An Investigation Of The Influence Of Femtocells Network On A Small Size Indoor Environment Using Itu-R And Winner Ii Path Loss Models

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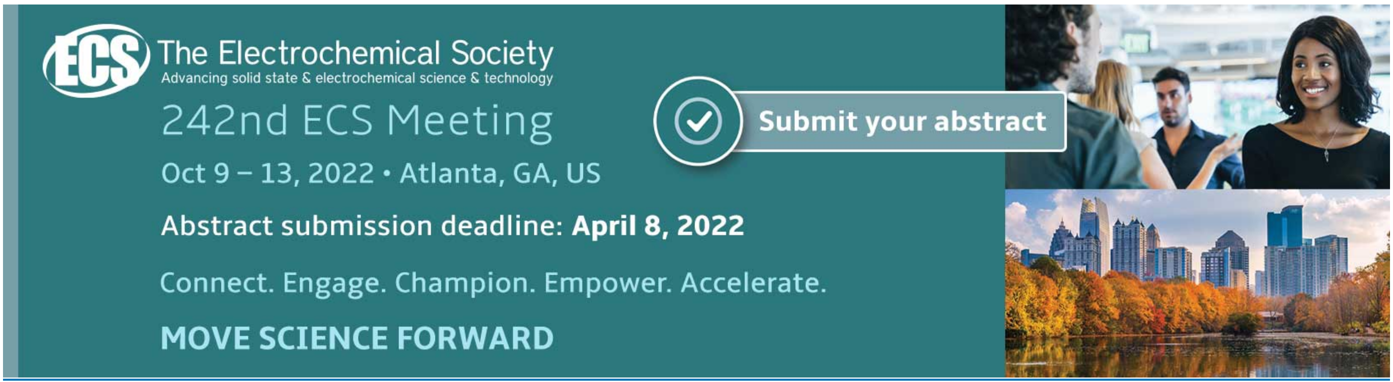

AN INVESTIGATION OF THE INFLUENCE OF FEMTOCELLS NETWORK ON A SMALL SIZE INDOOR ENVIRONMENT USING ITU-R AND WINNER II PATH LOSS MODELS

Osagie Ibhadode[1], A. Adekunle[1], Joseph Azeta[2], Y. K. Abimiku[1]

[1]Nigerian Building and Road Research Institute (NBRRI), Km 10 Idiroko Road, Ota, Ogun state, Nigeria.
(Federal Ministry of Science and technology, Abuja, Nigeria)
[2]Covenant University (CU), Km 10 Idiroko Road, Ota, Ogun state, Nigeria.

Corresponding Author; Osagie.ibhadode@gmail.com

Abstract
The rapid integrations of wireless controls in mechatronics, the broadening applications of wireless radio communications in aviation, and the exponential increase in the growth of mobile phone users in the last decade have made it necessary to expand the capacity of GSM users and ultimately increase the system performance. It has also become imperative for service providers to ensure adequate coverage is provided for all mobile users in areas with poor or no service. Even though many solutions such as distributed antenna system, relays, macrocells, and picocells were developed but they could not proffer the needed solution to indoor users. In this perspective, researchers were of the opinion that femtocells have a gifted technology to enhance indoor coverage because of properties such as short power, short coverage area, reduced distance between device and user and being a plug and play device. It was however discovered that research findings on large deployment of femtocells does not corroborate when a handful is deployed. This study therefore examines the influence of femtocells network on a small size indoor environment using ITU-R and WINNER II path loss models. To accomplish this, femtocells were modeled in six apartments of a building and parameters such as path loss, received power and signal to interference plus noise ratio were determined to ascertain the performance of a particular femtocell under the influence of co-tier interference. Results show that the ITU-R model was found to experience lower path losses which produced higher received powers than WINNER II (-57.0445dBm on the average).
Keywords: ITU-R, WINNER II, Path loss, Femtocell

1. INTRODUCTION

Telecommunication engineering industry is found to be one of the fastest growing industries in the world today, which finds practical applications in many high-tech fields including mechatronics, medicine, security and aviation—despite the accompanying aviation noise pollution etc. [1]. The need for more capacity for mobile operations cannot be overemphasized. As the costs of mobile phones and rate of calls are gradually falling, the number of users is increasing. Globally, subscribers now use more of voice and data services with their respective phones in indoor areas. Research has proven that 60% of the entire voice calls and 65% of the entire data traffic is from indoor environments. Indoor users are faced with poor coverage resulting from penetration loss from walls and underground regions thereby leading to overall signal loss because of attenuation. This is penetration loss from walls is due to density and type of walls. The conventional macrocells which stimulates wireless devices can no longer provide adequate coverage for indoor users since the distance between such macrocells and such indoor users are very large.

