Interference Modeling and Simulator

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Contents

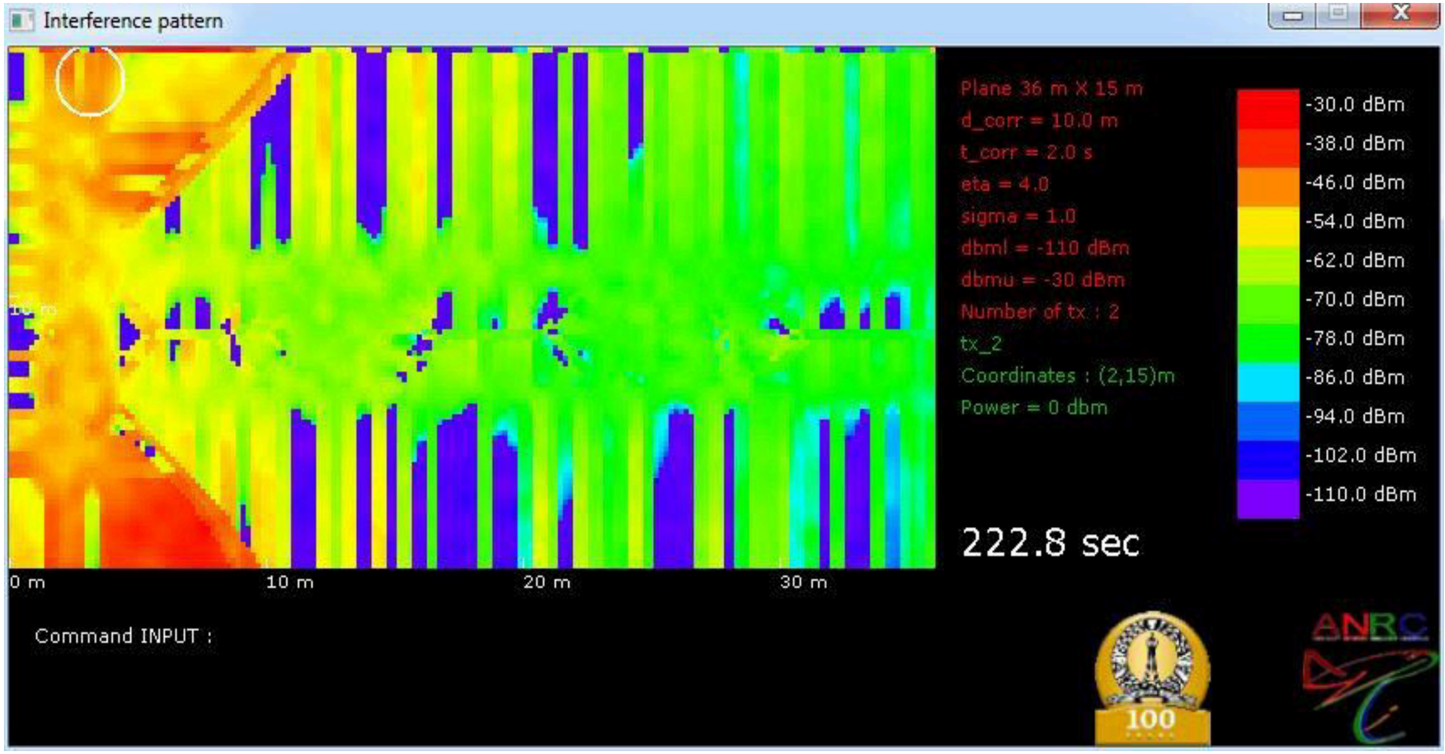
Objective:

To develop a Visualization tool to view the power pattern on a plane due to 13 Access Points:

- path loss values- real world dataset
- Shadowing-artificial

Overview

- Real world data – CRAWDAD website - incorporated into simulator
- Dataset-RSSI from 14 APs recorded at 581 points.
- Path loss values extracted from dataset-Linear interpolation
- Shadowing- still artificial



Dataset (floor plan)

