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

Distributed Spectrum Detection Algorithms for Cognitive Radio

T.J. Harrold, P.C. Faris and M.A. Beach

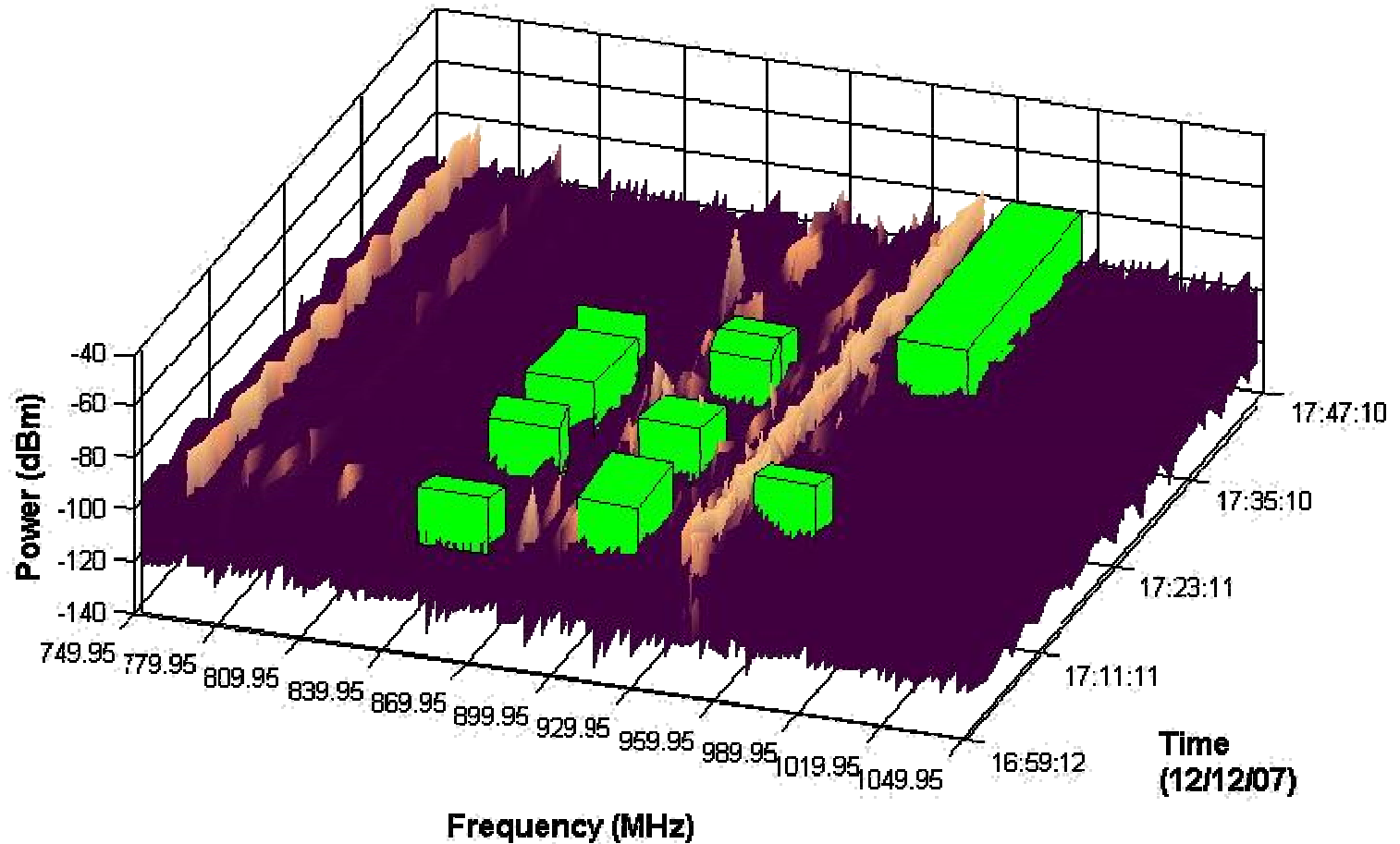
Thursday 18th September 2008



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

Background and Introduction

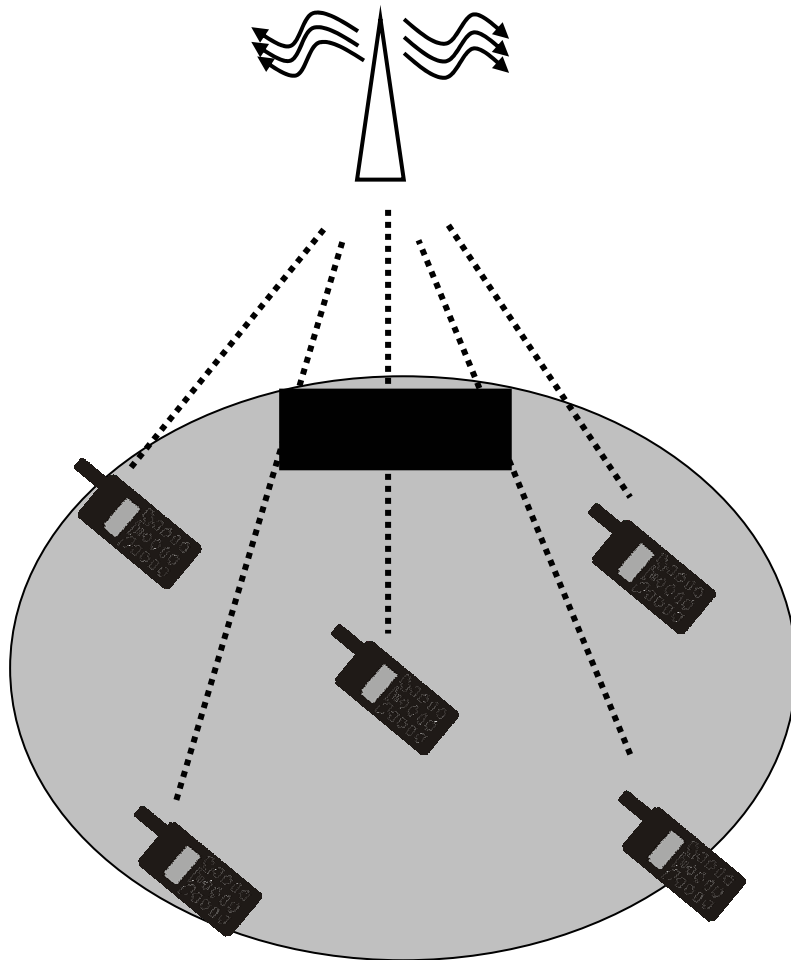


Spectrum Occupancy and White Space

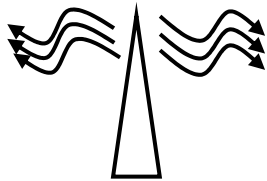
