Research Consortium in Speckled Computing

Channel Estimation for Specknet

Faisal Darbari

Supervised by

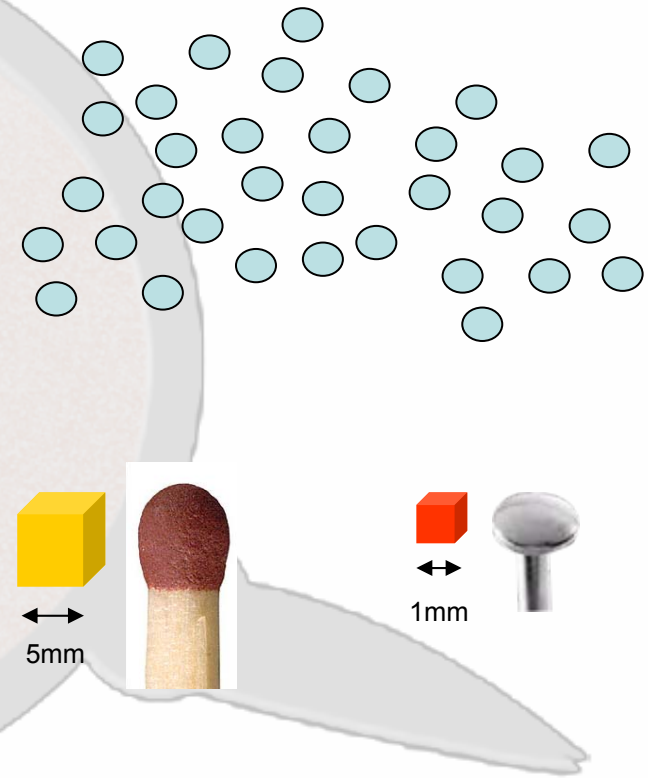
Professor Robert Stewart and Dr Ian Glover

University of Strathclyde

faisal@eee.strath.ac.uk

Introduction and Motivation

- Power Limitation
- Channel Model
  - Loss in Power
  - Material Dependence
  - Fading Model
  - Effect of Interference
  - SIR and BER
- Physical Aspects
  - Modulation
  - Frame Size
  - Encoding Schemes
  - Data Rate
  - Regions of Operations

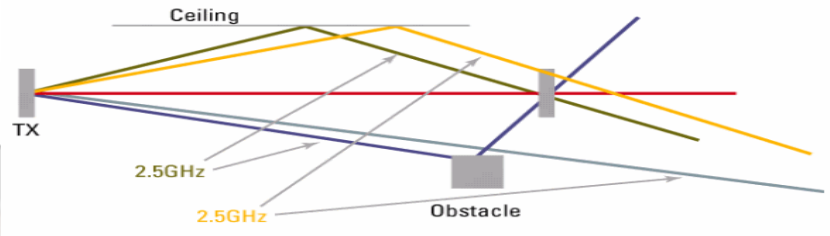


Sequence of Presentation

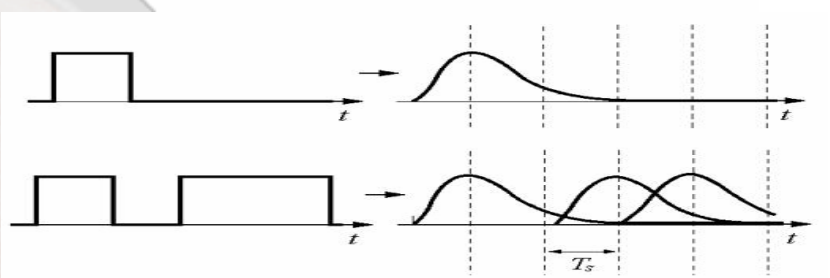
- Channel Characterization and Proposed Model
- Empirical Measurements
- Physical Layer Design
- Conclusion and Future Work

Channel Modelling

- Multipath



- Inter-symbol Interference (ISI)



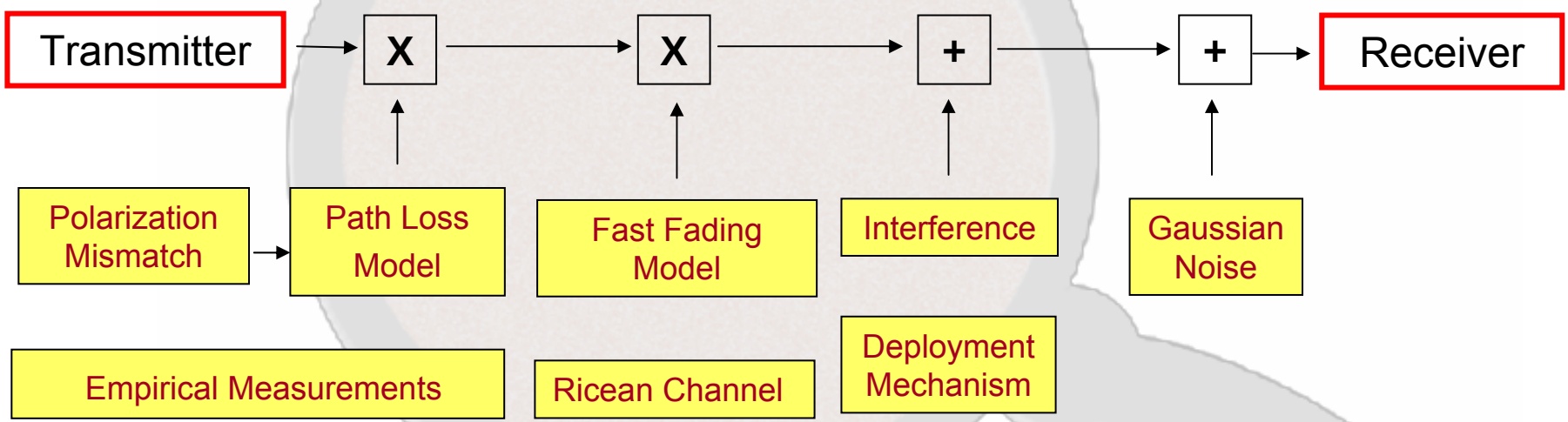
- Path Delay Sufficient to Cause ISI will Carry Negligible Power

  (Difference in FSPL at 10cm and 30m is -57 dB)