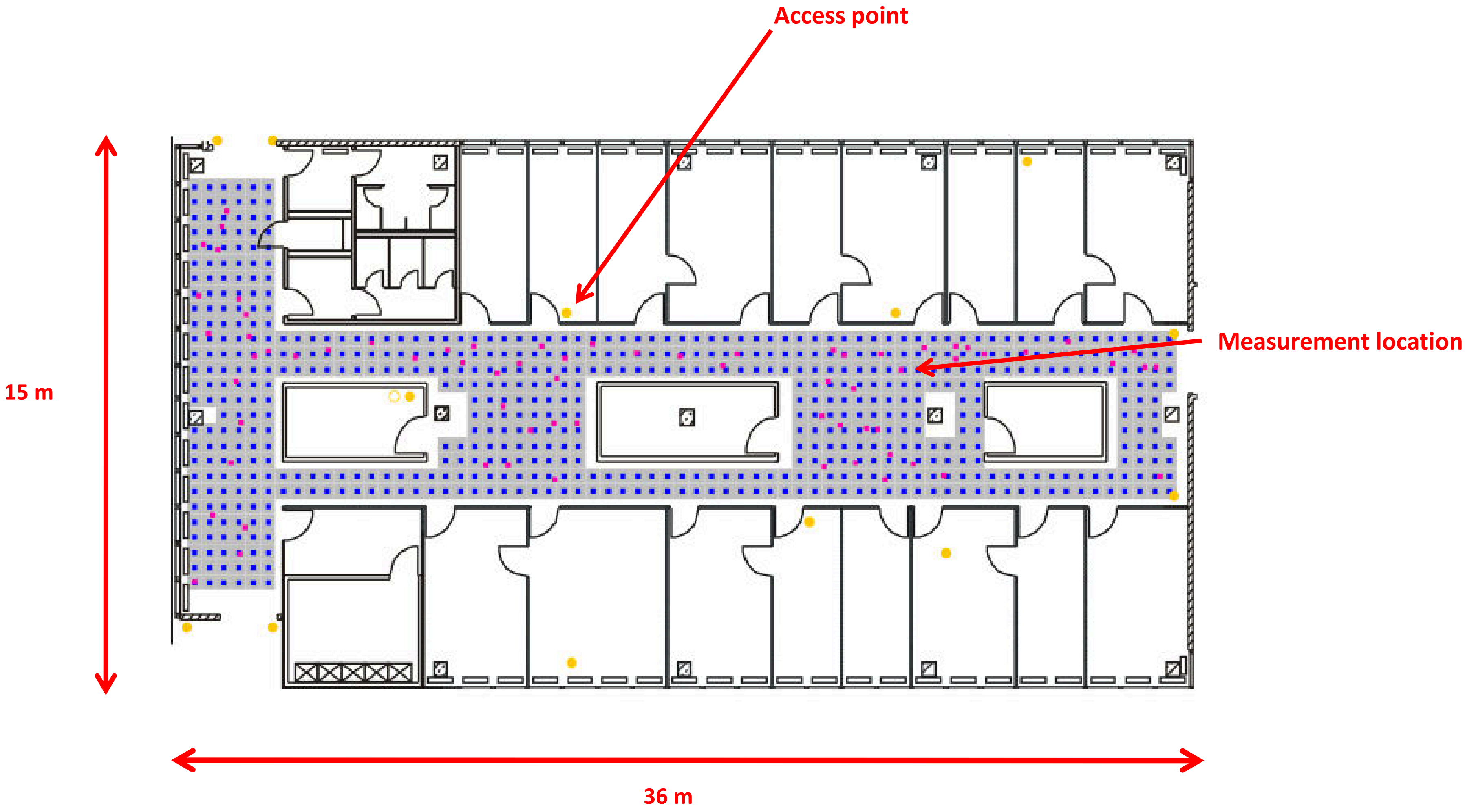


Fig: Floor plan

Dataset (format)

