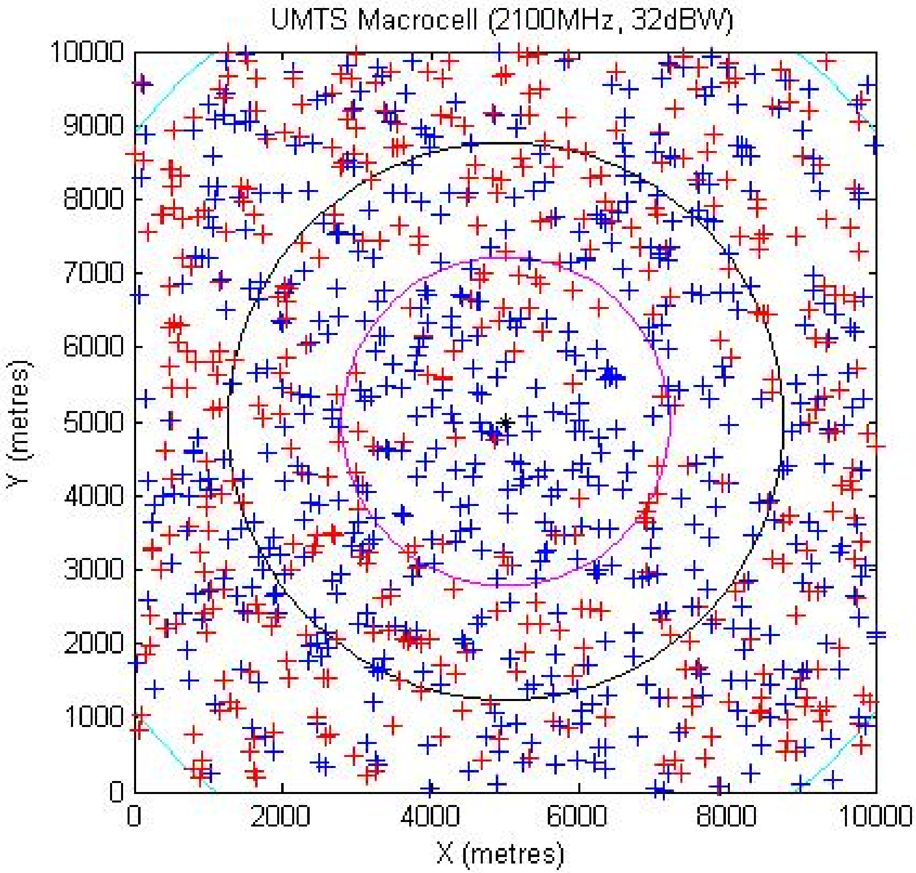
Weighted Algorithm

- Various Trade-offs exist
  - How many neighbour nodes to include?
  - How to weight the importance of neighbour nodes' decisions?
  - How to weight the importance of the own node's decision
  - How to weight historic results
- Factors
  - Extra control traffic required
  - Accuracy of results and false-positives