Spectrum Sensing Challenges

- 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

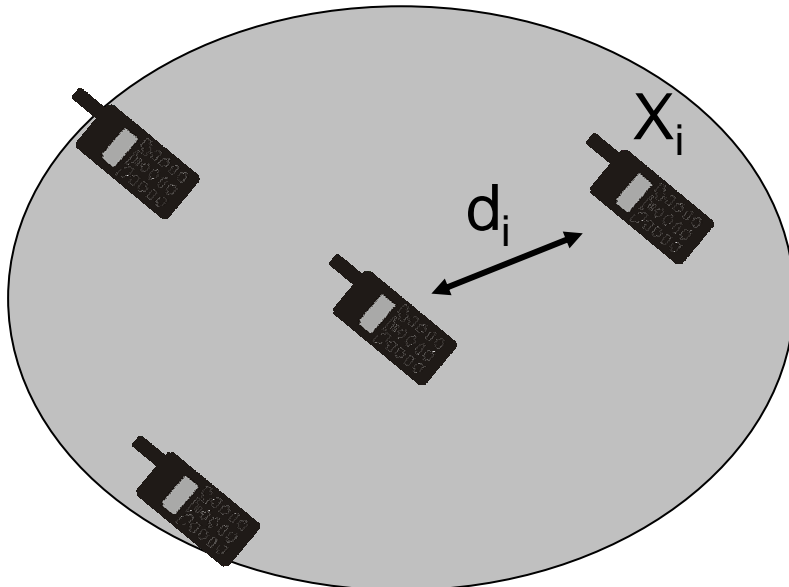
Distributed Sensing



Distributed Sensing



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



M	Number of previous results/time-steps included
N	Number of neighbouring nodes included
X_n	Sensing result from neighbouring node n [+1,-1] Eg. $D_i = 1000/d_i$, $D_i \leq 1$
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]

