

# Auditing the use of CPM for Long Term Reception Power Modeling in TOSSIM



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## Overview and Algorithm

- Currently TOSSIM models noise but assumes that reception power is constant.
- We propose to use the CPM algorithm [1] together with experimentally collected reception power traces to model reception power in simulation.
- Collecting power traces is more complex than collecting noise traces, since (1) power can only be approximated by sampling the RSSI register; (2) if a packet is lost, then even the RSSI estimate is not possible. Experiments collected were very sensitive and minor changes in mote position yielded very different results.
- Let  $S$  be the signal wave and  $N$  be the resultant wave from the sum of all noise waves. Then

$$RSSI \text{ (dBm)} = |S - N| \text{ and}$$

$$\text{Signal power} = |S| = |RSSI - N|$$

where  $S - N$  and  $|RSSI - N|$  considers wave phases.

- We propose to use the following algorithm:**

1. Calculate average noise. E.g.:  $N = -90$  dBm

Either (2a) OR (2b):

2a. Scan RSSI trace and record the number of packets expected lost by the following formula:

$$\text{Expected lost} = 1/PRR - 1$$

Power trace: -82 -87 -85 -86 -82 -81

SNR: 8 ? ? 3 5 ? 4 8 ? 9 ?

PRR: .99 ? ? .1 .4 ? .2 .99 ? 1.0 ?

Expected lost: 0 ? ? 9 1.5 ? 4 0 ? 0 ?

Lost packets: 5; Expected lost packets: 14.5

2b. Compute average RSSI. E.g.  $RSSI = -85$  dBm

3. Fill in the noise trace. If (2a) chosen, first a distribution is constructed:

Power Value: -81 -82 -85 -86 -87

# Remaining to fill: 0 0 1.5 4 9

% of those remaining: 0% 0% 10.3% 27.6% 62.1%

Then, the distribution is sampled:

-82 -87 -86 -87 -85 -87 -86 -82 -87 -81 -85

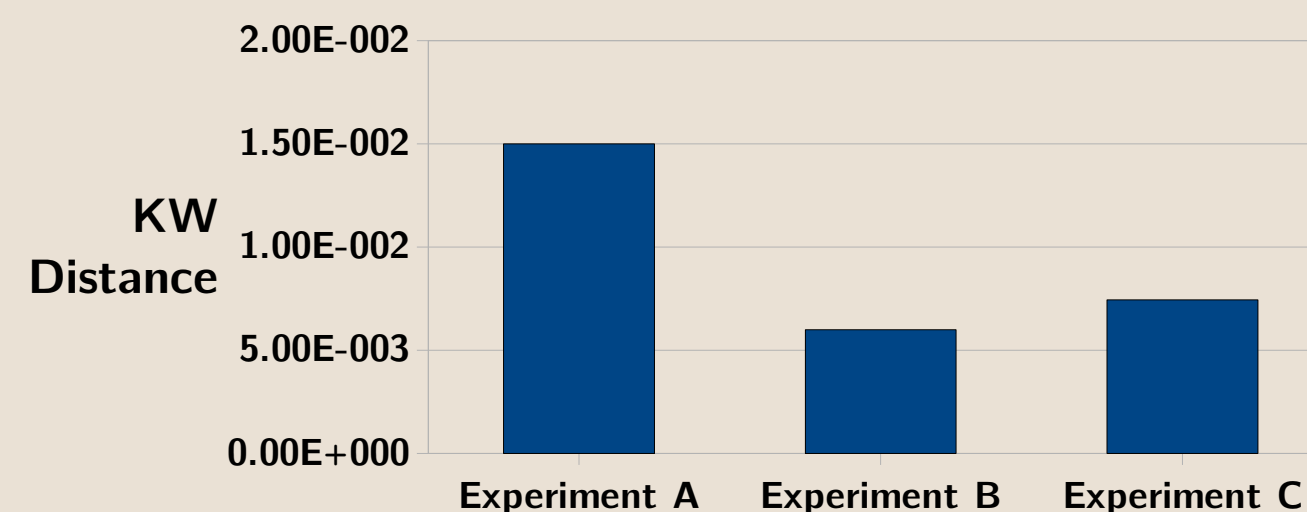
If (2b) is chosen, we fill the trace with  $RSSI$ :