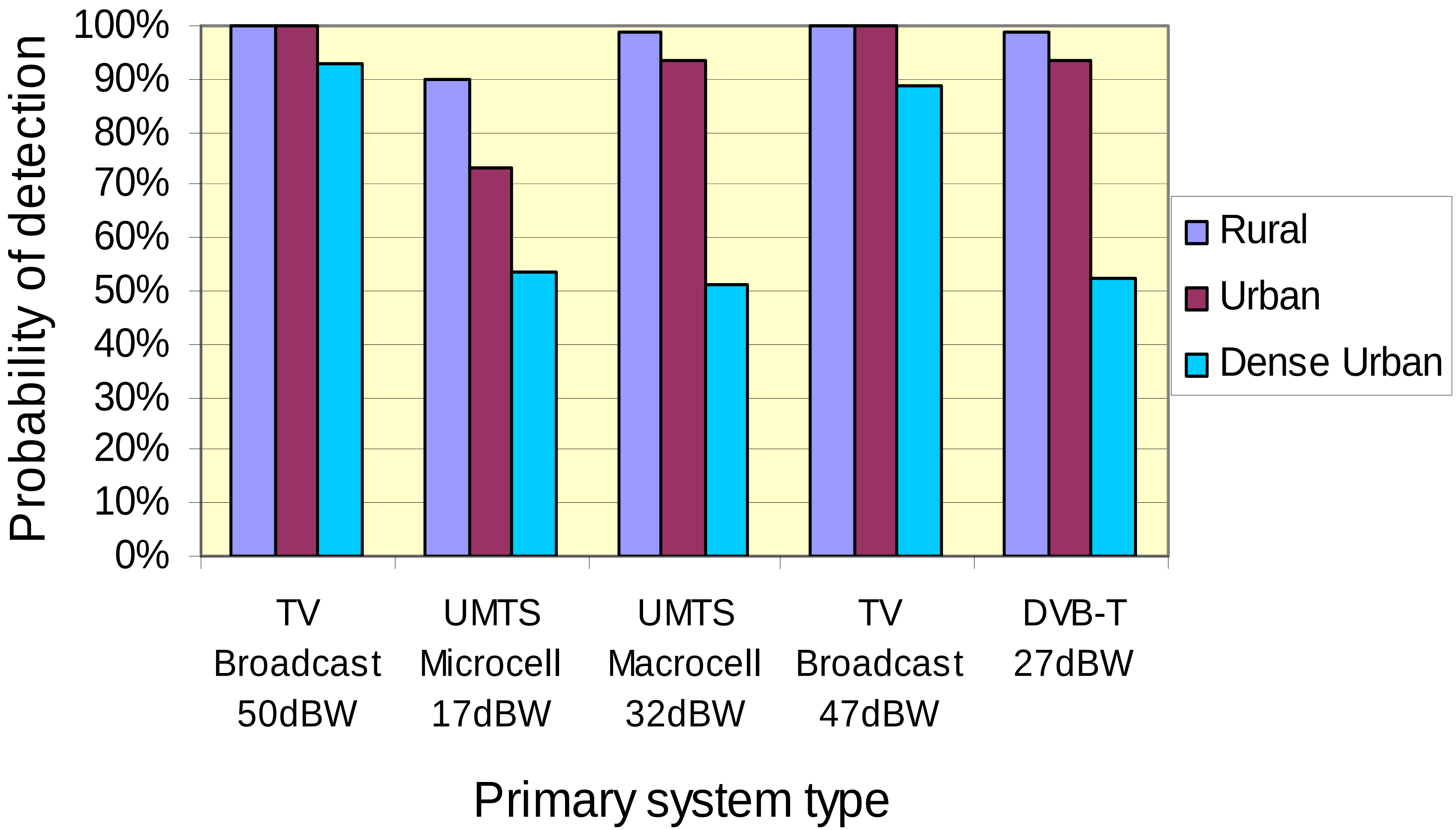
Simulations

- MATLAB simulations to test algorithm performance
  - Sensor nodes deployed randomly
  - Aim is to test the probability of detecting a transmission
  - Compare single node vs distributed algorithm
- 5 Different transmitter types to detect
  - Distinguished by transmitter power
- 3 scenarios
  - Simulation area
  - Path loss exponent
  - Shadowing variance