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Femtocells were predicted and introduced as solution to bad signal coverage within indoor areas. Femtocells are otherwise known as home evolved node base stations (HeNBs) which works with the conventional macrocells using the same electromagnetic spectrum. The HeNBs gateway serves as the mediator between HeNBs and the core of the mobile network. It is able to connect with the core operator's network through broadband internet services. The coverage distance (10-30m) and power (10-100mW) of femtocell is kept low so that it can have minimal interference with macrocells. It can communicate with four or more indoor users at the same time depending on the hardware technology. Due to the two layer design of femtocells, co-tier interference becomes a serious threat if the network is not planned to accommodate such interference. Also when an area is covered with large number of femtocell coexisting with macrocell, then cross-tier interference may likely occur. Femtocells can be deployed in both urban and rural regions where there is dearth of such base stations within a macrocell base station to ensure overall efficiency of the system. Managing femtocells from a centralized controller is practically unrealistic because of the unplanned nature of deployment [2].

To tackle interference problems without central controller, some procedure is essential to avoid interference as much as possible. Such techniques have been adopted by computing true life situations, generating models and analyzing parameters such as path loss, received power, signal to interference plus noise ratio. These parameters are then used to execute interference minimization scheme and performance of the system. The path loss models employed in this study are ITU-R and WINNER models to determine the parameters stated in the long term evolution (LTE) between femtocell base stations and their users. Path loss or attenuation takes place naturally with distance. The quantity of path loss is determined by frequency of signal and hindering material type and thickness. In general, when the frequency of communication is reduced then a better signal will travel through air and objects. In [3], power control method was adopted. This is a scheme where femtocells are employed to counter the interference in the system. As long as the transmission power of femto base station is controlled and optimized, the macro user is also secured. He highlighted open loop power settling and close loop power settling. These two methods reduce the interference of the macro users originated by femtocell. Femto aware spectrum technique was developed by [4] to put off uplink cross tier interference. The available spectrum is shared into two portions namely: devoted channel for macrocell only and the remaining is shared mutually between macrocells and femtocells. [5] Worked on resourceful channel allotment using open access mode, close access mode and hybrid access mode. For open access, all the users within femtocell coverage are automatically permitted access to femtocell. For close access, only the users subscribed to femtocell coverage area are permitted access. For hybrid users, precedence is given to users that subscribe to femtocell. The aim of this research is to conduct an investigation into the influence of femtocells network on a small size indoor environment using ITU-R and WINNER II path loss models while the specific objectives are to deploy femtocell in apartments on a small scale, to determine path losses for each user using the models considered, to determine the received powers and to determine signal to interference plus noise ratio (SINR) [6] [7] [8] [9].

Fig. 1: A typical Femtocell developed by some manufacturers.

2. METHODOLOGY

2.1 Introduction

Femtocells are deployed within apartments of a building with minimum of one user in each apartment. As shown in Figure 2. Based on the number of walls between femtocells, users and path loss models used, path losses are determined for each user with respect to the base stations adopted. Other parameters such as received powers and SINR are subsequently obtained.

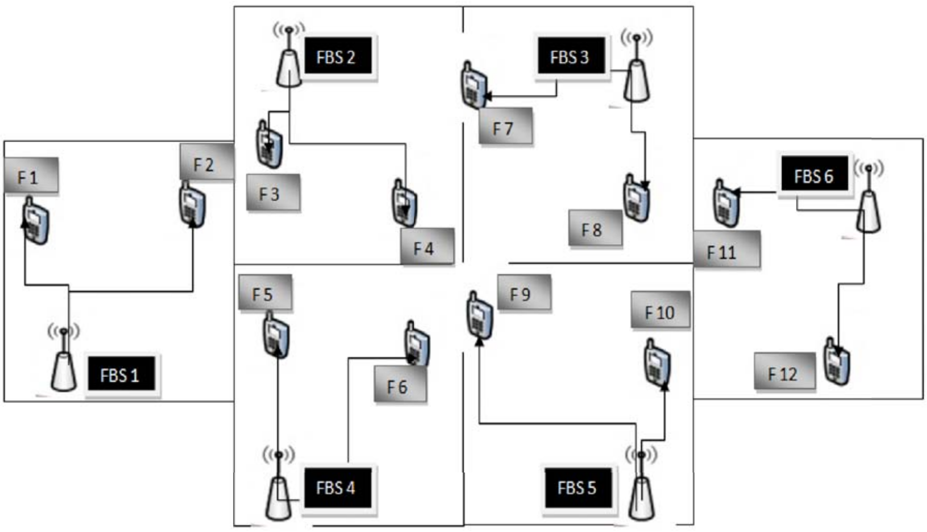

Fig 2: Small scale deployment of femtocells in a building

2.2 ITU-R P1238-7 Model

This is known as international telecommunication union radio communication path loss model developed to be engaged in situations within indoor environments [10]. This model is to be operated on frequencies between 900MHz-6GHz. The path losses are for both line of sight and non- line of sight as shown equations (1) and (2)