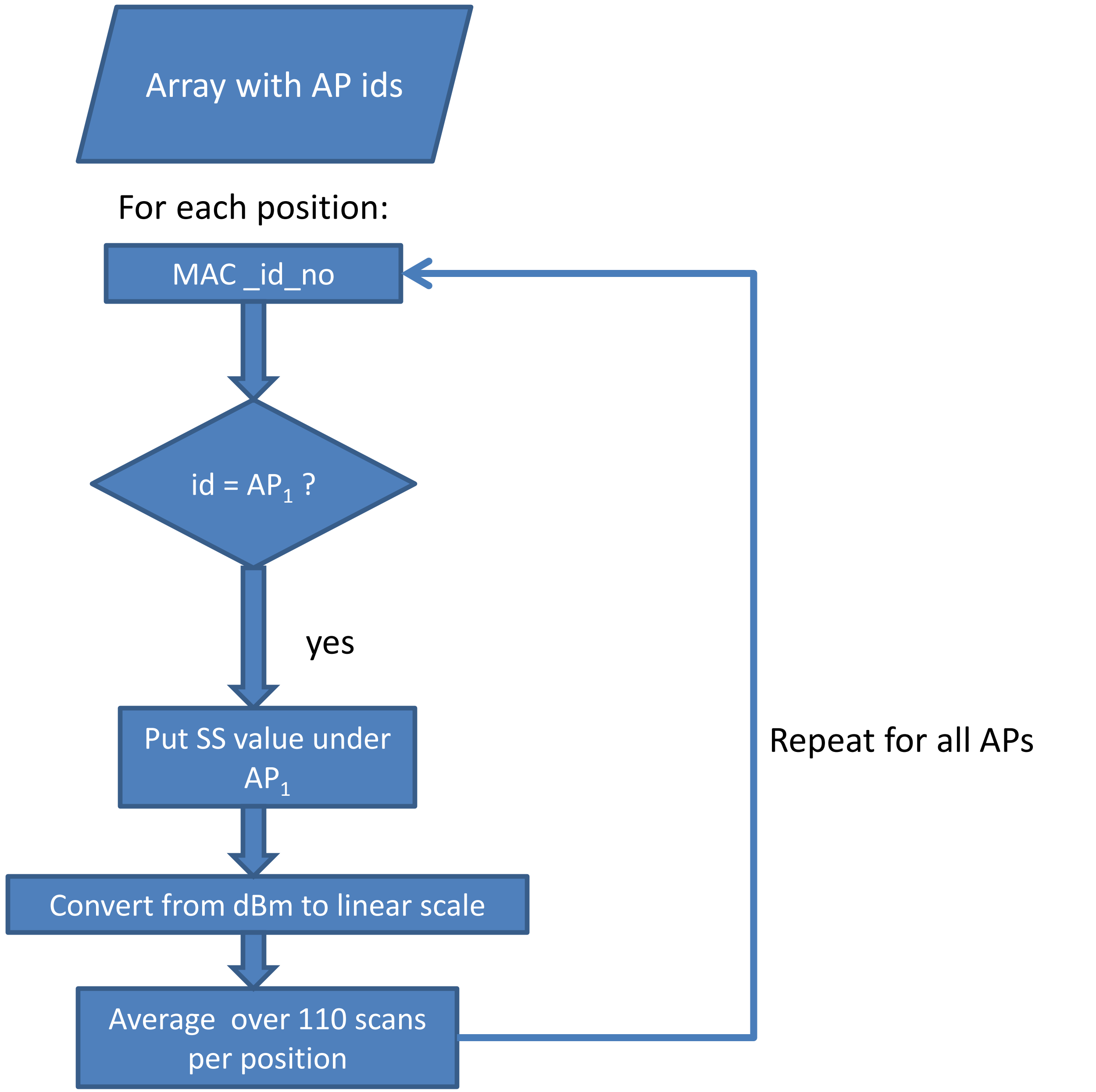
t	id	pos	degree	MAC_AP_1= SS , freq, mode	MAC_AP_2= SS , freq, mode	……	MAC_AP_N= SS , freq, mode

t	Timestamp
id	MAC-scanning device
pos	Coordinate-(x,y,z)
degree	Orientation-degrees
MAC_AP_No.	MAC -responding AP
SS	Signal strength in dBm
freq	Channel frequency
mode	Access point =3, adhoc=1