-82 -85 -85 -87 -85 -85 -86 -82 -85 -81 -85

4. CPM is run on the resulting reception power trace.

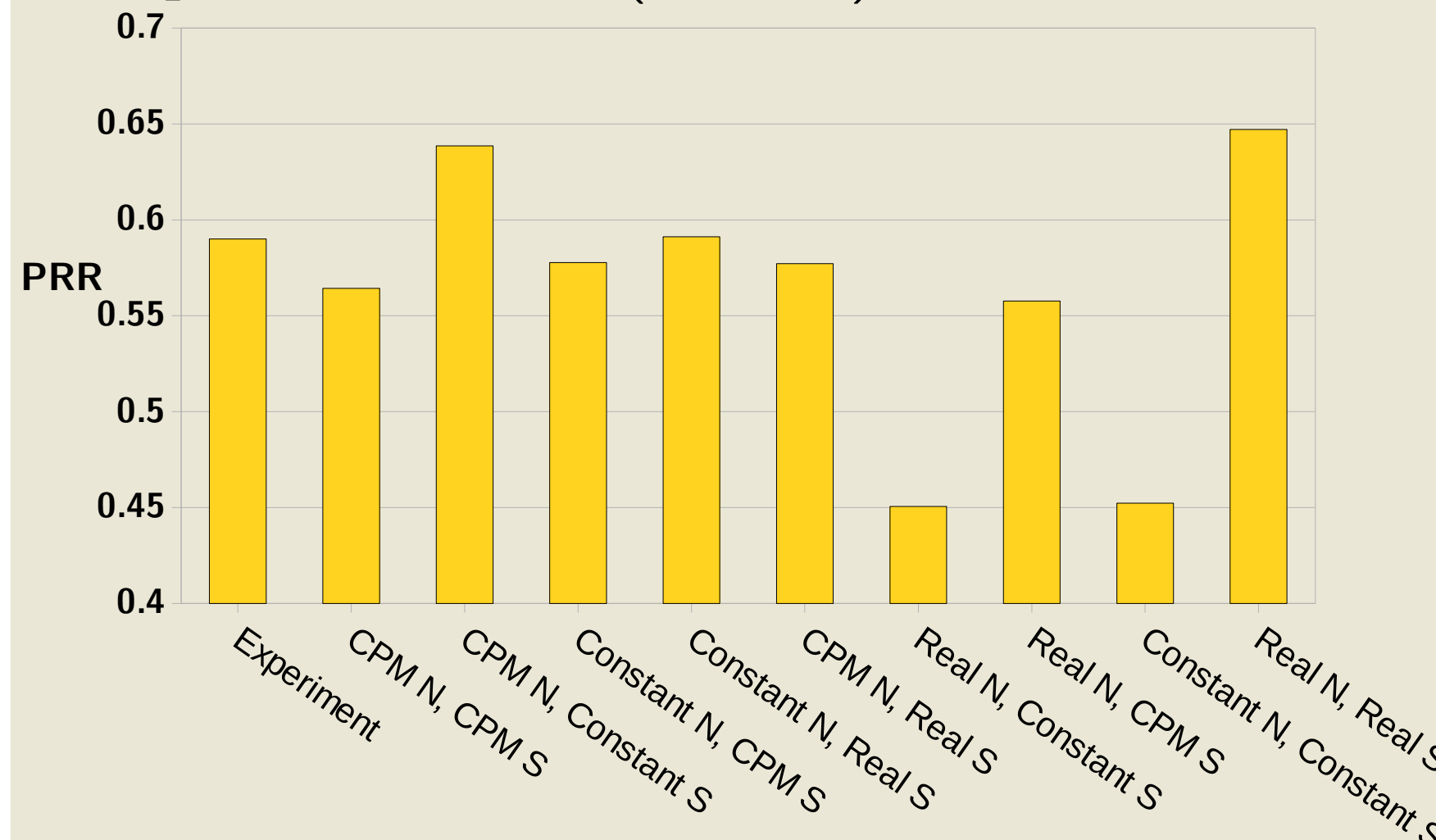
## Effectiveness of CPM Modeling Reception Power

- To check the effectiveness of modeling the filled-in power traces, the Kantorovich-Wasserstein distance metric was used to compare CPDF's of experimental traces to simulation results (CPM Power, Constant noise, to Real Power trace).
- Very low KW Distances. For example:



## Comparison to Current TOSSIM Simulation Model

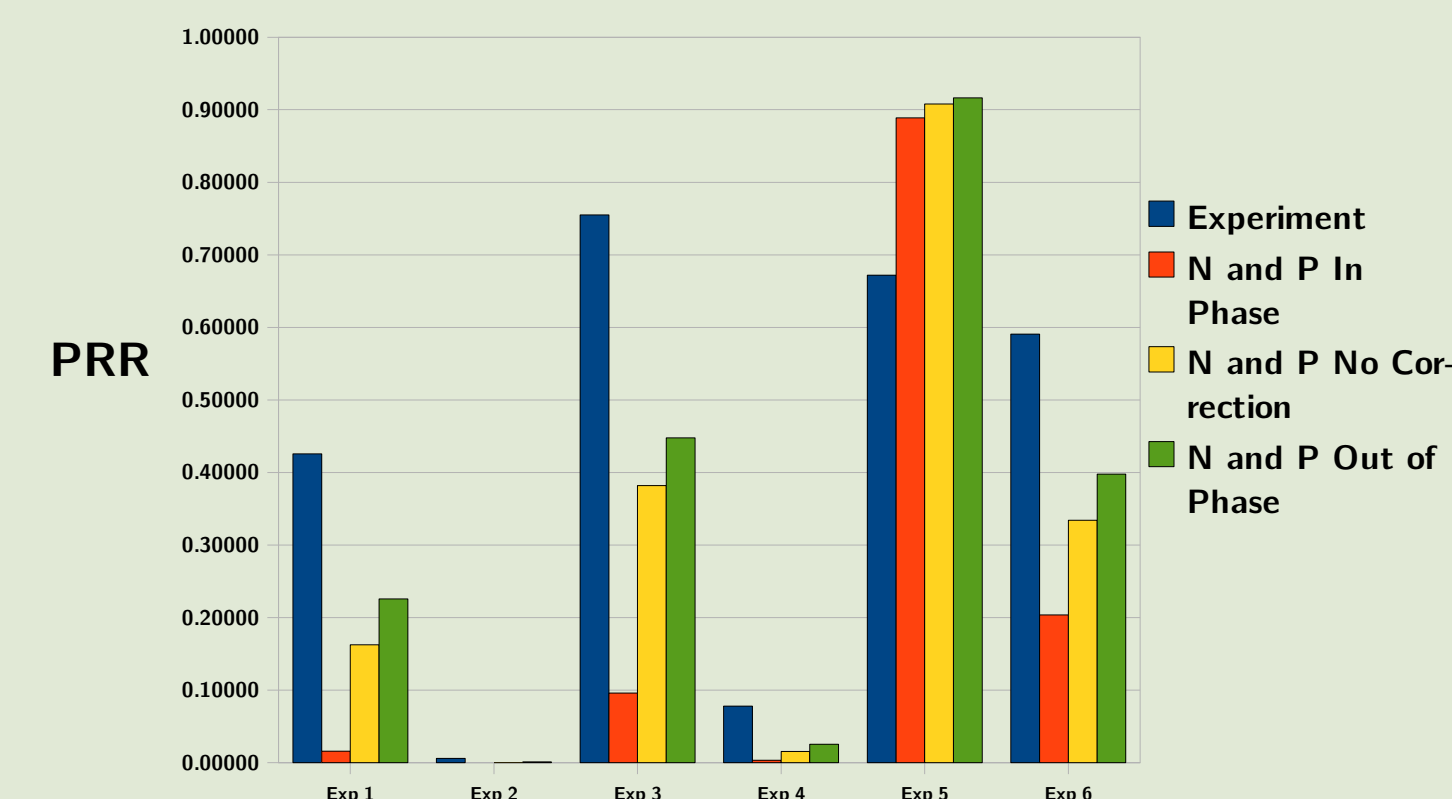
- The following graph compares a single experiment with noise (N) and power (P) simulated using the CPM model and the constant, average approximation. "Real" power means that the real experimental trace (filled in) is used.