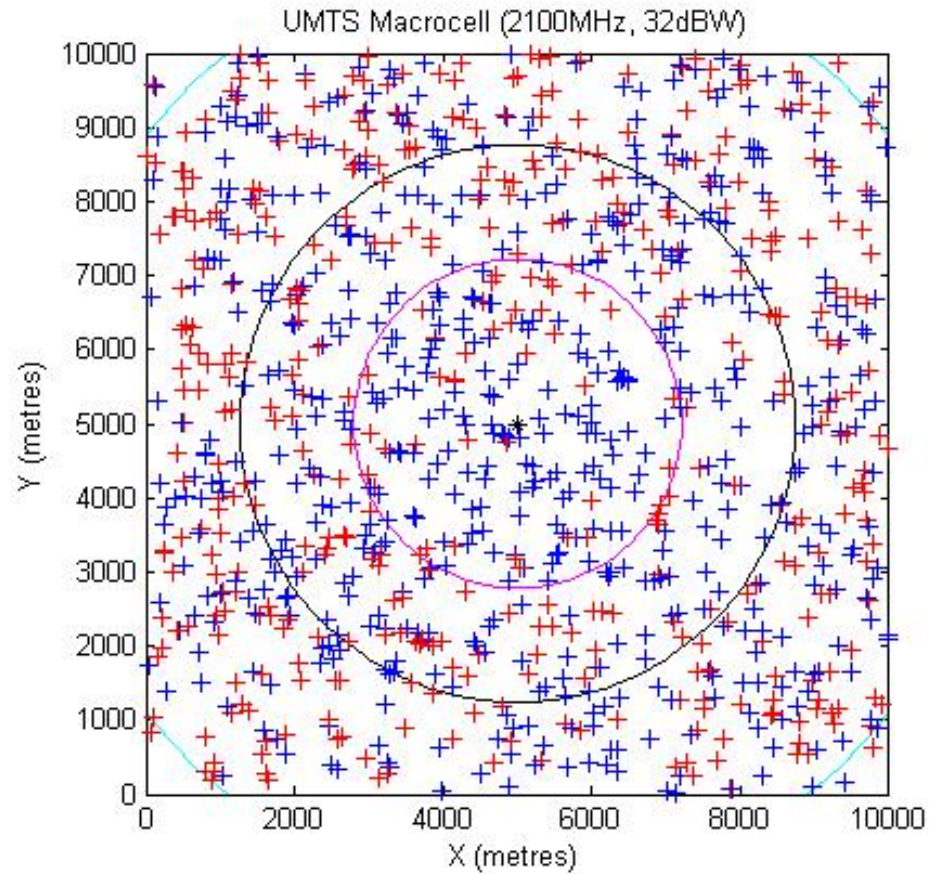
Weighted Algorithm

- 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