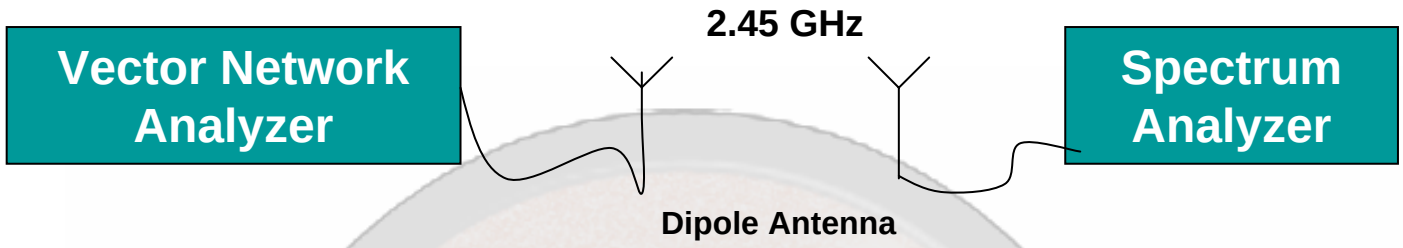
- Narrow Band Channel Model

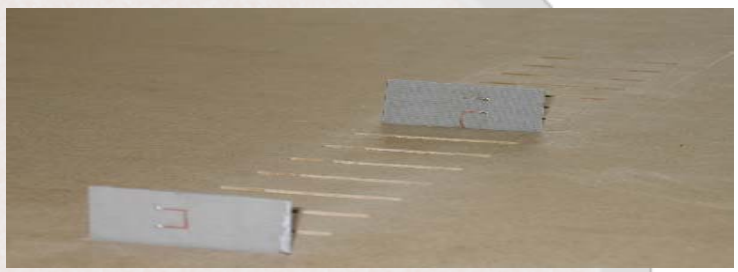
Proposed Model

- Narrow Band Channel Model



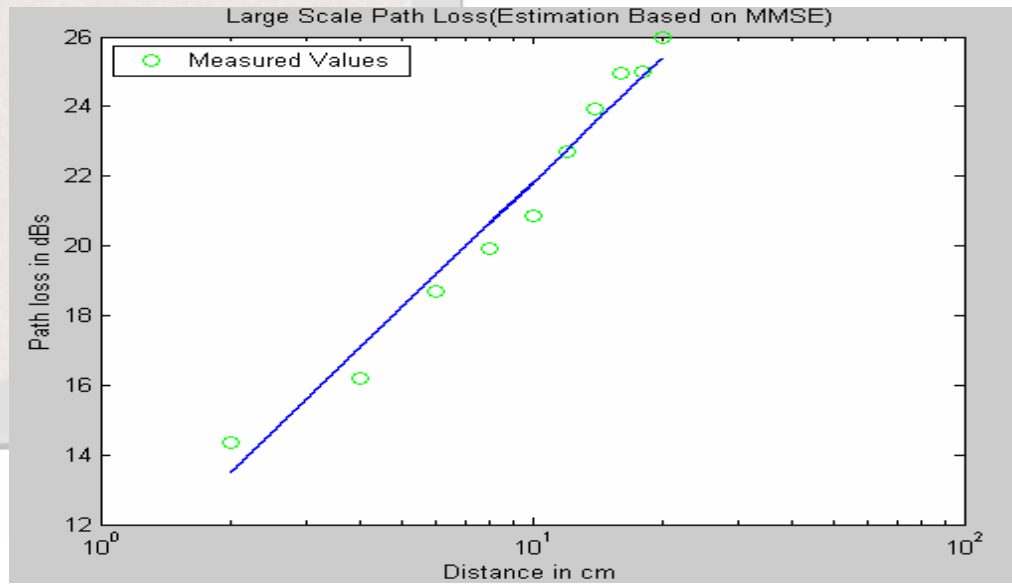
Path Loss Measurements (LOS and NLOS)



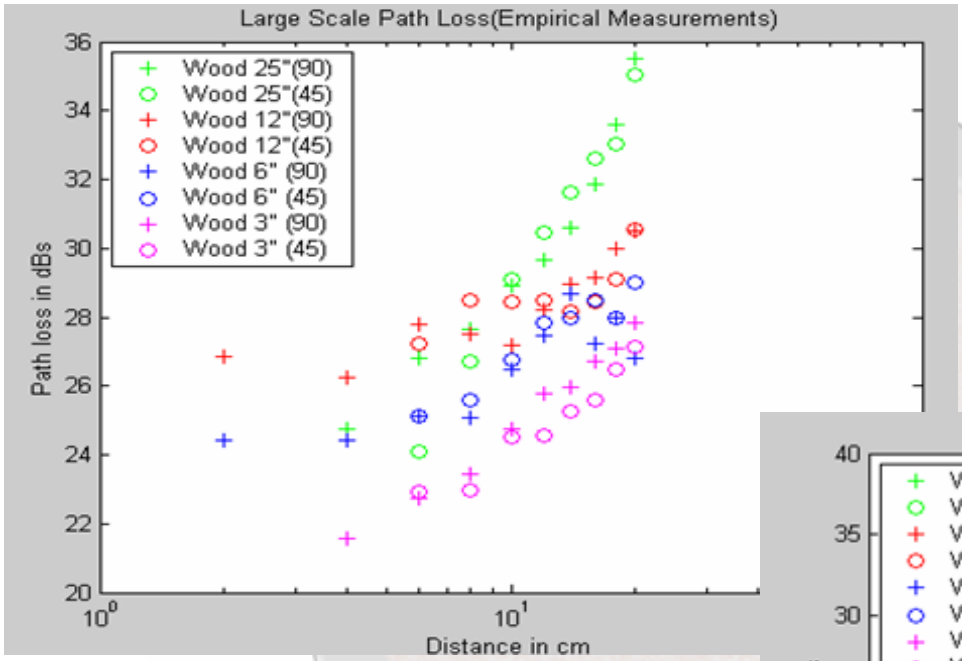


- $L_{dB} = K + n10\log_{10} R_{cm}$
- **Path Loss Exponent & Received SNR (MMSE)**

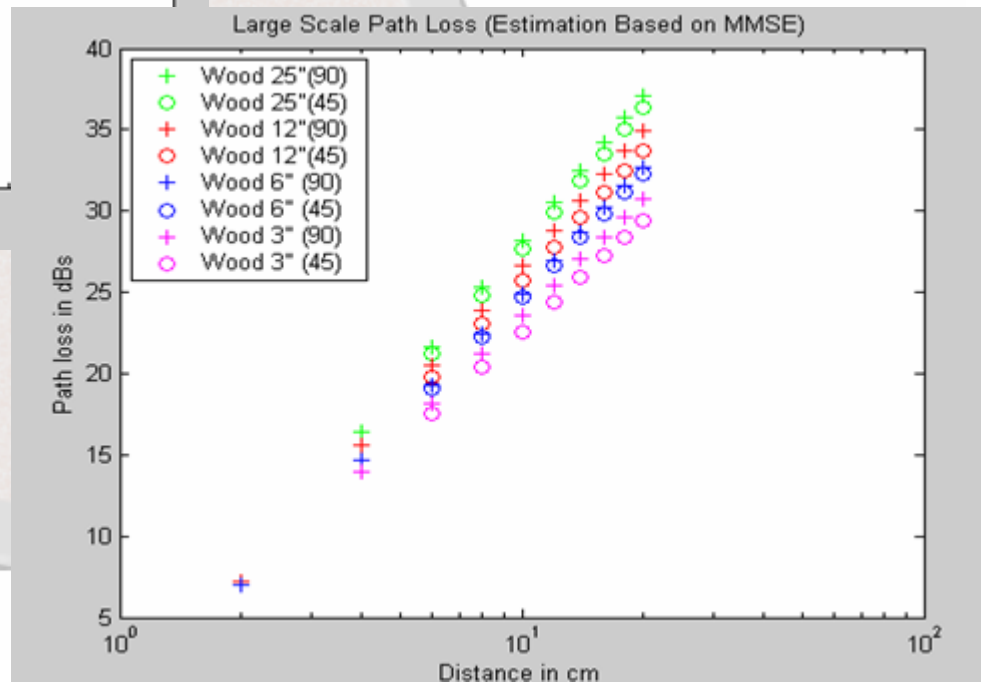
K	n
13.5 dBm	2.11



Path Loss Measurements



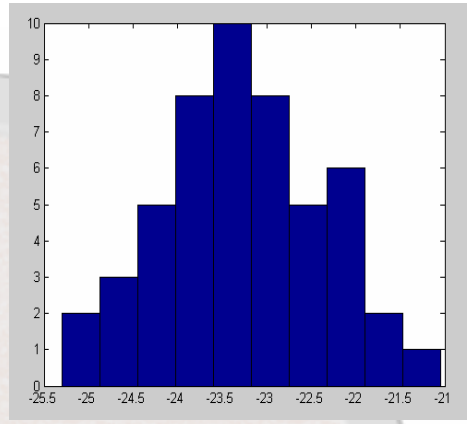
- **Metal**
- **Wood**
- **Plastic**
- **Human Body**

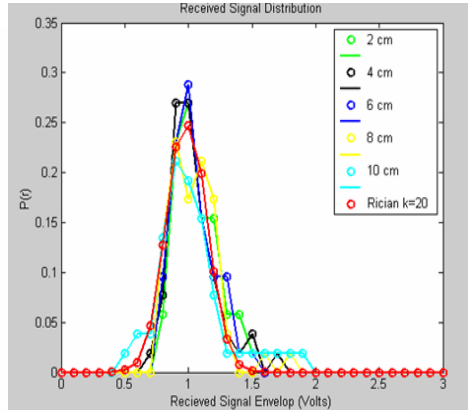


Path Loss Exponent [n]
Varies between: 2.25 & 3.5

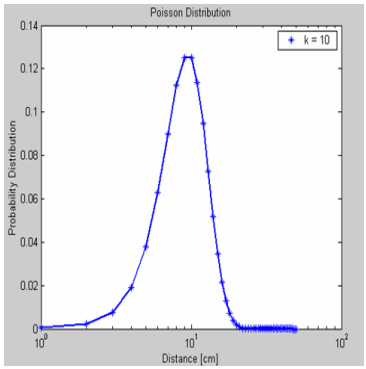
Fading Distribution

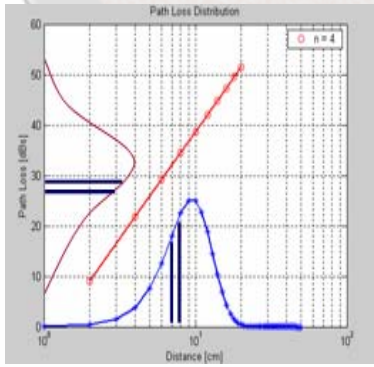
- Statistical Modelling of the Channel
- Ricean Channel (k = 20)