Raw data:

#	trace	started	2006-10-14	09:42:16
#	iwlib	based	active	scan
t=1160811736850	pos=0.0,0.0,0.0	id=00:02:2D:21:0F:33	00:14:BF:B1:97:81=-43,2.467E9,3,-102	00:14:BF:B1:7C:54=-50,2.412E9,3,-94
t=1160811737110	pos=0.0,0.0,0.0	id=00:02:2D:21:0F:33	00:14:BF:B1:97:81=-47,2.467E9,3,-100	00:14:BF:B1:7C:54=-50,2.412E9,3,-96
t=1160811737394	pos=0.0,0.0,0.0	id=00:02:2D:21:0F:33	00:14:BF:B1:97:81=-43,2.467E9,3,-95	00:14:BF:B1:7C:54=-52,2.412E9,3,-97
t=1160811737662	pos=0.0,0.0,0.0	id=00:02:2D:21:0F:33	00:14:BF:B1:7C:54=-49,2.412E9,3,-94	00:14:BF:B1:97:8D=-58,2.417E9,3,-98
t=1160811737938	pos=0.0,0.0,0.0	id=00:02:2D:21:0F:33	00:14:BF:B1:97:81=-44,2.467E9,3,-99	00:14:BF:B1:7C:54=-50,2.412E9,3,-97
t=1160811738206	pos=0.0,0.0,0.0	id=00:02:2D:21:0F:33	00:14:BF:B1:97:81=-44,2.467E9,3,-100	00:14:BF:B1:7C:54=-49,2.412E9,3,-95
t=1160811738474	pos=0.0,0.0,0.0	id=00:02:2D:21:0F:33	00:14:BF:B1:7C:54=-49,2.412E9,3,-95	00:14:BF:B1:97:81=-46,2.467E9,3,-92
t=1160811738750	pos=0.0,0.0,0.0	id=00:02:2D:21:0F:33	00:14:BF:B1:7C:54=-48,2.412E9,3,-97	00:14:BF:B1:97:81=-46,2.467E9,3,-94
t=1160811739034	pos=0.0,0.0,0.0	id=00:02:2D:21:0F:33	00:14:BF:B1:97:81=-45,2.467E9,3,-99	00:14:BF:B1:7C:54=-48,2.412E9,3,-97

Data Extraction:



Data extracted using Matlab

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	'positions'	'00:11:88:28:5...	'00:14:BF:B1...	'00:14:BF:B1...	'00:13:46:26:...	'00:14:BF:B1...	'00:13:46:32:...	'00:11:88:28:...	'00:14:BF:B1...	'00:14:6C:62...	'00:14:BF:3B...	'00:14:6C:62...	'00:14:6C:62...	'00:0F:B5:D...	'00:14:BF:B1...	'00:14:BF:B1...
2	'pos=0.0,0.0,0.0'	1.8093e-06	9.5565e-06	1.9552e-06	1.3916e-07	3.8967e-07	NaN	2.6031e-07	1.5484e-07	1.3567e-08	5.8708e-08	2.7495e-09	1.4622e-09	NaN	3.3263e-05	6.5705e-07
3	'pos=0.0,0.5,0.0'	4.6165e-06	2.0375e-05	1.4790e-06	1.5860e-07	3.7309e-07	NaN	4.5052e-07	5.9199e-08	5.5183e-08	1.0188e-07	2.2018e-09	9.9142e-10	7.9900e-10	7.6558e-05	2.3048e-06
4	'pos=0.0,1.0,0.0'	2.3662e-06	1.4943e-05	4.8906e-06	9.0921e-08	3.9527e-07	NaN	2.8840e-07	4.4365e-07	1.6114e-08	7.3533e-08	2.1151e-09	8.4978e-10	6.8010e-10	6.0902e-05	2.5306e-06
5	'pos=0.0,1.5,0.0'	2.3363e-06	7.2863e-06	4.3787e-06	3.1748e-07	7.0657e-07	NaN	3.3346e-07	4.8396e-07	2.9006e-08	1.1210e-07	1.9475e-09	1.7940e-09	6.8974e-10	3.4950e-05	1.1796e-06
6	'pos=0.0,2.0,0.0'	1.2130e-06	2.1483e-06	3.2767e-06	2.0099e-07	1.1970e-06	3.1623e-09	2.8551e-07	5.2641e-07	1.5642e-08	8.4234e-08	1.5685e-09	1.0951e-09	7.5201e-10	3.3268e-05	1.7739e-06
7	'pos=0.0,2.5,0.0'	2.7468e-06	4.2785e-06	2.2540e-06	5.3725e-07	1.0392e-06	NaN	4.1961e-07	1.7205e-07	1.6253e-08	7.0558e-08	2.4345e-09	1.1227e-09	8.9080e-10	4.1204e-05	3.9430e-06
8	'pos=0.0,3.0,0.0'	2.1596e-06	5.0041e-06	1.6357e-06	4.4488e-08	1.4648e-06	NaN	4.2925e-07	2.7954e-07	7.6622e-09	1.3271e-07	1.6615e-09	1.4363e-09	6.9214e-10	2.5152e-05	3.6593e-06
9	'pos=0.0,3.5,0.0'	2.6249e-06	6.8730e-06	5.8339e-07	7.5081e-08	1.5766e-06	NaN	3.6236e-07	5.5727e-07	2.4784e-08	6.3280e-08	2.7784e-09	3.8353e-09	1.1476e-09	1.8153e-05	2.2291e-06
10	'pos=0.0,4.0,0.0'	2.3857e-06	5.6642e-06	8.7496e-07	1.8375e-07	5.9532e-07	4.6642e-09	2.2902e-07	5.1434e-07	3.6260e-09	5.4781e-08	1.5779e-09	9.9952e-10	1.0666e-09	1.8878e-05	4.9291e-06
11	'pos=0.0,4.5,0.0'	4.6747e-06	9.5667e-06	1.2515e-06	4.4144e-07	6.7152e-07	4.4536e-09	2.1203e-07	7.6807e-07	9.5683e-09	8.9647e-08	1.7994e-09	1.0920e-09	4.9429e-10	1.9743e-05	4.3646e-06
12	'pos=0.0,5.0,0.0'	2.8465e-06	3.0160e-06	8.7623e-07	1.0345e-07	3.8409e-07	NaN	1.2723e-07	2.2818e-07	1.4488e-08	5.4339e-08	2.8824e-09	1.1111e-09	6.2762e-10	3.1513e-05	5.6700e-07
13	'pos=0.0,6.0,0.0'	3.4627e-06	1.3861e-06	3.6777e-07	1.1721e-07	6.9919e-07	NaN	3.9499e-07	4.5271e-07	3.4050e-09	3.5455e-08	1.6443e-09	1.8510e-09	NaN	3.2388e-06	2.2048e-06
14	'pos=0.0,6.5,0.0'	4.8199e-06	2.4915e-06	2.1872e-06	4.0692e-07	6.7155e-07	NaN	2.3162e-07	3.3362e-07	9.4176e-09	5.2980e-08	3.3780e-09	7.9439e-10	8.2344e-10	1.4614e-06	8.3418e-07

Linear Interpolation

- Solve the system of equations:

  $z_1 = ax_1 + by_1 + c;$

  $z_2 = ax_2 + by_2 + c;$

  $z_3 = ax_3 + by_3 + c;$

- $z_{1,}\ z_{2,}\ z_3$: power measurements
- $(x_1\ ,\ y_1\ ),(x_2,\ y_2\ ),(x_3\ ,\ y_3\ )$: position of measurements.
- Find a,b and c.

- $z_4 = ax_4 + by_4 + c$;
- (x_4 , y_4): point –value needed.
- Z_4 –value after interpolation

Done for all (184 X 98) points.

To Pick $(x_1, y_1),(x_2, y_2),(x_3, y_3)$:

1. Find distance to all 581 points from (x_4, y_4).
2. Sort distances–ascending order
3. Pick 3 points (least distance) such that:
   - Should not be collinear
   - Power value-available at that point.