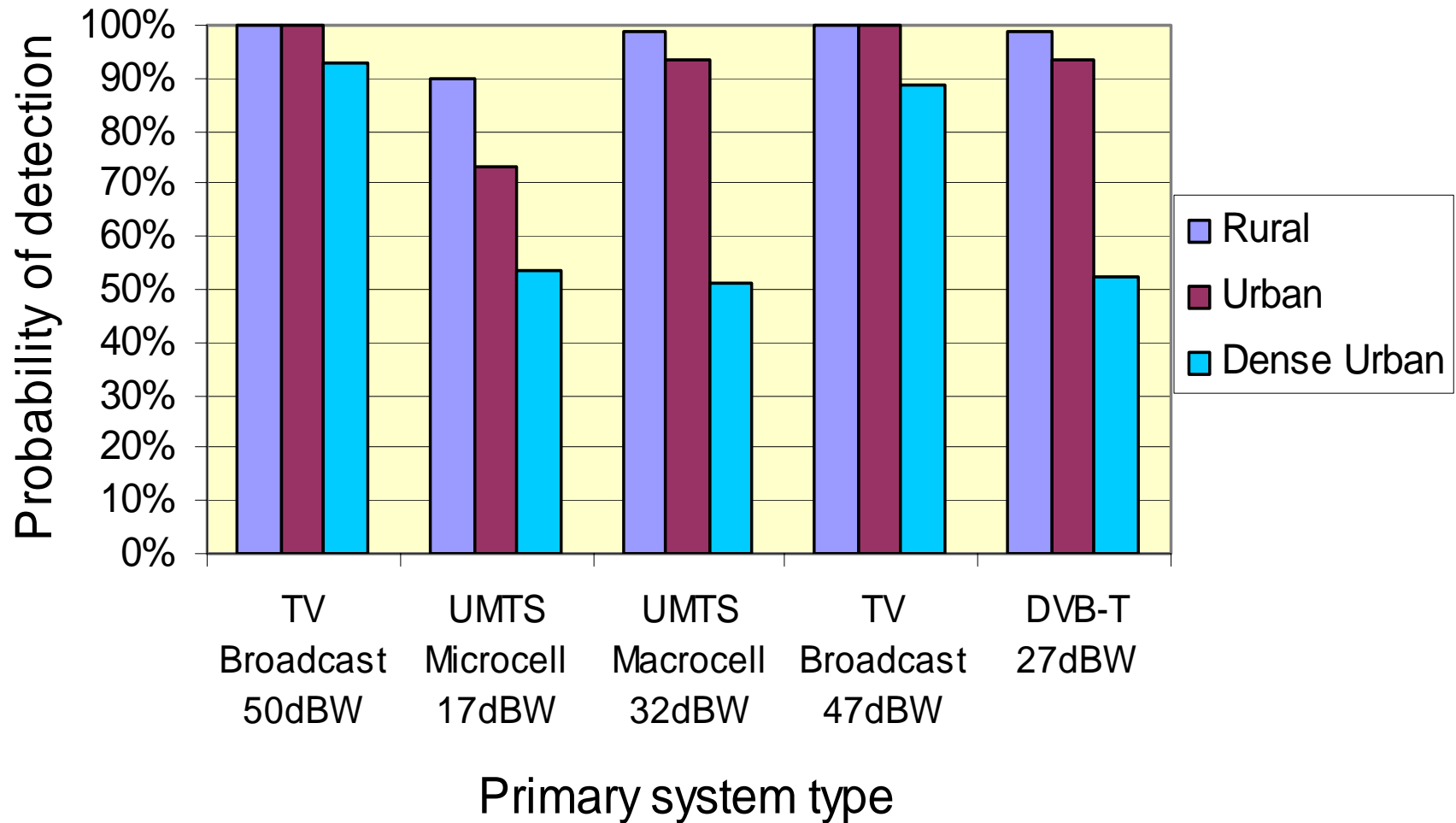
Simulations

- 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