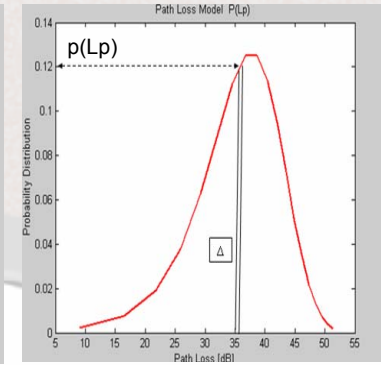


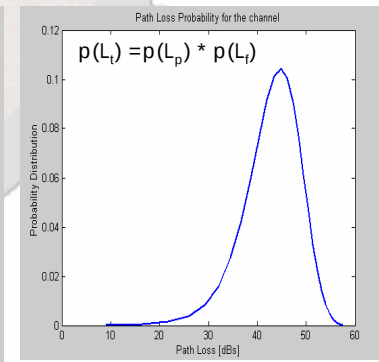


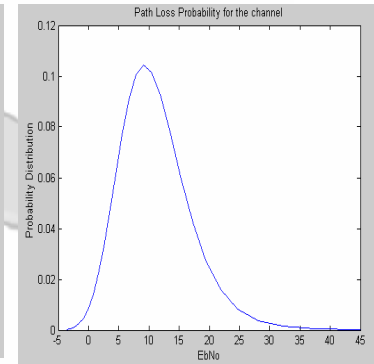
Transformation of Random Variables



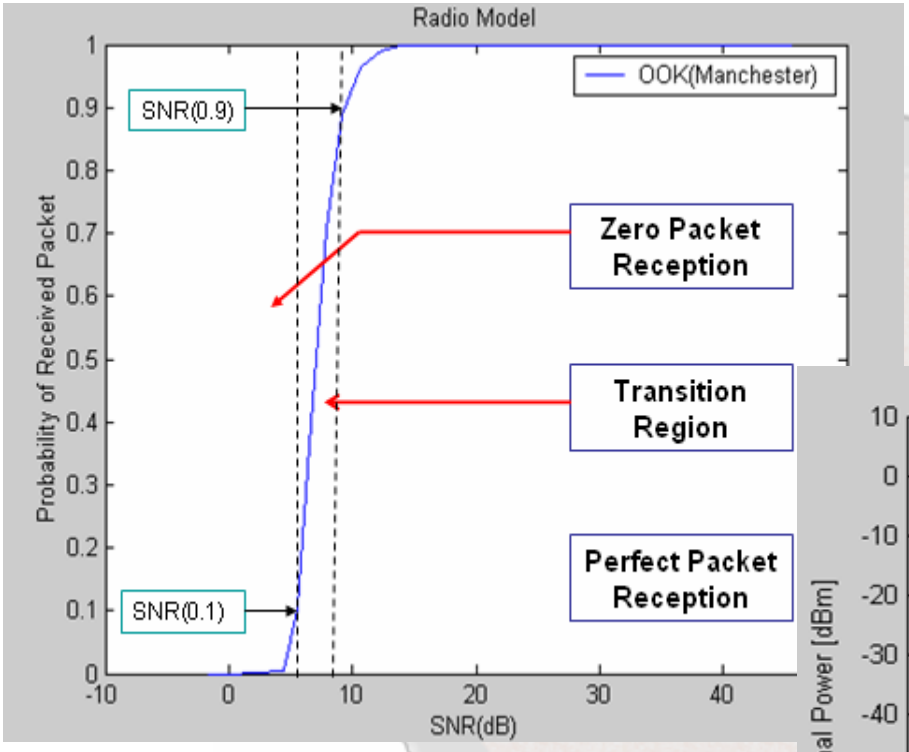


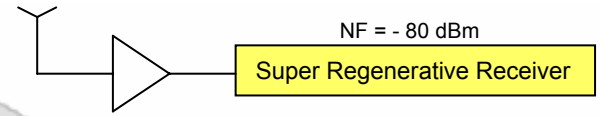




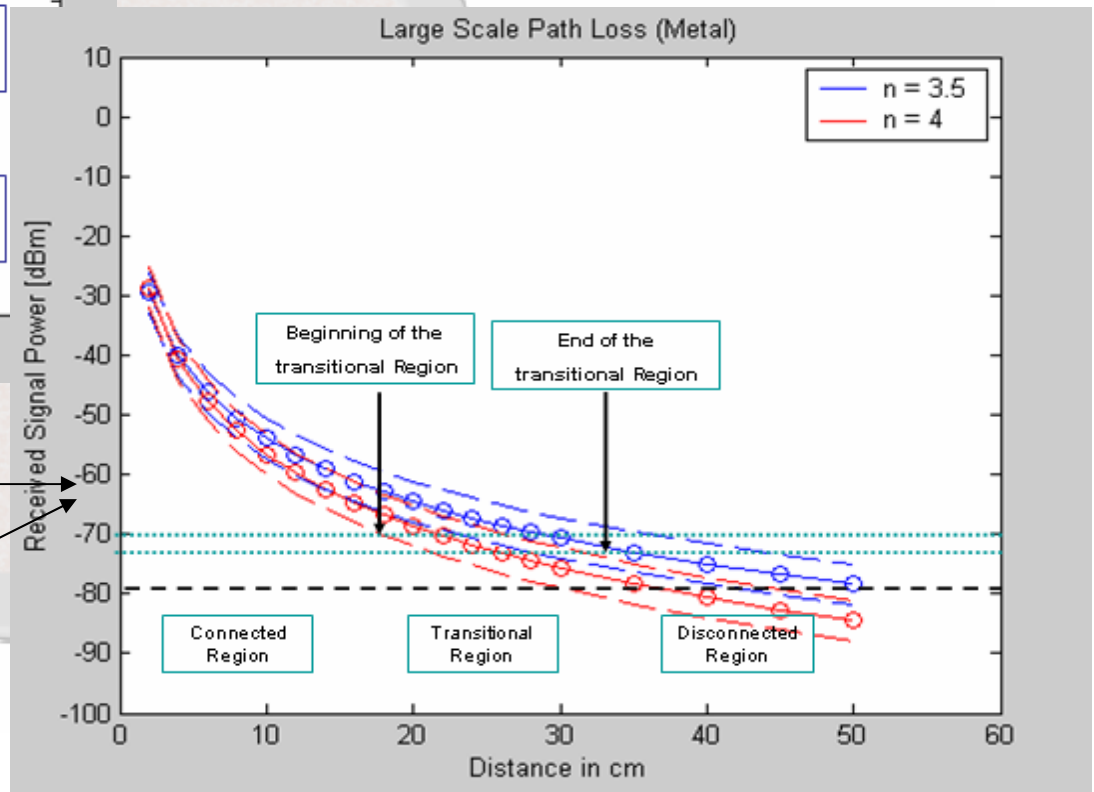


Regions of Operation in Wireless System





Receiver Architecture



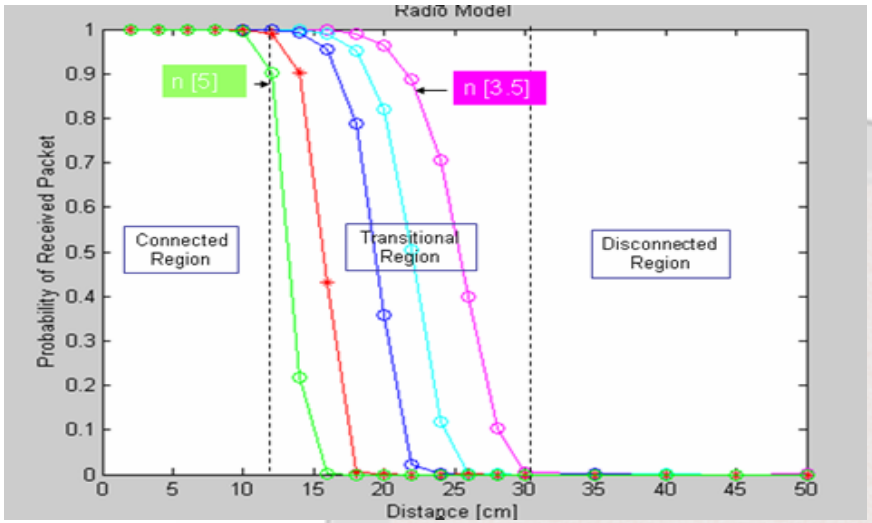
Design Parameters

- Modulation Scheme
- Frame Size
- Encoding Scheme