Simulator

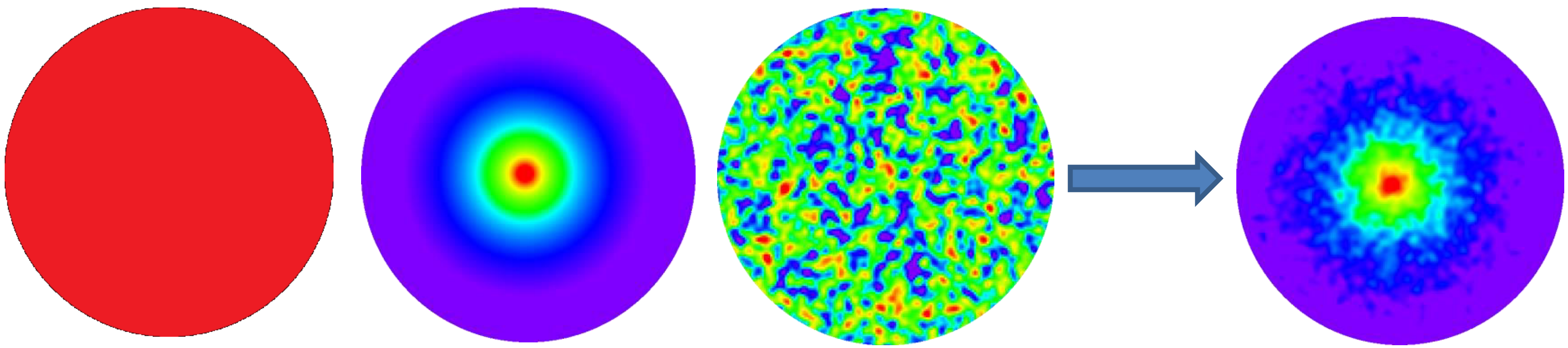
- 13 Access Points at fixed locations.
- AP_i - power P_i.
- Power value -effect of all APs calculated - colour displayed corresponding to the power level.
- power radiated by each AP- path-loss + time varying shadowing.

Power pattern for individual transmitters

$$P_0 \times \left(\frac{1}{d}\right)^{\eta} \times e^{\beta X}$$

Path loss

Shadowing



$\eta : 2 \; to \; 6$

$$\beta = \frac{\ln 10}{10}$$

Power at each point:

- P(x,y) at (x,y):

$$P(x,y) = \sum_{i=1}^{tx\_num} P_i e^{\beta X} \left(\frac{d_0}{d((x,y),(x_i,y_i))} \right)^{\eta}$$

tx_num	No. of transmitters
$d((x,y),(x_i,y_i))$	Euclidean distance
η	path loss exponent
X	Gaussian distributed space time correlated random field