L_{LOS}= 18*Log (f_C) +y*Log(x)-28…………………………………….. (1)

L_{NLOS}= 18*Log (f_C) +y*Log(x) + 4(n_w)-28…………………………… (2)

Where;

f_C=carrier frequency in MHz
y= Coefficient of Power loss=28
x= distance between femtocell and user
n_w=number of walls

2.3 WINNER II D112 V1.2 Model

This path loss model is known as the Wireless World Initiative New Radio (WINNER) developed to improve performance of mobile communication. It was adopted for different situations ranging from indoor to outdoor environments and the frequency range is 2 to 6 GHz [10-11].

L_{LOS}= 46.8+20*Log ($\frac{f_C}{5}$) +18.7*Log(x) …………………………..………. (3)

L_{NLOS}= 46.4+20*Log ($\frac{f_C}{5}$) +20*Log(x) + 5($n_w - 1$)…………………………… (4)

Channel gain (G) =$\frac{Power\ Received(PR)}{Power\ Transmitted(Pt)}$= $\frac{Pr}{Pt}$……………………………………..………. (5)

Therefore, path loss (L) in terms of channel gain= $\frac{1}{G}$

$\frac{1}{L}$=$\frac{Pr}{Pt}$ ……………………………………………………………………… (6)

Pr= $\frac{Pt}{L}$

Pr= $Pt - L$ (dBm) ………………………….…………………………….…… (7)

SINR= $\frac{Pr}{I_{T+T_N}}$ …………………………..…………………………… (8)

Where;

Pr=Power received

I_T= Total interference power based on femto user (Power receive from other femtocell base station)

T_N= Thermal noise at 150 KHz

3. RESULT AND DISCUSSION

Table 1: Input parameters and their values

Parameter	Value
Number of femtocells	6
Apartment size (m)	4m by 4m
Number of femto users	12
Carrier frequency	2GHz
Carrier bandwidth	150KHz
Transmission Power	18dBm

Cell Layout	Circular cell
Thermal noise	-121.42dBm/Hz

Table 2: Distance between femtocells and FUEs in meters (m)

FEMTOCELLS/ USERS	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**
FBS1	4.1	5.2	5.0	5.0	3.0	5.1	8.1	9.8	8.0	10.0	11.4	12
FBS2	5.1	6.8	1.4	2.0	5.1	4.1	3.2	5.2	6.4	7.8	7.3	9.4
FBS3	10.0	8.1	6.1	5.4	7.8	5.7	2.2	7.0	5.1	5.1	2.8	5.8
FBS4	8.1	14.1	7.0	6.1	3.0	4.5	8.1	9.3	5.8	7.6	10.0	9.5
FBS5	13.0	9.0	9.9	8.5	7.6	6.4	7.6	1.0	3.6	3.0	6.1	3.6
FBS6	15.1	13.9	11.2	10.0	11.2	9.1	7.3	7.1	6.3	4.5	3.2	2.8

Table 3: Distance between FBSs in meters (m)

	FBS1	**FBS2**	**FBS3**	**FBS4**	**FBS5**	**FBS6**
FBS1		6.4	9.8	4.2	10.4	14.1
FBS2			5.2	8.1	10.0	10.4
FBS3				10.0	8.1	5.8
FBS4					7.0	12.1
FBS5						6.4
FBS6						

Table 4: Number of walls between FUEs and FBSs

FEMTO USERS	**Number of walls**					
	w.r.t.FBS1	w.r.t.FBS2	w.r.t.FBS3	w.r.t.FBS4	w.r.t.FBS5	w.r.t.FBS6
F1	0	1	2	1	2	3
F2	0	1	2	1	2	3

F3	1	0	1	1	2	3
F4	1	0	1	1	2	3
F5	1	1	2	0	1	2
F6	1	1	2	0	1	2
F7	2	1	0	2	1	1
F8	2	1	0	2	1	1
F9	2	2	1	1	0	1
F10	2	2	1	1	0	1
F11	3	2	1	2	1	0
F12	3	2	1	2	1	0