- Receiving Filter
- Environment (Path Loss)

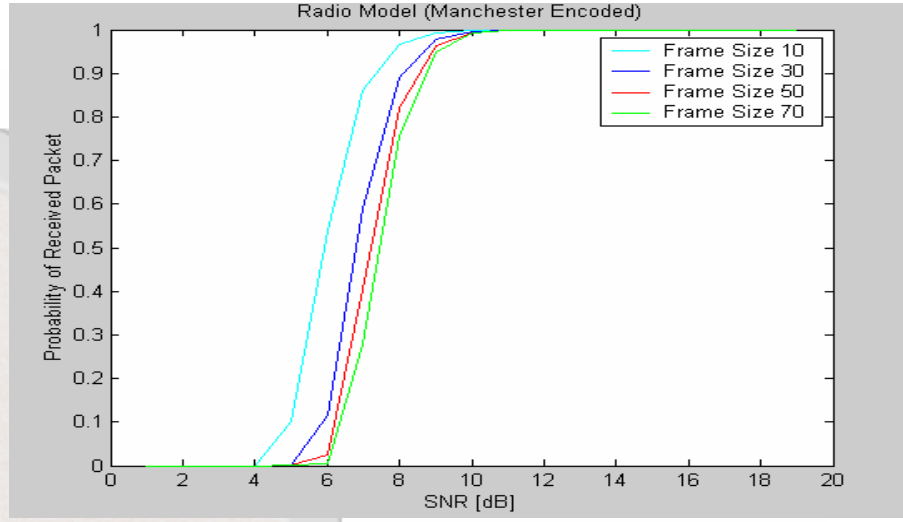
$P_n + Y_u$

$P_n + Y_l$

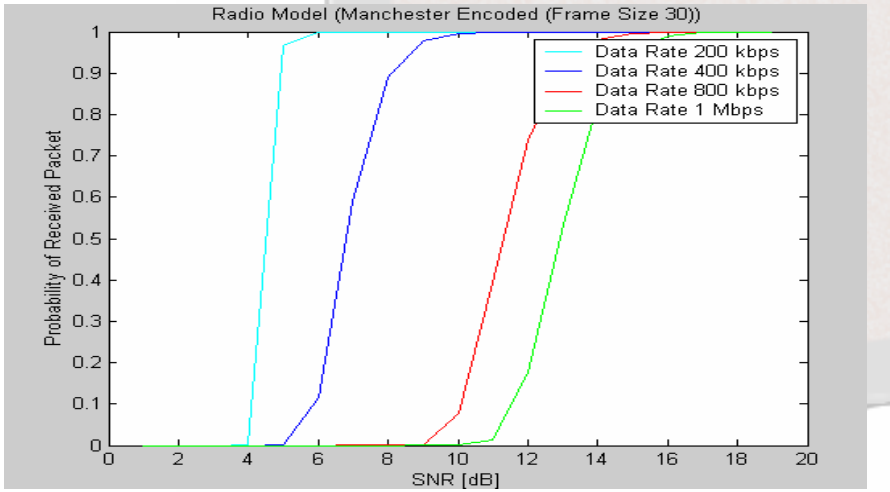
Effect of Frame Size and Data Rate



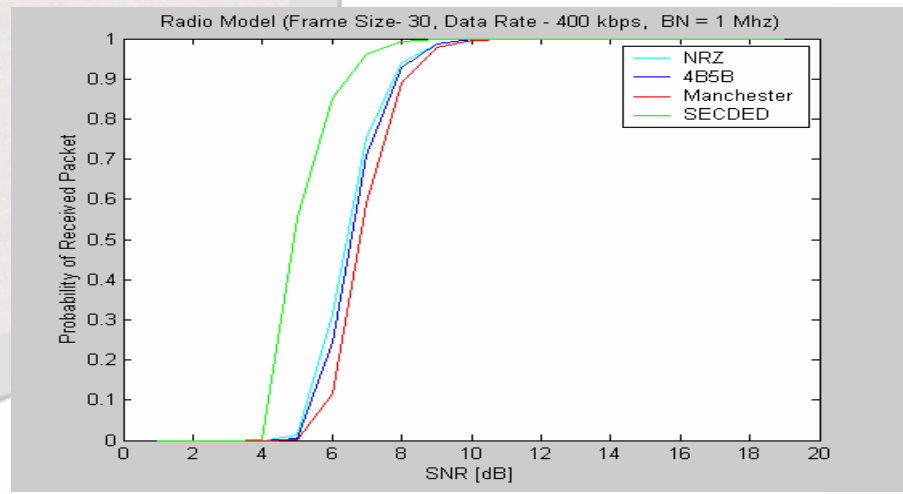
Effect due to Path loss [n]



Effect due to Frame Size



Effect due to Data Rate

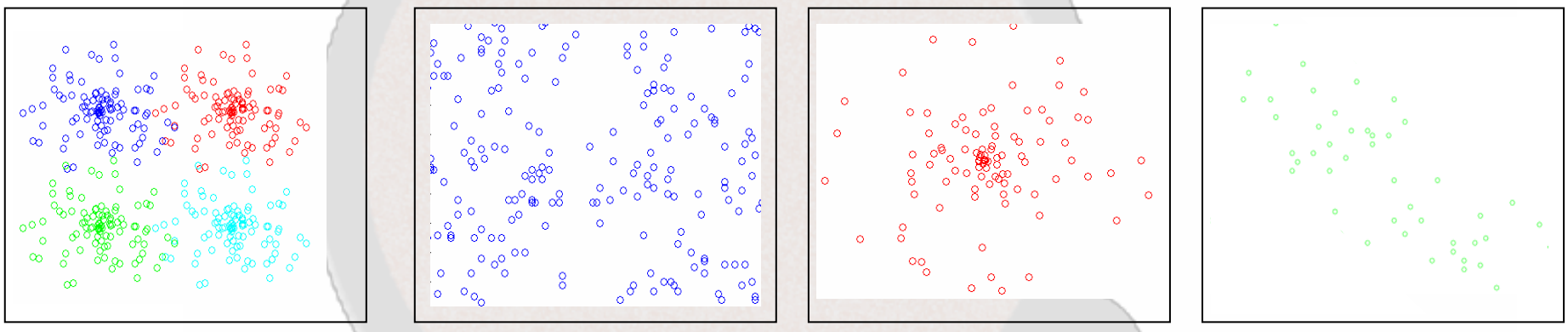


Effect due to Encoding Scheme

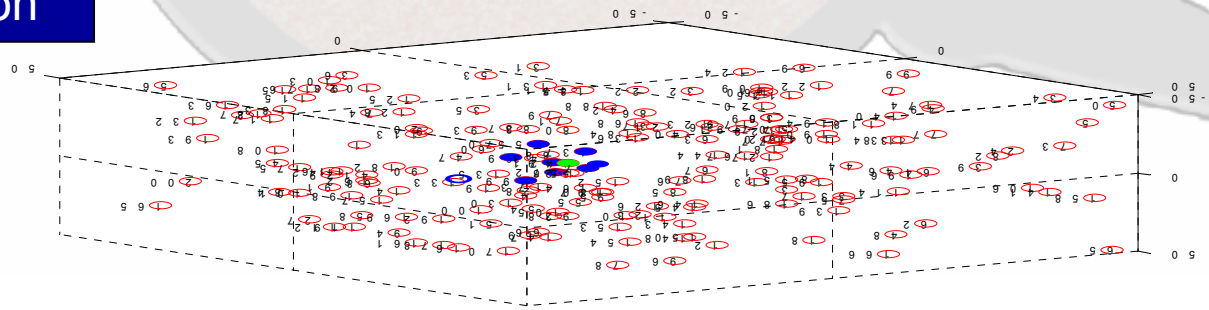
Interference Analysis (Deployment of Specks)