β = $\log(10)/10$

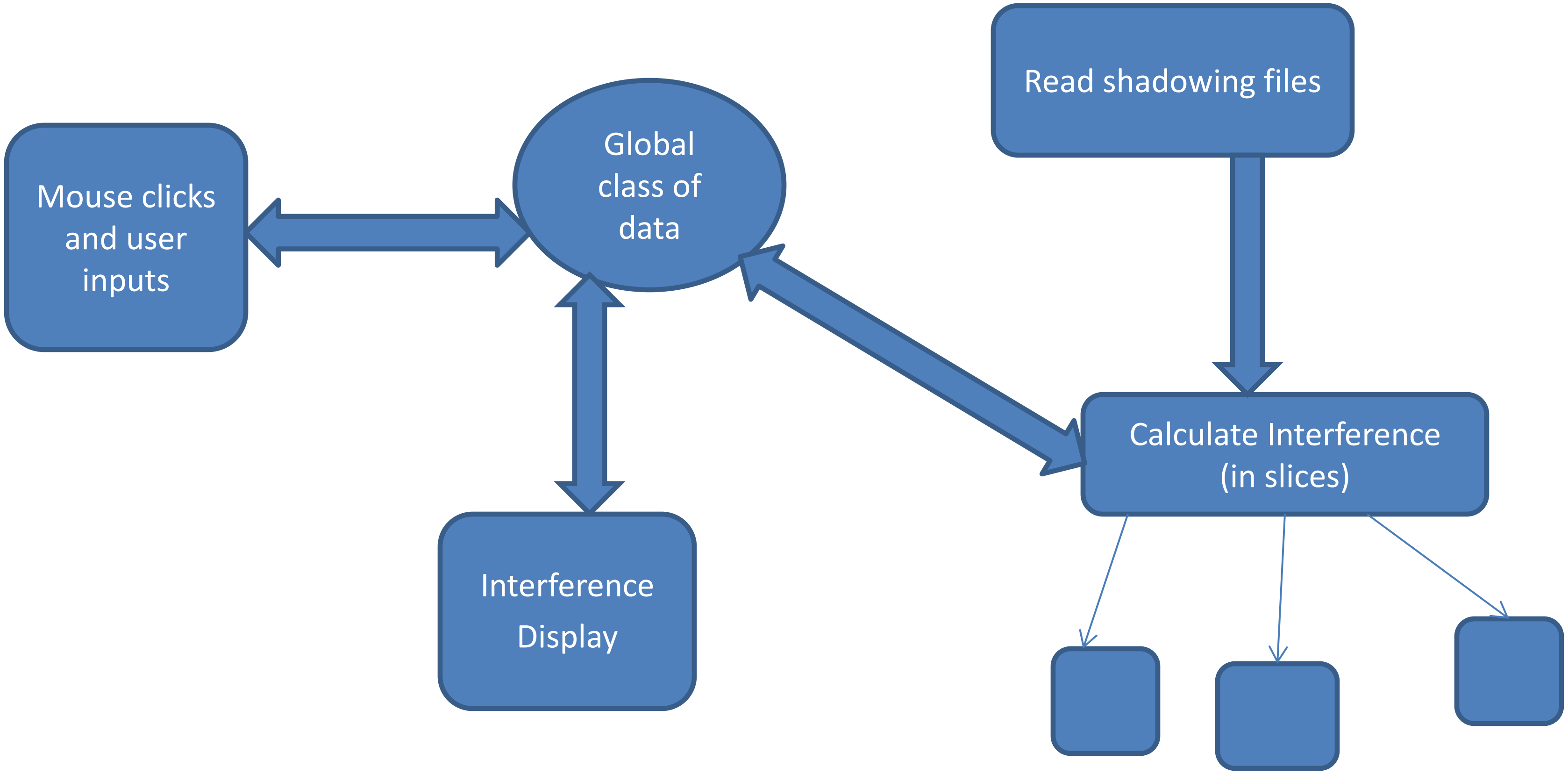
$$\mathbf{E}\left[X(x,y,t)X(x+\delta_x, y+\delta_y, t+\tau)\right] = e^{-\frac{{\delta_x}^2+{\delta_y}^2}{{d_{corr}}^2}-\frac{\tau^2}{{t_{corr}}^2}}$$

d_{corr} Decorrelation distance

t_{corr} Decorrelation time

Demo

Structure of simulator



Modifications

Mouse clicks and user inputs

- No movement of APs -fixed locations
- t_corr,sigma,dbml,dbmu -changeable

Interference Display

- Scaling-according to floor plan-window size
- Scaling-no change with d_corr

Modifications-contd

Arrays –
•X & Y coordinates of APs
•Path loss values –each AP_1 , AP_2 etc

Calculate Interference

Switch case:
Read from AP_1 if k=1
Read from AP_2 if k=2 etc

•Put in shadowing values
•*log* (output power)
•Plot corr colour

Further Improvements

- Extracting shadowing information from the dataset.
- Using other interpolation techniques.
- Change shadowing by changing the decorrelation distance d_corr.
- Improving the GUI

Bibliography

- Dataset from CRAWDAD:
  http://crawdad.cs.dartmouth.edu/meta.php?name=mannheim/compass#N100E0
- Deployment, Calibration, and Measurement Factors for Position Errors in 802.11 based Indoor Positioning Systems- Thomas King, Thomas Haenselmann,Wolfgang Effelsberg.
- An interference simulator for shadow fading environments – Document by Joyson Sebastian
- stackoverflow.com