Table 5: Path loss using NLOS ITU-R P1238-7 Model

FEMTO USERS	**ITU-R (dB)**					
	w.r.t.FBS1	w.r.t.FBS2	w.r.t.FBS3	w.r.t.FBS4	w.r.t.FBS5	w.r.t.FBS6
F1	48.57649	55.2305	67.41854	60.85612	70.60895	76.42989
F2	51.46663	58.72879	64.85612	67.59668	66.13733	75.42295
F3	54.9897	35.51012	57.40778	59.08129	67.29633	72.79664
F4	54.9897	39.84738	55.92557	57.40778	65.44227	71.41854
F5	48.77794	55.2305	64.39719	44.77794	60.08132	68.79664
F6	55.2305	52.57649	60.58304	49.70849	57.99158	66.2717
F7	64.85612	49.56274	41.00637	64.85612	60.08132	59.59158
F8	67.17287	55.46663	55.08129	66.53606	35.41854	59.25377
F9	64.70506	61.99158	55.2305	56.79452	46.99501	57.80008
F10	67.41854	64.39719	55.2305	60.08132	44.77794	53.70849
F11	73.01188	63.59158	47.93896	67.41854	57.40778	45.56274
F12	73.63561	66.66612	56.79452	66.7948	50.99501	43.93896

Table 6: Path loss using NLOS WINNER II D112 V1.2 Model

FEMTO USERS	**WINNER (dB)**					
	w.r.t.FBS1	w.r.t.FBS2	w.r.t.FBS3	w.r.t.FBS4	w.r.t.FBS5	w.r.t.FBS6
F1	105.6969	112.5926	123.4412	116.6109	125.7201	132.0207
F2	107.7613	115.0914	121.6109	121.4256	122.5261	131.3015
F3	112.4206	96.36376	114.1478	115.3432	123.3539	129.4256
F4	112.4206	99.4618	113.0891	114.1478	122.0296	128.4412
F5	107.9836	112.5926	121.2831	102.9836	116.0575	124.4256
F6	112.5926	110.6969	118.5587	106.5055	114.5648	122.622
F7	121.6109	108.5442	100.2897	121.6109	116.0575	115.7077
F8	123.2657	112.7613	110.3432	122.8109	98.4412	115.4664
F9	121.503	119.5648	112.5926	113.7098	104.5672	114.428
F10	123.4412	121.2831	112.5926	116.0575	102.9836	111.5055
F11	129.5793	120.7077	107.3844	123.4412	114.1478	103.5442
F12	130.0248	122.9038	113.7098	122.9957	109.5672	102.3844