1 Dimension

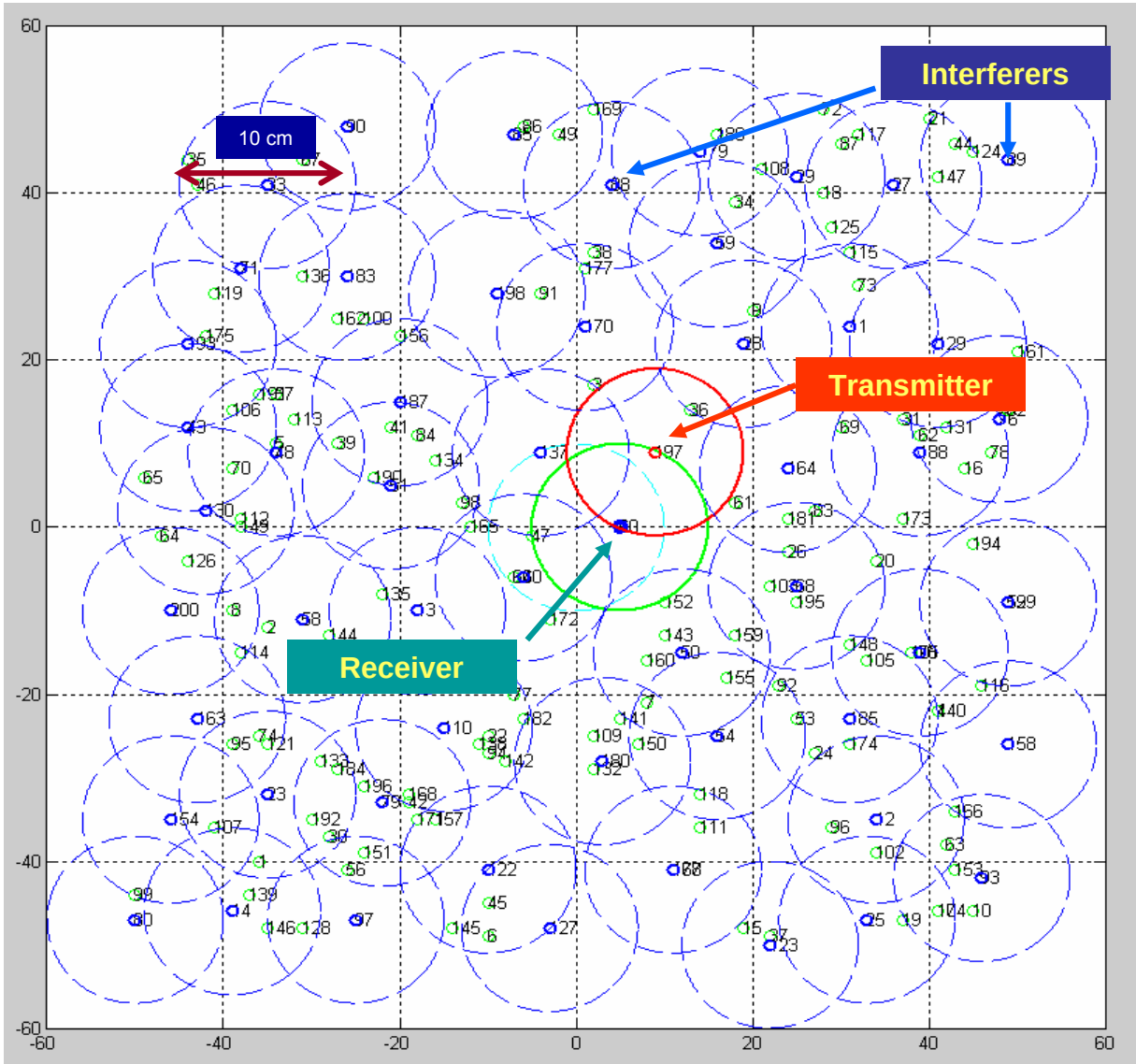
2 Dimension



3 Dimension



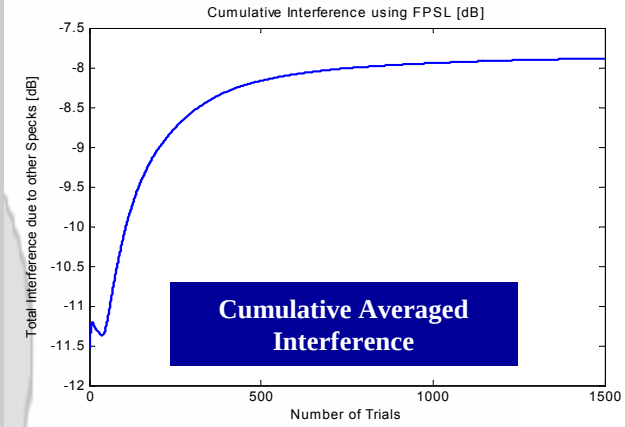
2 Dimensional Deployment (Omni directional Antenna)