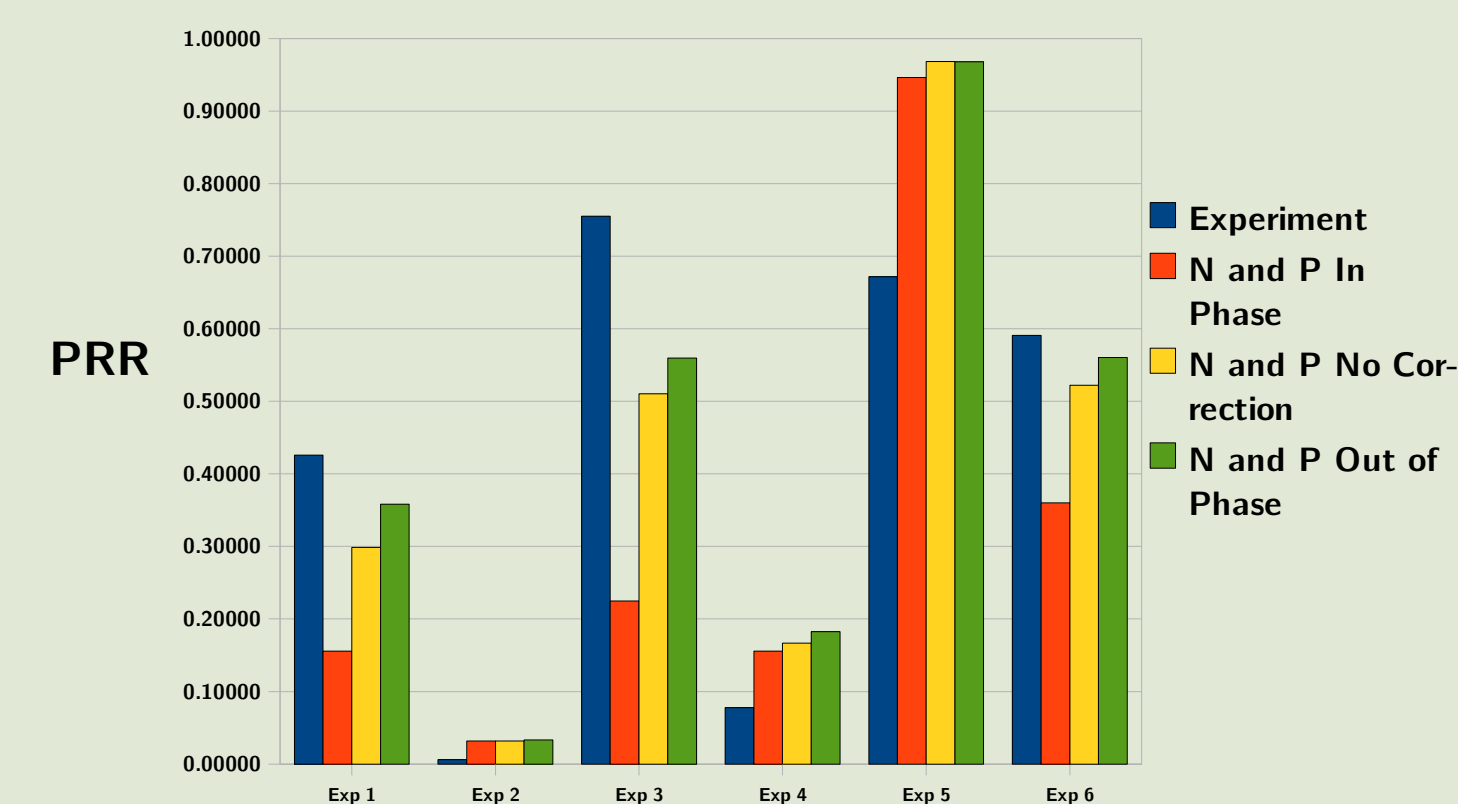
- For CPM, out of phase, expected power filling and correction used.

## Model Variations

- Power trace filled in from expected-value PMF ((2a) in Algorithm):



- Power trace filled in from average-value of power ((2b) in Algorithm):



- Note that different experiments are better approximated by different simulation methods.
- Preliminary results as of 2/22/2008 presented here.
- Future work:
  - Continue the analysis of the data measured using simulations following the CPM and constant average noise and power models.
  - Check correlation between simulation and measured data.

### Acknowledgement

I would like to acknowledge the help of Prof. Z. Haas at Cornell University in guiding this work during the Fall 2007 Semester.

[1] H. Lee, A. Cerpa, and P. Levis. Improving wireless simulation through noise modeling. In IPSN '07: Proceedings of the 6th international conference on Information processing in sensor networks, pages 21-30, New York, NY, USA, 2007. ACM Press.