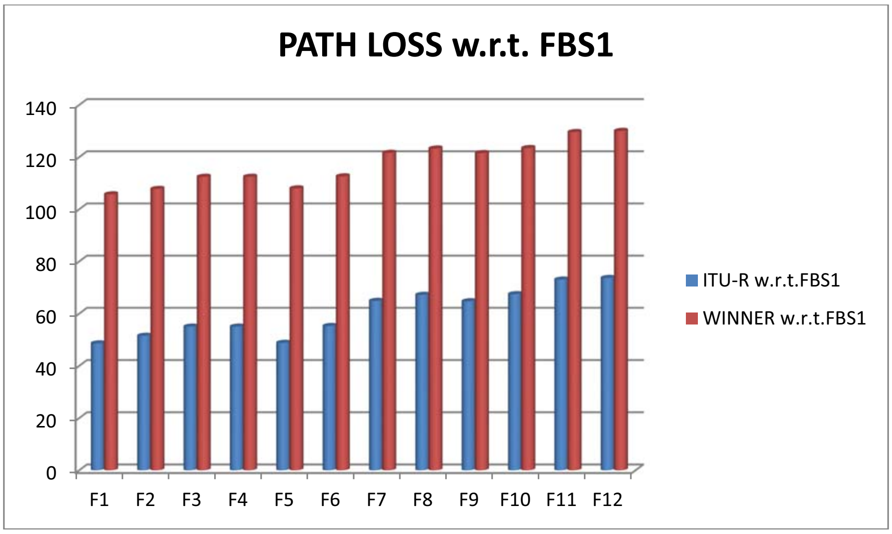

Figure 3:Path loss with respect to FBS1

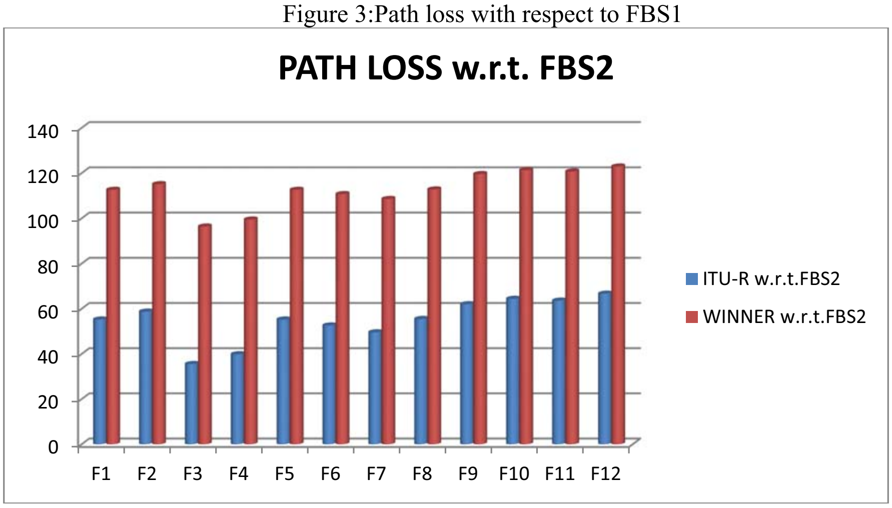

Figure 4:Path loss with respect to FBS2

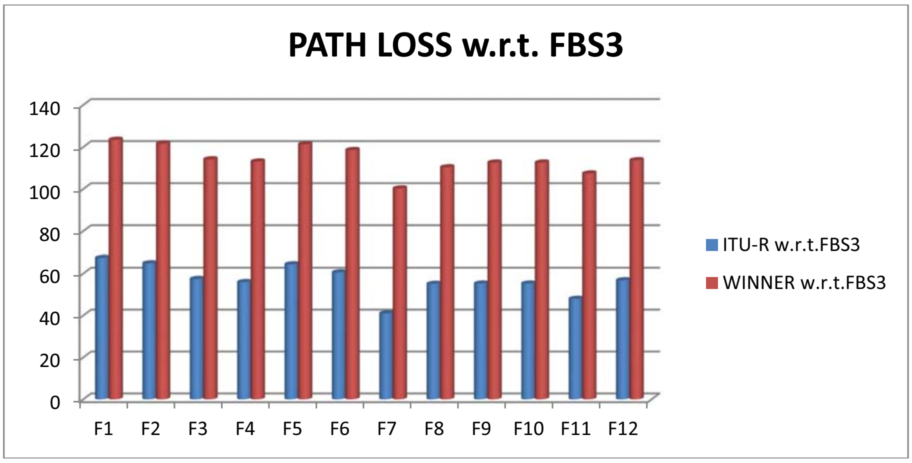

Figure 5:Path loss with respect to FBS3

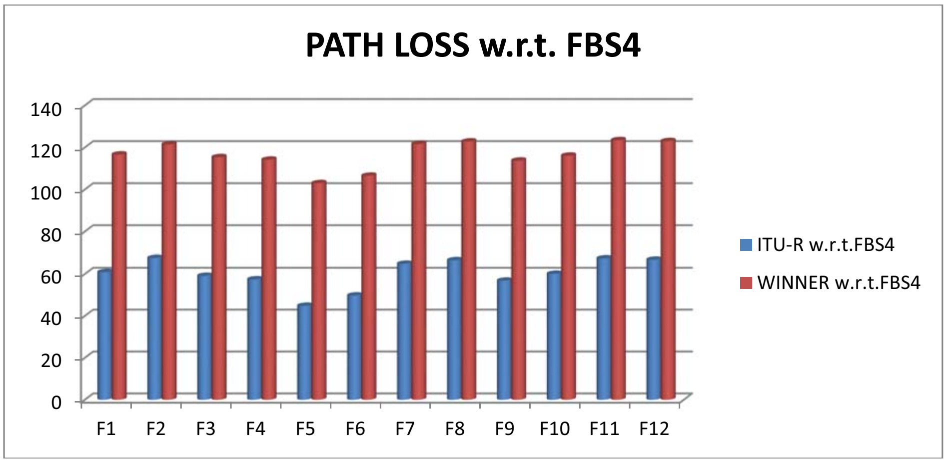

Figure 6:Path loss with respect to FBS4

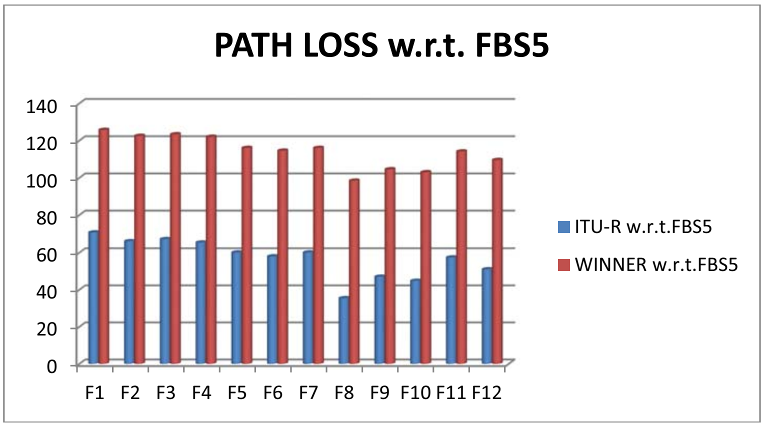

Figure 7:Path loss with respect to FBS5

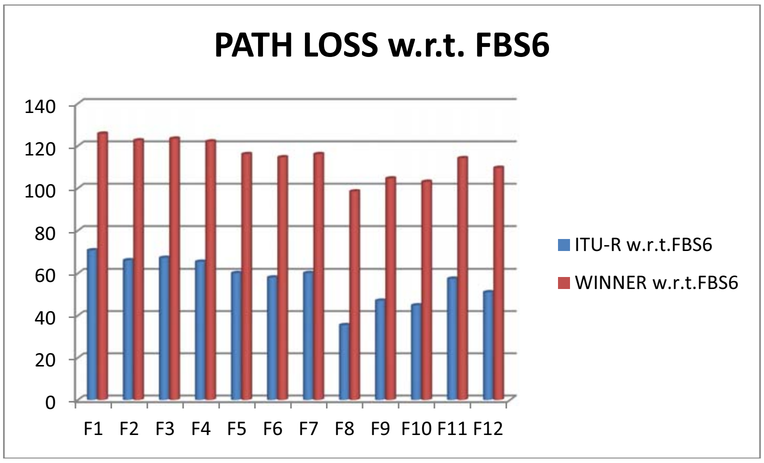

Figure 8:Path loss with respect to FBS6

Figures 1 to 8 show that every femtocell experiences diverse path loss due to different distances as obtained in table 1. It also shows that as femto users are farther away from femto base stations, the path losses increase but decreases when users are at close proximity to the femtocells. Comparing the two path losses considerd, ITU-R model shows much lower path losses (57.04449 on the average) owing to the disparities in penetration loss of walls and power loss coefficient.

Table 7: Received Power using NLOS ITU-R P1238-7 Model

FEMTO USERS	ITU-R (dBm)					
	w.r.t.FBS1	w.r.t.FBS2	w.r.t.FBS3	w.r.t.FBS4	w.r.t.FBS5	w.r.t.FBS6
F1	-30.5765	-37.2305	-49.4185	-42.8561	-52.609	-58.4299
F2	-33.4666	-40.7288	-46.8561	-49.5967	-48.1373	-57.423
F3	-36.9897	-17.5101	-39.4078	-41.0813	-49.2963	-54.7966
F4	-36.9897	-21.8474	-37.9256	-39.4078	-47.4423	-53.4185

F5	-30.7779	-37.2305	-46.3972	-26.7779	-42.0813	-50.7966
F6	-37.2305	-34.5765	-42.583	-31.7085	-39.9916	-48.2717