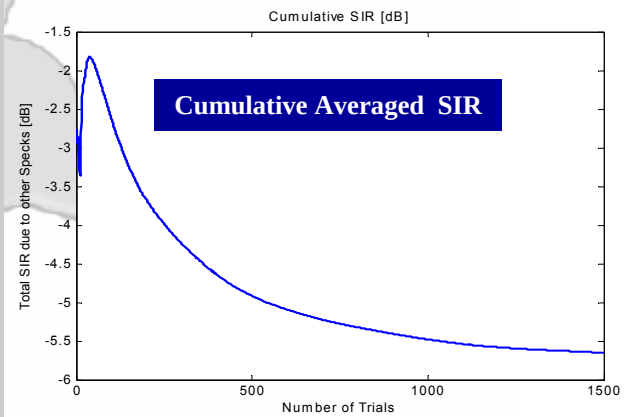


Inhibition Distance = 10cm

Number of Int (100x100 cm) = 51

Specks/Area = 0.02 specks/cm^2





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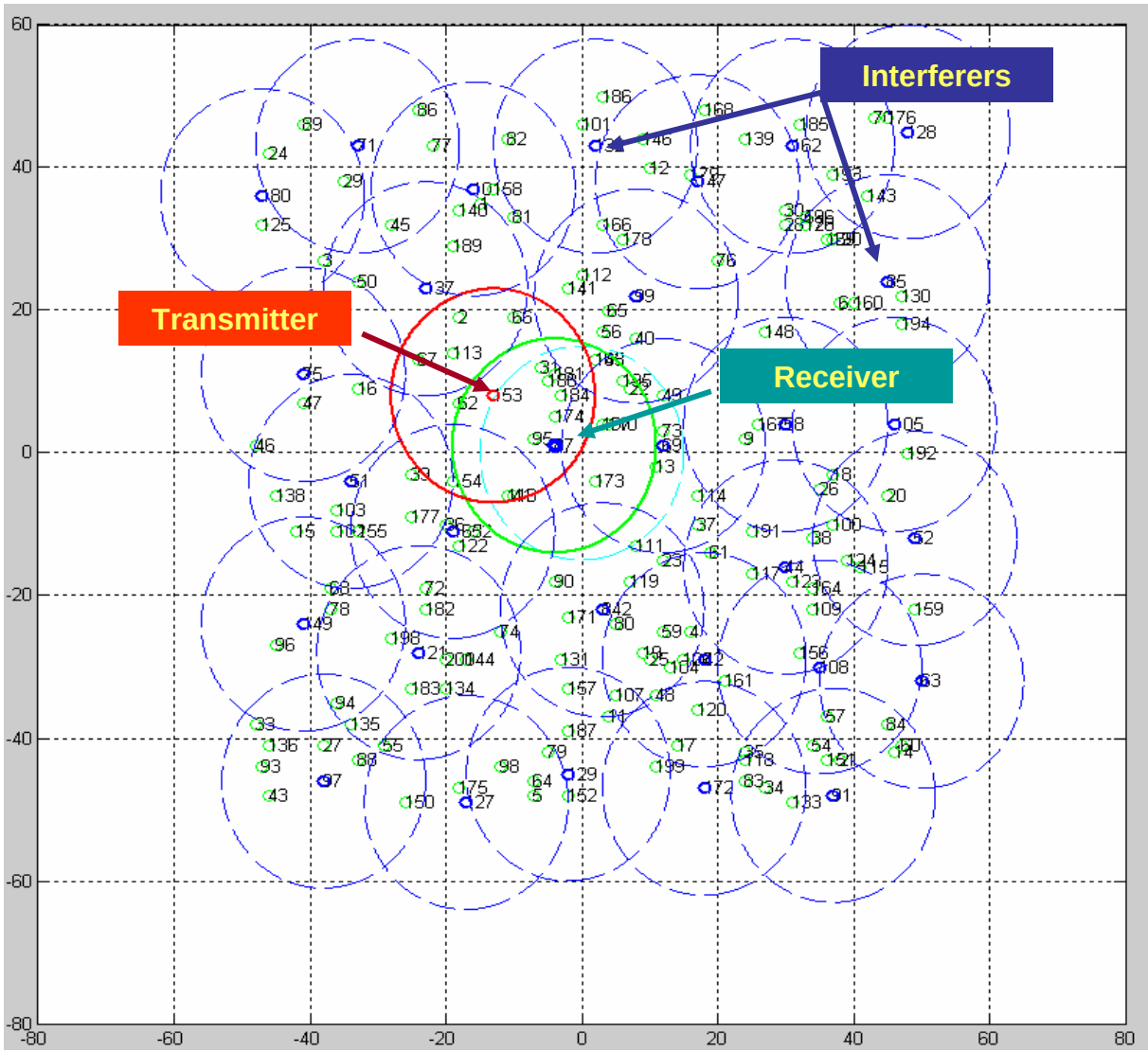
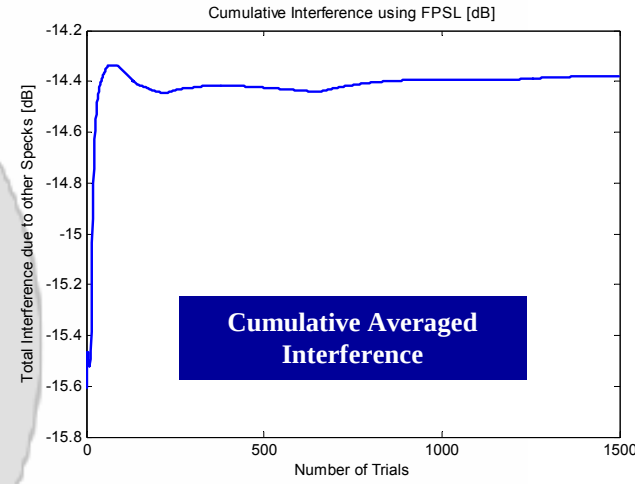
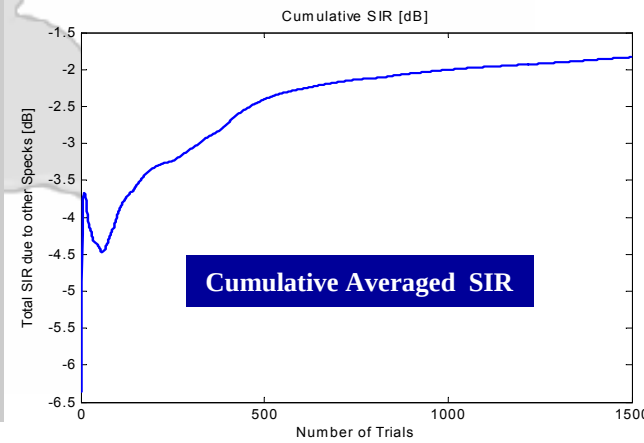


