Comparative Analysis of Indoor Building Coverage (IBC) Planning on 4G LTE 1800 MHz And 900 MHz using the Cost 231 Multiwall Model

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Abstrack - Indoor Building cellular network system is one solution to overcome weak signals transmited by eNodeB. Building with high cellular communication traffic levels , requiring indoor network system to maintain continuity of communication by Users Equipment (UE). It is necessary to plan an Indoor Building Coverage using Femtocell Access Point (FAP). This research is based on network design indoor propagation COST 231-Multiwall Model using the software Radiowave Propagation Simulator (RPS). The collection of data obtained is used to perform calculations on research variables include the calculation of capacity and coverage. The research showed the number of FAP are 3 FAP. The Coverage Results for scenario 2 is the best result compared with the other scenarios, with the following results, the frequency of 1800 MHz at Building 1 of -19.86 dBm and for the 900 MHz frequency in Building 1 at -13.38 dBm.

Keywords :RPS, COST 231-Multiwall, LTE FDD, IBC, Indoor Building Coverage

I. INTRODUCTION

LTE is a technology development of GSM (Global System for Mobile Communications) and UMTS (Universal Mobile Telecommunication System) with a speed higher datarate.

LTE Femtocell technology can improve Indoor Building Coverage (IBC) because of the placement of femtocell eNodeB placed in indoor building. The signal quality indoor is better because of the reduced distance between FAP (Femtocell Access Point) with the user using 1800 Mhz and 900 Mhz. Based on this background, the authors took the research on the topic “Comparative Analysis Of Indoor Building Coverage (IBC) Planning On 4G LTE 1800 Mhz And 900 Mhz Using The Cost 231 Multiwall Model”.

II. BASIC THEORY

A. LTE (Long Term Evolution)

LTE (Long Term Evolution) is the development of third generation technology (3G) WCDMA- UMTS from the 3rd Generation Partnership Project (3GPP) [3].

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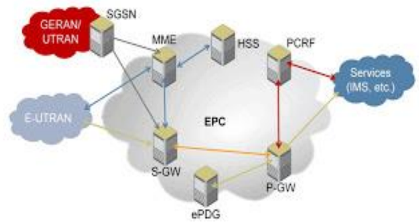

FIGURE 1. LTE Architecture [1]

B. Indoor Building Coverage (IBS)

Indoor Building Coverage is a solution to overcome the problem of weak signal in the room or building, expanding the coverage area of the cell, and overcome high UE Traffic inside the building.[1]

C. Femtocell

Femtocell is a micro base stations technology that use low power level as a solution for customers who are in the room or building.

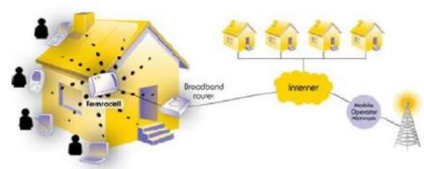

FIGURE 2. Femtocell Concept [2]

Femtocell architecture consists of three main things:
a. Femtocell Access Point (FAP)
b. Security Gateway (SeGW)
c. Femtocell Device Management System (FMS)

D. Indoor Propagation Network

Indoor network propagation model are: [4], [5]

a. One Slope Model is a model that takes into account propagation parameters that affect the calculation of pathloss exponent.

b. Keenan Motley indoor propagation model is a model that takes into account the entire wall in the vertical plane between the transmitter and receiver.

c. Cost 231 Multi-Wall Model is a propagation model where all the walls in the vertical plane and properties of materials between transmitter and receiver included in the calculation

$$LT = LFSL + LC \sum_{i=1}^{M} nwi.Lwinf^{\left[\frac{nf+2}{nf+1} - b\right]} Lf \qquad (1)$$

Information :
LFLS = free space loss
Lfsl = 20 + ^{10}log fMhz 20 ^{10}log d (km) +32.5
LC = constant loss = 37 dB
NWI = the value of the type penetrated wall (partition wall material)
LWI = wall type of loss
LW1 = L Light Wall
Lw2 = L Heavy Wall
Lf = loss between floors adjacent to each other.

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b = empirical parameter (0.46)
M = Number of wall type :
L_{FLS} = *free space loss*
LFSL = 20 ^{10}log fMhz + 20 ^{10}log d(km)+32,5
L_C = *constant loss* = 37 dB
nwi = partition wall materials
Lwi = *wall type loss*
Lw1 = L *Light Wall*
Lw2 = L *Heavy Wall*
L_f = *loss between floors adjacent to each other.*
b = *empirical parameter* (0,46)
M = *Number of wall type*
nf = value from *penetrated floors*

E. **Determining the Number of FAP**

1. **Based on Capacity, [6], [7]**

a. Calculating Future Population

$$\textit{Future Population} = P_0[1 + GF)]^n \quad \textbf{(2)}$$

b. Calculating *Throughput*

Throughput = Bearer rate x Session time x Session duty ratio x [1/(1-BLER)] **(3)**

c. Calculating *Single User Throughput*

Single User Throuhput =

$$\frac{[\Sigma\left(\frac{Throughput}{Session}\right) x\ BHSA\ x\ Penetration\ Ratio\ x\ (1+PAR)]}{3600} \quad \textbf{(4)}$$

d. *Uplink Network Throughtput* (IP)

Uplink Network Throughtput (IP) = Total User Number x UL Single Throughput
(5)

e. *Downlink Network Throughtput* (IP)

Downlink Network Throughput (IP) = Total User Number x DL Single User Throughput **(6)**

f. Total FAP

$$\textbf{FAP Amount} = \frac{User\ Amount}{\text{Number of Users per cell}} \quad \textbf{(7)}$$

2. **Based on Coverage**

a. COST 231 *Multiwall Model*

$$L_T = L_{FSL} + \mathrm{LC} \sum_{i=1}^{M} nwi.Lwi + nf^{\left[\frac{nf+2}{nf+1} - b\right]} Lf \quad \textbf{(8)}$$

b. The covered area

$$L = 2,6\, d^2 \quad \textbf{(9)}$$

c. Femtocell Numbers

$$\textbf{FAP Amount} = \frac{(The\ area\ covered)}{(area\ of\ cell\ coverage)} \quad \textbf{(10)}$$

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III. RESEARCH METHODOLOGY

A. Research Instruments

The research instrument required is a laptop that already installed Radiowave Propagation Simulator (RPS), a site plan of research, and the type of building materials.