F7	-46.8561	-31.5627	-23.0064	-46.8561	-42.0813	-41.5916
F8	-49.1729	-37.4666	-37.0813	-48.5361	-17.4185	-41.2538
F9	-46.7051	-43.9916	-37.2305	-38.7945	-28.995	-39.8001
F10	-49.4185	-46.3972	-37.2305	-42.0813	-26.7779	-35.7085
F11	-55.0119	-45.5916	-29.939	-49.4185	-39.4078	-27.5627
F12	-55.6356	-48.6661	-38.7945	-48.7948	-32.995	-25.939

Table 8: Received Power using NLOS WINNER II D112 V1.2 Model

FEMTO USERS	**WINNER (dBm)**					
	w.r.t.FBS1	w.r.t.FBS2	w.r.t.FBS3	w.r.t.FBS4	w.r.t.FBS5	w.r.t.FBS6
F1	-87.6969	-94.5926	-105.441	-98.6109	-107.72	-114.021
F2	-89.7613	-97.0914	-103.611	-103.426	-104.526	-113.301
F3	-94.4206	-78.3638	-96.1478	-97.3432	-105.354	-111.426
F4	-94.4206	-81.4618	-95.0891	-96.1478	-104.03	-110.441
F5	-89.9836	-94.5926	-103.283	-84.9836	-98.0575	-106.426
F6	-94.5926	-92.6969	-100.559	-88.5055	-96.5648	-104.622
F7	-103.611	-90.5442	-82.2897	-103.611	-98.0575	-97.7077
F8	-105.266	-94.7613	-92.3432	-104.811	-80.4412	-97.4664
F9	-103.503	-101.565	-94.5926	-95.7098	-86.5672	-96.428
F10	-105.441	-103.283	-94.5926	-98.0575	-84.9836	-93.5055
F11	-111.579	-102.708	-89.3844	-105.441	-96.1478	-85.5442
F12	-112.025	-104.904	-95.7098	-104.996	-91.5672	-84.3844

Table 7 and Table 8 show Received Power using NLOS ITU-R P1238-7 and Received Power using NLOS WINNER II D112 V1.2 Models. They were obtained through distances of femtocells from one apartment to another as shown in Tables 1 to 3. These received Powers were employed to determine the various throughputs obtained afterwards.