Inhibition Distance = 15cm

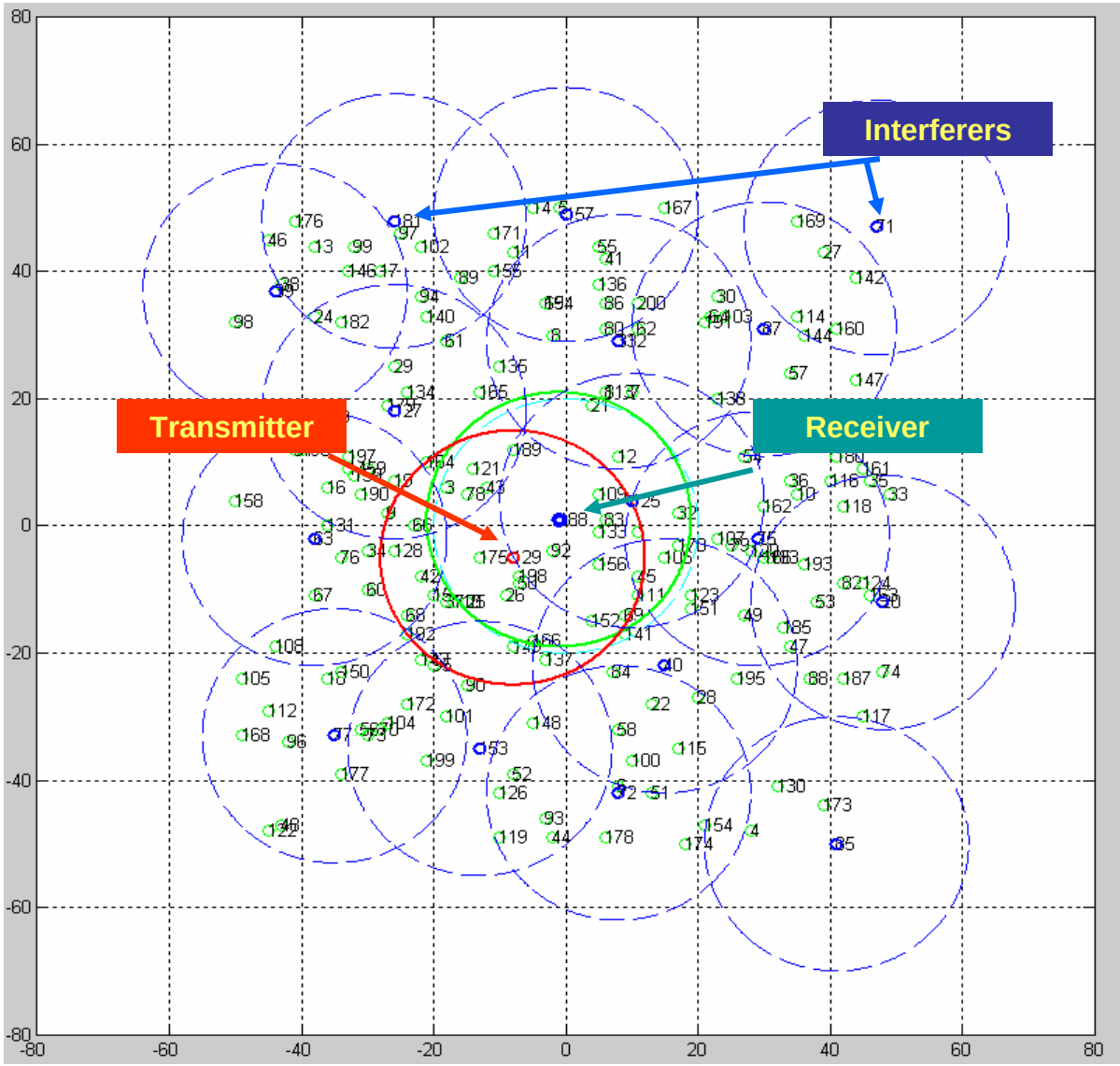
Number of Int (100x100 cm) = 26

Specks/Area = 0.02 specks/cm^2





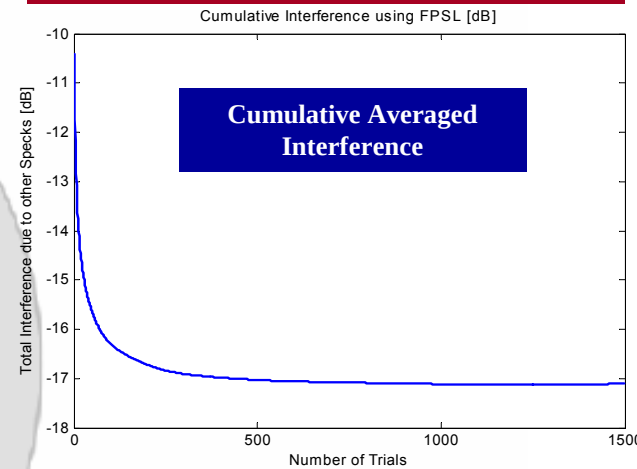
2 Dimensional Deployment (Omni directional Antenna)