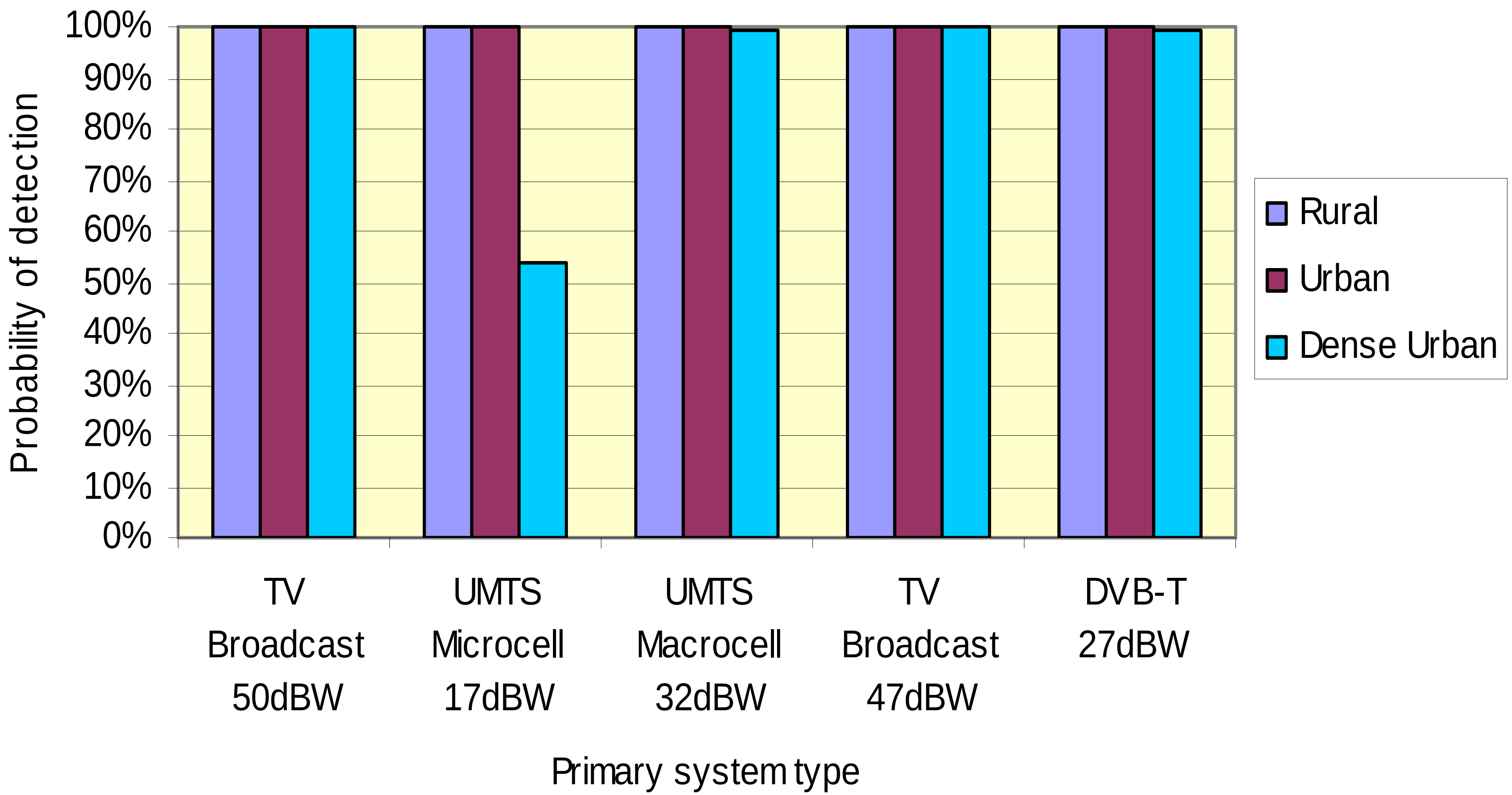
Simulations



Performance – Single Node Sensing



Performance – With Distributed Detection



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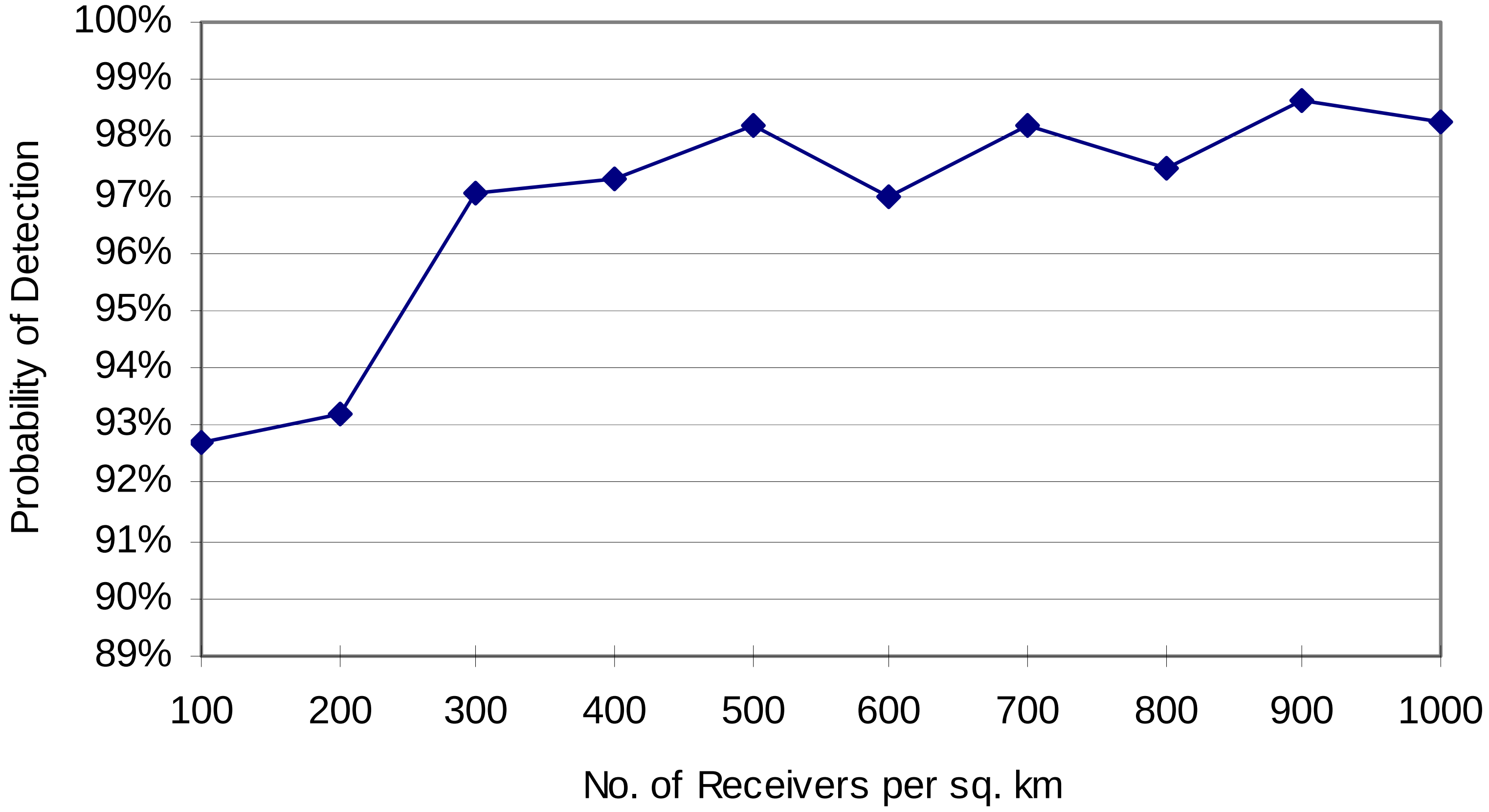
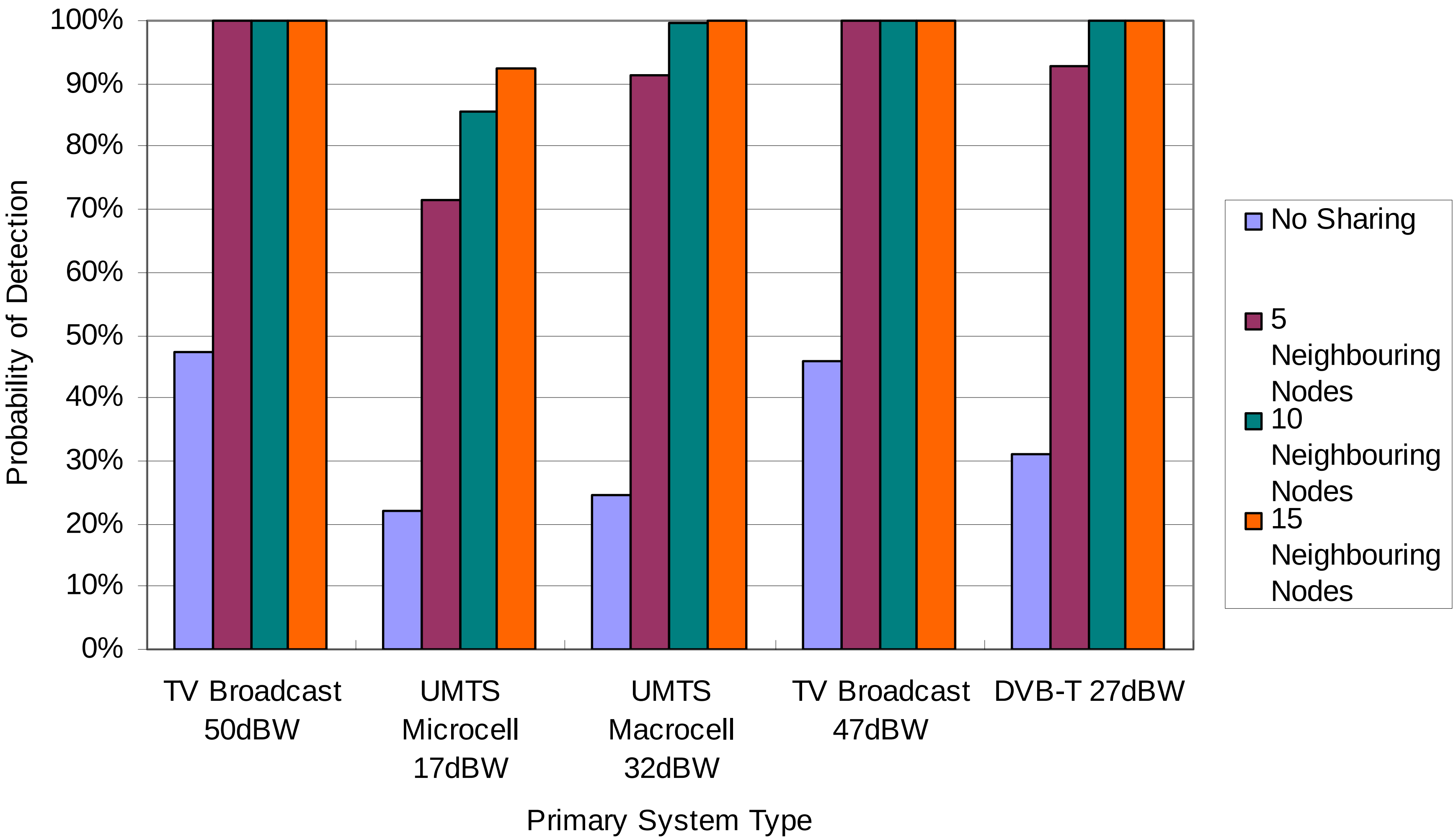
Sensitivity – Node Density

- Dense Urban Scenario – 1km^2



Sensitivity – Number of Neighbours



Conclusions

- Sharing of single channel sensing information
  - Can greatly improve detection accuracy
  - >99% accuracy has been shown in these simulations
  - Not so good for lower power transmissions in highly shadowed propagation environments
- Applications and further work
  - Allocation of sensing task for multiple channels
  - WiMAX bandsharing with swept radar
  - Real-time updating
  - Spectrum Access

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- Thank you for your attention