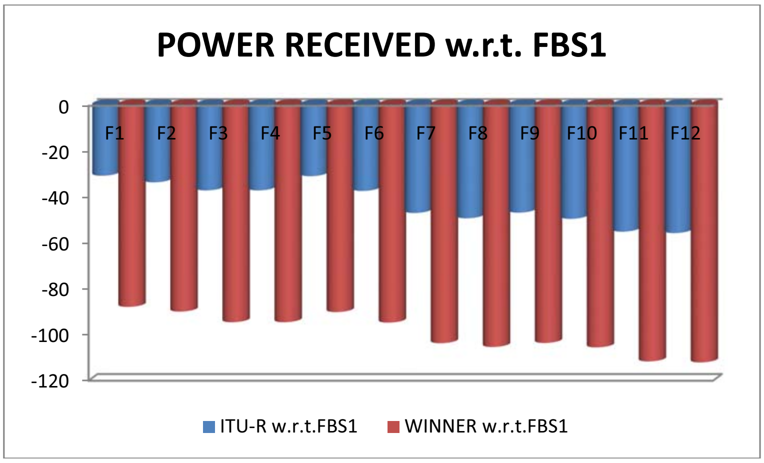

Figure 9:Received power with respect to FBS1

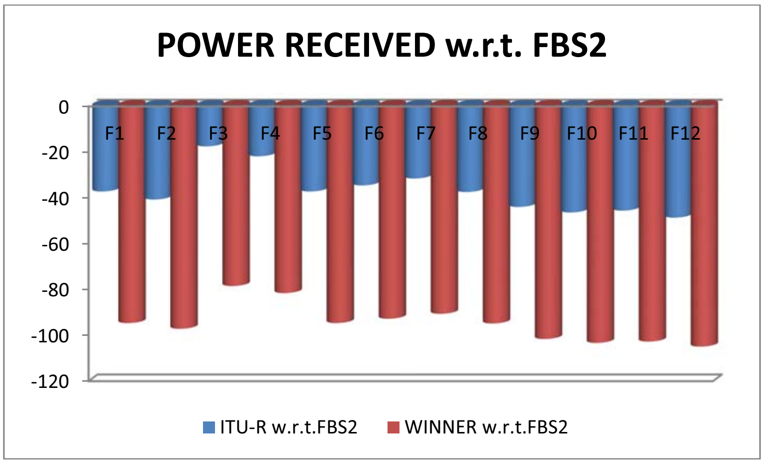

Figure 10:Received power with respect to FBS2

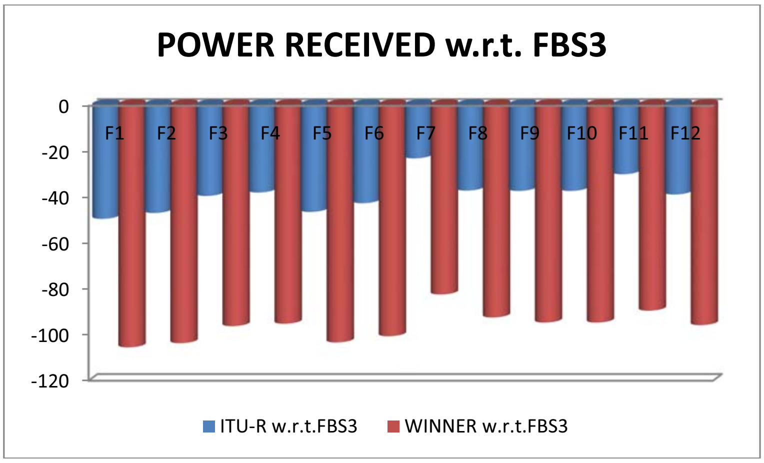

Figure 11:Received power with respect to FBS3

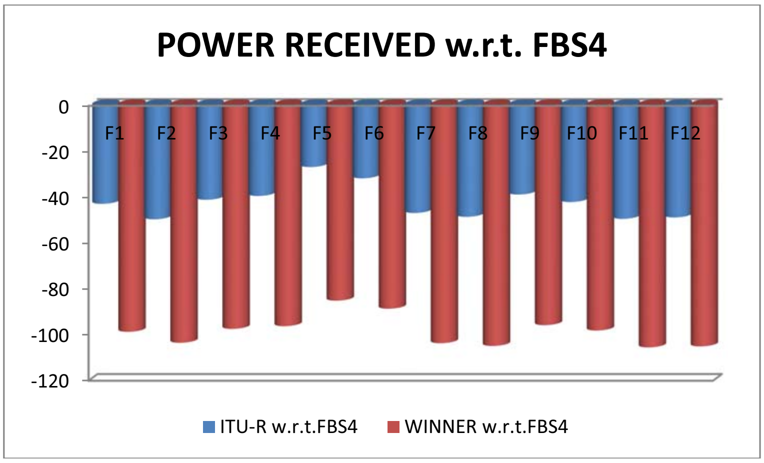

Figure 12:Received power with respect to FBS4

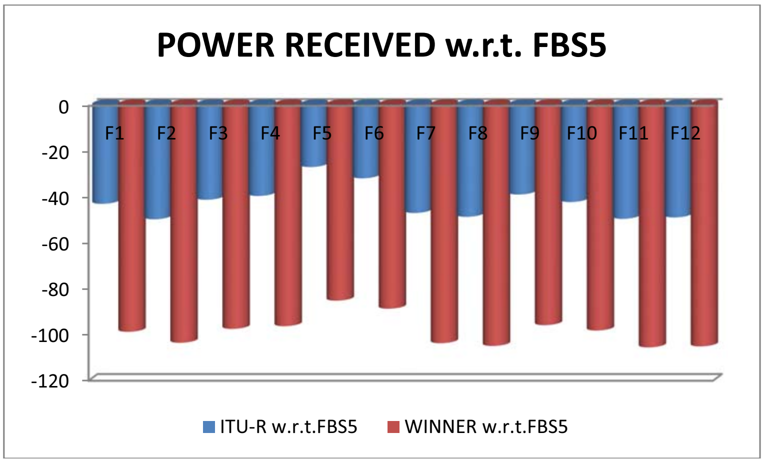

Figure 13:Received power with respect to FBS5

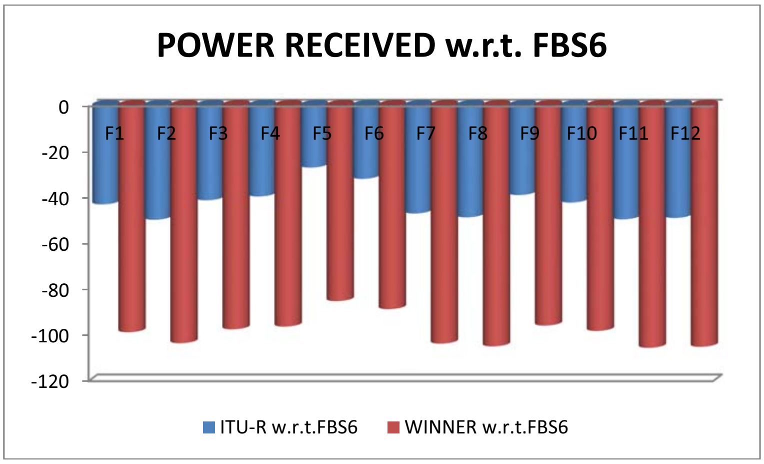

Figure 14:Received power with respect to FBS6

Figures 9 to 14 show the power received for individual femtocells and users for WINNER II and ITU-R models. The ITU-R model was found to experience lower path losses which produced higher received powers than WINNER II (-57.0445dBm on the average).

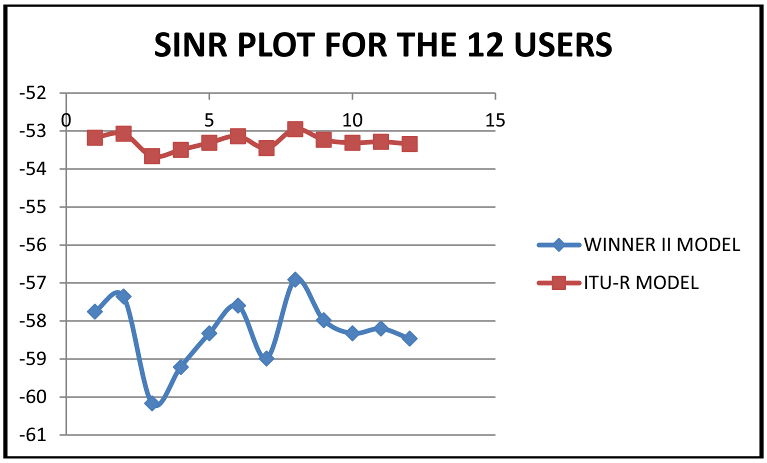

Figure 15:SINR plot for twelve users

Figure 15 shows SINR plot for twelve users where ITU-R model as higher SINRs compared to WINNER II model. It means interference is more paramount in WINNER II model. This interference problem in WINNER II model is as aresult of high concrete penetration wall

4. CONCLUSION

This study considered deployment of indoor femtocells on small scale. Indoor penetration loss is a key parameter in this study. SINR plot for twelve users was obtained where ITU-R model has higher SINRs compared to WINNER II model. It also shows that as femto users are farther away from femto base stations, the path losses increase but decreases when users are at close proximity to the femtocells. It was also observed that the power received for individual femtocells and users for WINNER II and ITU-R models were obtained. The ITU-R model was found to experience lower path losses which produced higher received powers than WINNER II (-57.0445dBm on the average)

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