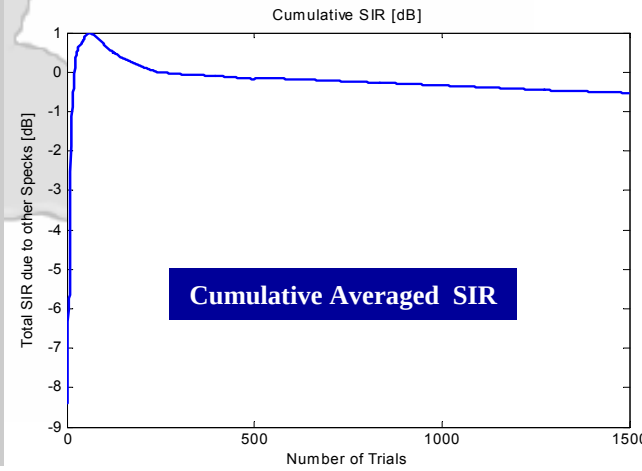


Inhibition Distance = 20cm

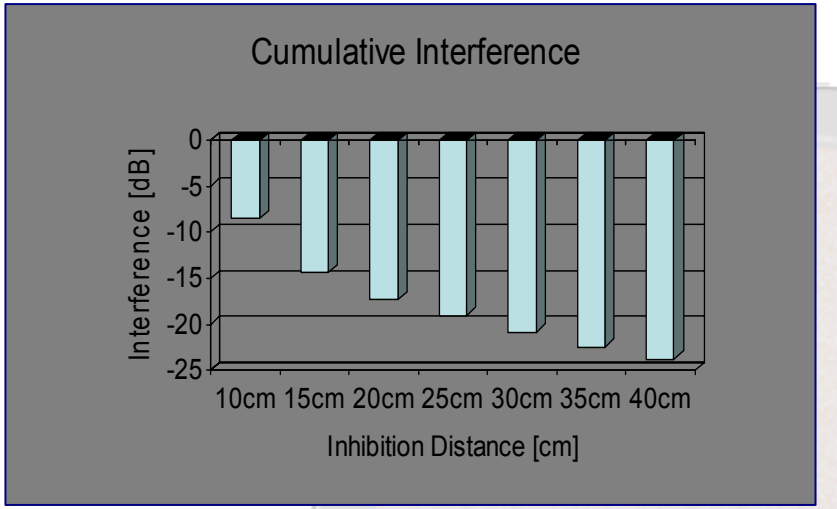
Number of Int (100x100 cm) = 15

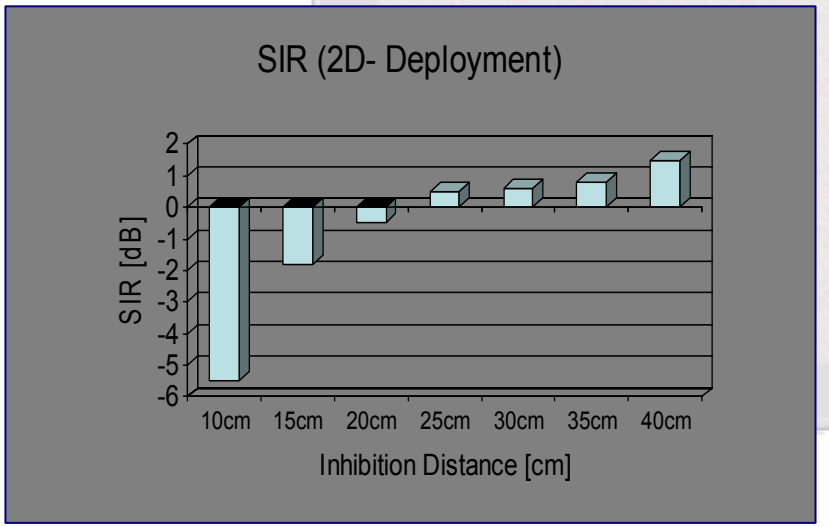
Specks/Area = 0.02 specks/cm^2





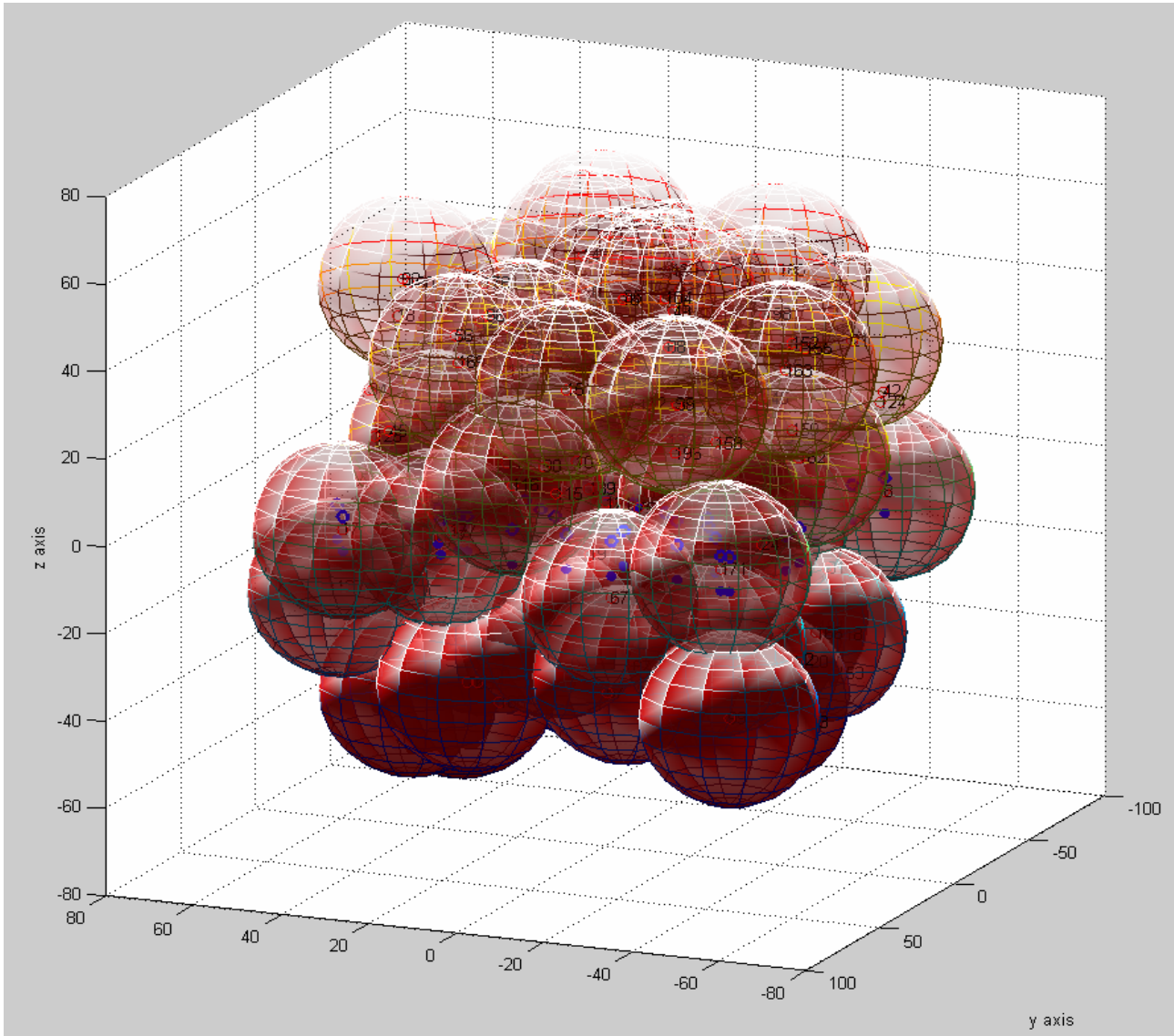
SIR and Inhibition Distance





SIR (for inhibition distance of 10 cm)	**- 5 dB**
Receiver Bandwidth B = Rs(1+ α)	**400 kHz**
Path Loss Index [n = 2] (Environment Dependent)	**FPSL**
Speck Density (speck/unit area (cm^2)) Application Dependent	**0.02**
Modulation	**OOK**
Data Rate	**200 kbps**
E_b/N_o	**- 1.9 dB**
Probability of Bit Error	**0.3**

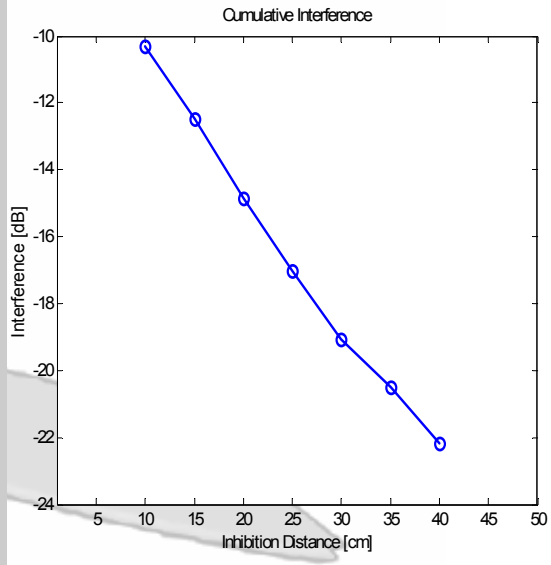
Three Dimensional Deployment



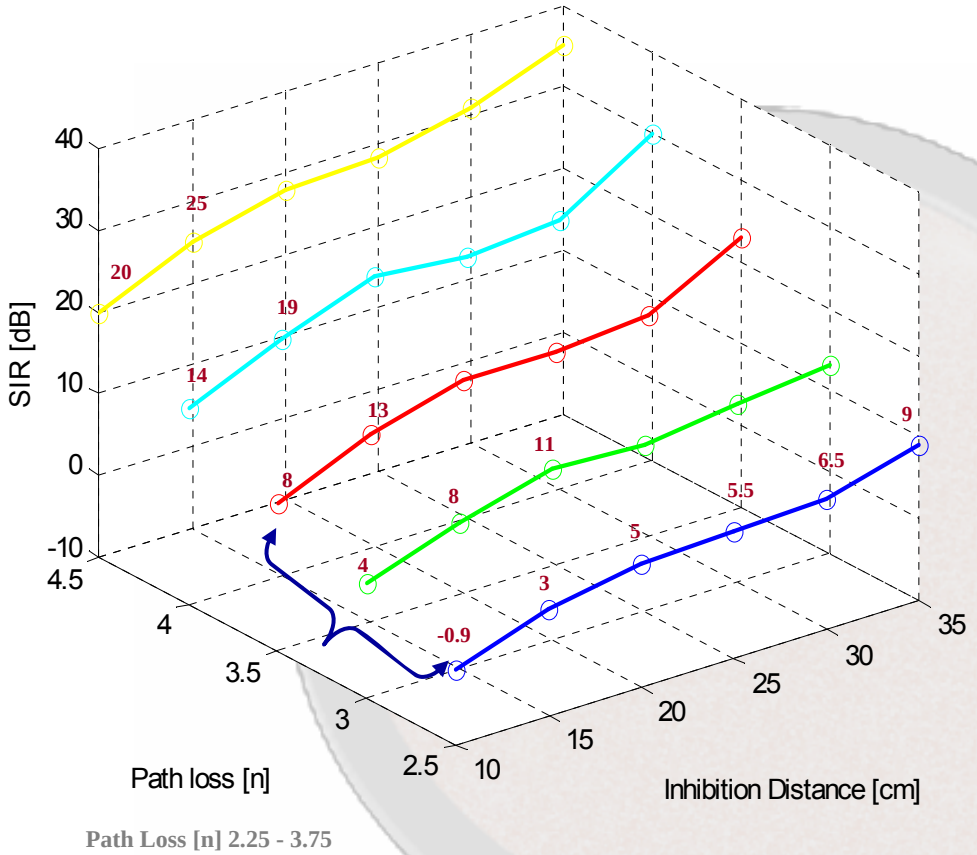
Inhibition Distance = 20cm

Number of Int (100 cm^3) = 25

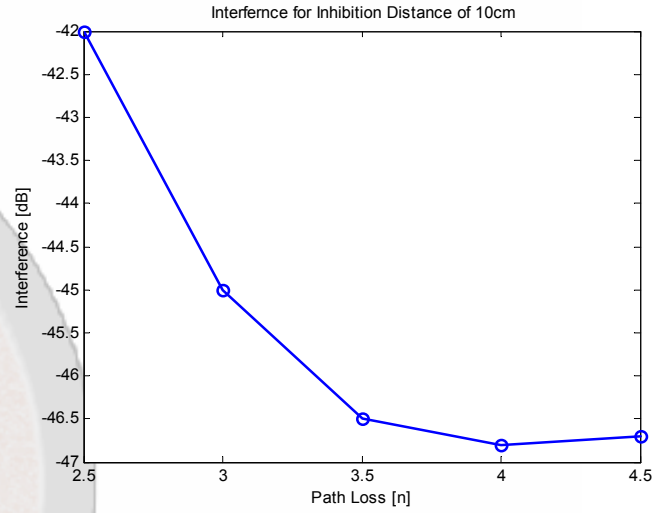
Specks/volume $specks/cm^3$ = 0.02

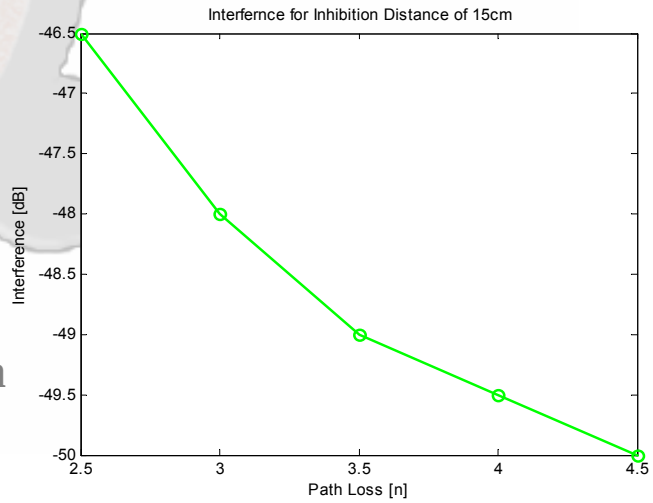


Effect of Path Loss [n] on Inhibition Distance



Path Loss [n] 2.25 - 3.75





BER 10^{e-2} and 10^{e-3} --- SNR (9-12 dB) – Audio Application

BER 10^{e-5} and 10^{e6} --- SNR (13-15 dB) – Data Application

Conclusion and Future Work

- Specked Computing is a Unique Concept of Ubiquitous Computing.
- Antenna Effects
  - Polarization
- UWB Channel Modelling
  - Delay and Frequency Domain
  - Polarization and Space Diversity
- Ray Tracing Software


Thank You