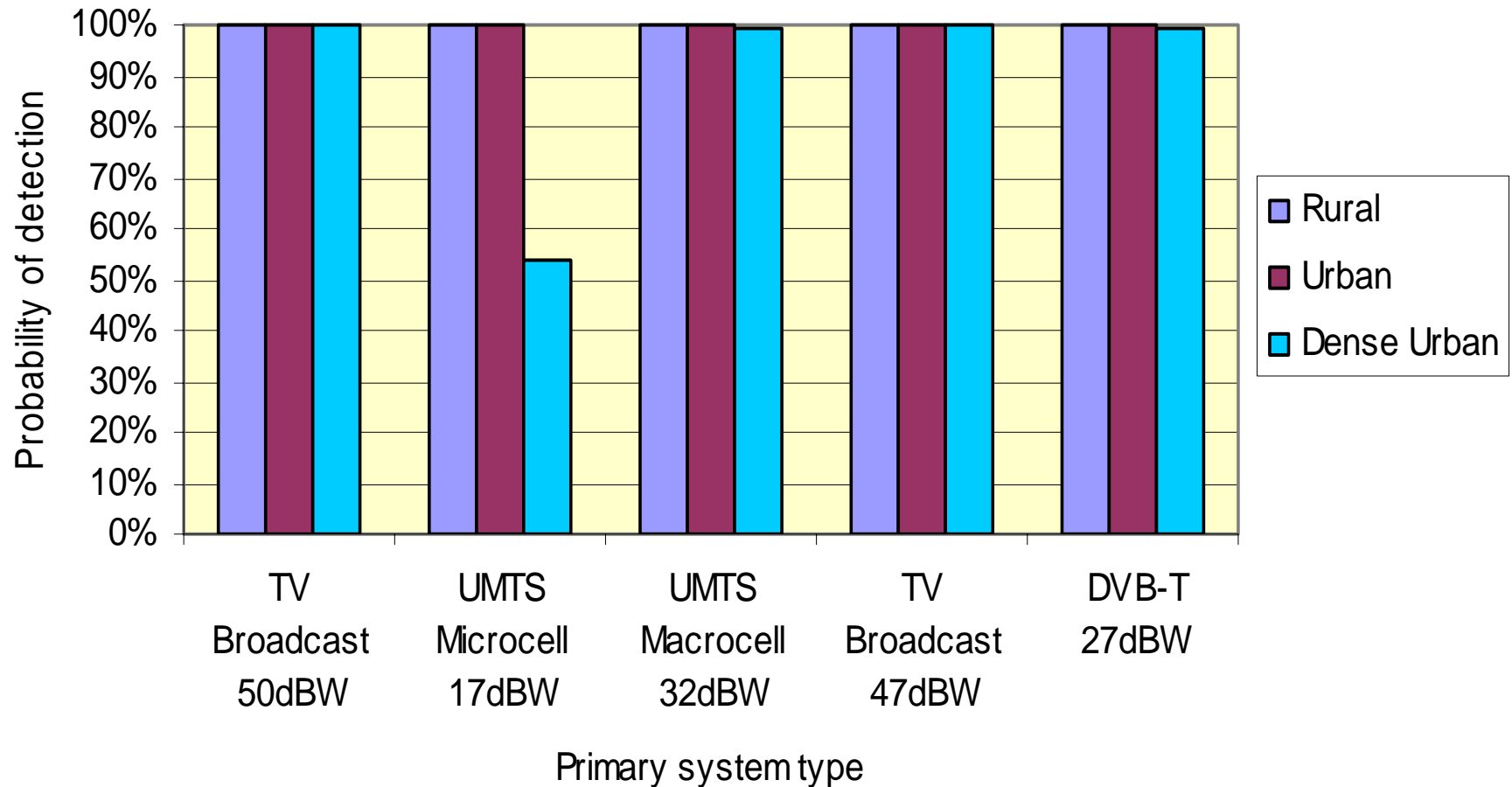
Simulations



Performance – Single Node Sensing

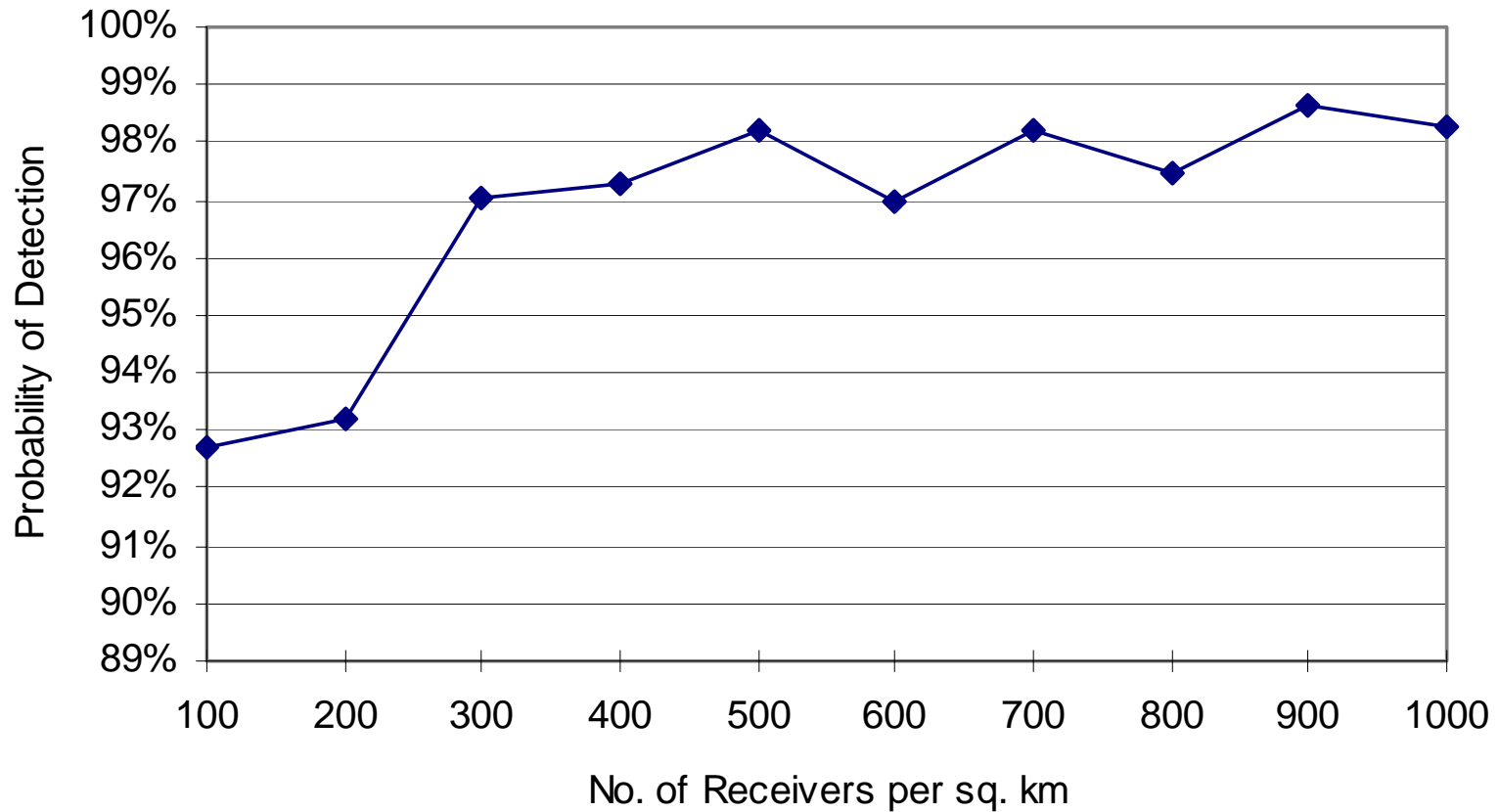


Performance – With Distributed Detection

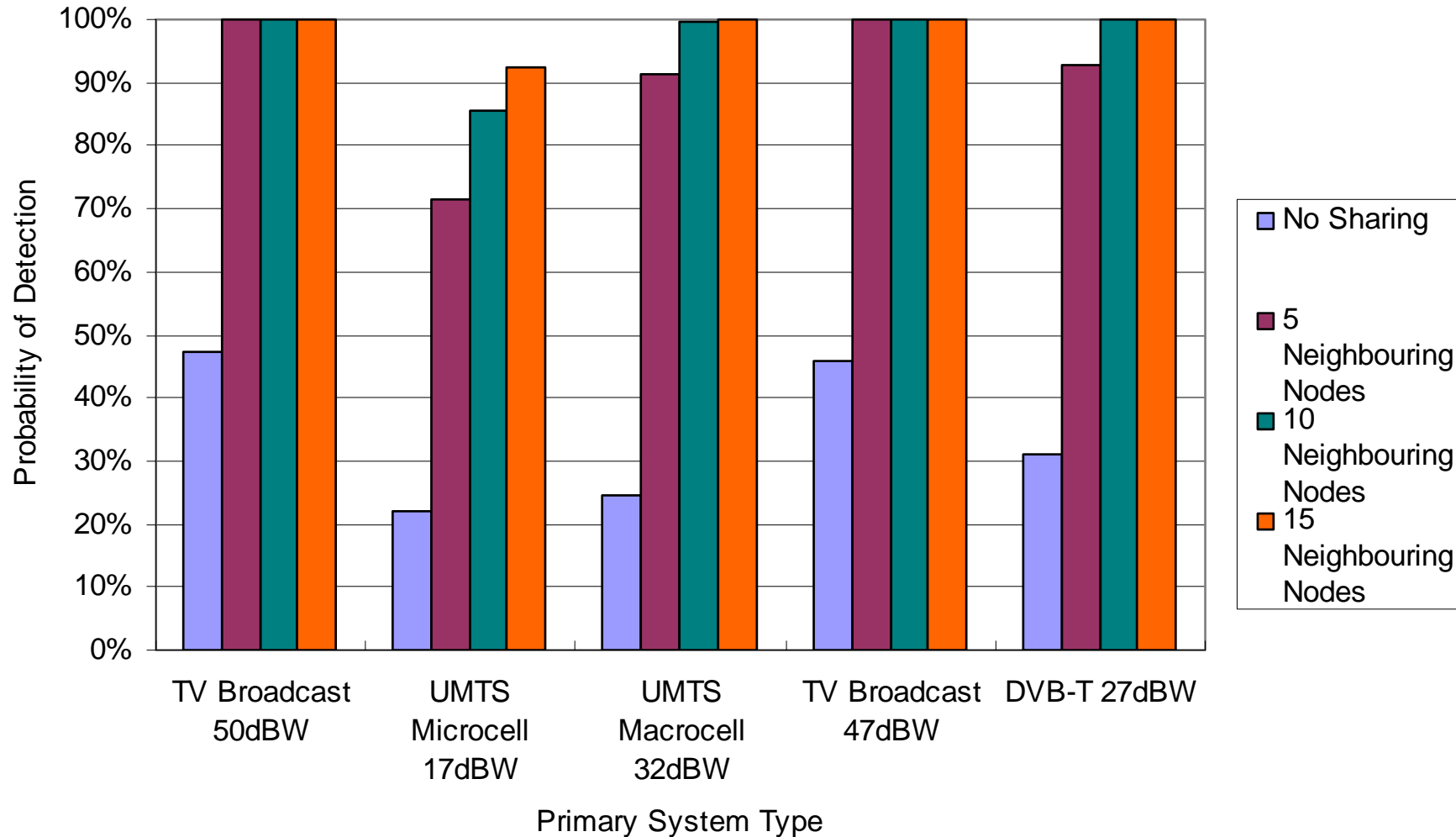


Sensitivity – Node Density

- Dense Urban Scenario – 1km²



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

- Thank you for your attention