B. Research Methods

The research methodology used was simulated. By creating a design that uses Radiowave Propagation Simulator version 5.4.

C. Data Collection

Data preparation for designing The IBC LTE network are femtocell , partition materials, frequency.

IV. DESIGN ANALYSIS AND SIMULATION RESULTS

RESULTS CALCULATION

A. The following describes the calculation of the indoor network planning.

TABLE 1. MAPL *Downlink* Calculation

	Transmitter	**Value**	***Calculation***
A	Max TX *Power* (dBm)	34	
B	TX Antena *Gain* (dBi)	0	
C	*Cable Loss* (dB)	2	
D	EIRP (dBm)	32	d=a+b-c
	Receiver	**Value**	**Calculation**
E	UE *Noise FIGURE* (dB)	7	
F	*Thermal Noise* (dBm)	-137.445	KTB
G	*Receiver Noise Floor* (dBm)	-130.445	g=e+f
H	SINR (dB)	-9	
I	*Receiver Sensitivity* (dBm)	-139.445	i=g+h
J	*Load Factor*	0.7	
K	*Interference Margin* (dB)	4	
L	*Control Channel overhead* (%)	0.1	10%
M	RX Antena *Gain* (dBi)	0	
N	*Body Loss* (dB)	0	
O	*Maximum Path Loss*	**158,445**	o=d-g-k+m-n

Downlink MAPL calculations obtained 158.445 dB.

B. *Indoor Attenuation*

Indoor loss calculation is done to get how big a result of loss of material such as the type of walls, floors, insulation, glass, etc.

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TABLE 2. Building Obstacle Total *Loss*

Obstacle Type	dB	Amount	Total (dB)
Glass	0.8	9	7.2
Concrete	4	6	24
Wood Door	4	1	4
Obstacle Total *Loss*			**35.2**

TABLE 3. Propagation losses in Building

Max Path Loss (dB)	158.445.104
Soft Handoff Gain	0
Obstacle Total *Loss*	35.2
***Allowed Propagation Loss for cell range* (dB)**	**123,245104**

C. **ANALYSIS OF TOTAL FEMTOCELL ACCESS POINT (FAP)**

1. Coverage Based Analysis

TABLE 4. Number of FAP Coverage Based on 1800 and 900 MHz

Parameter	1800 Mhz	900 Mhz
The area	85,62 m^2	85,62 m^2
Coverage Cells	189540 m^2	758160 m^2
FAP Number	1	1

2. Capacity Based Analysis

Capacity based analysis used to estimate the number of users that can be served by a single cell..

TABLE 5. Number of FAP

Parameter	UL	DL
Area	508,15 m^2	
User	50	
Network Throughput (Mbps)	2,400182	20,92775
Site Capacity (Mbps)	10,10878	8,423976
FAP Number	1	3
FAP User Number	50	16,66667

D. ***RADIOWAVE PROPAGATION SIMULATOR ANALYSIS***

1. FAP is placed on the left side of the room

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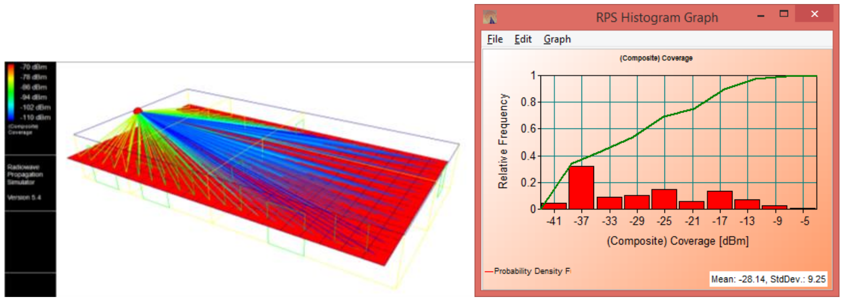

FIGURE 3. FAP display Simulation and *Composite Coverage Result*

2. FAP is placed in the middle of the room

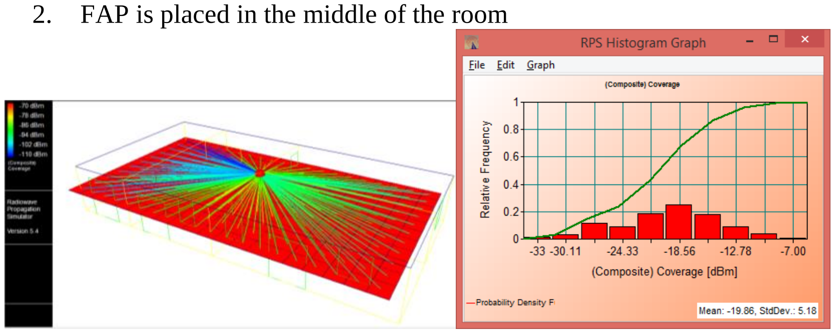

FIGURE 4. FAP display Simulation and Composite Coverage Result

3. FAP is placed on the right side of the room

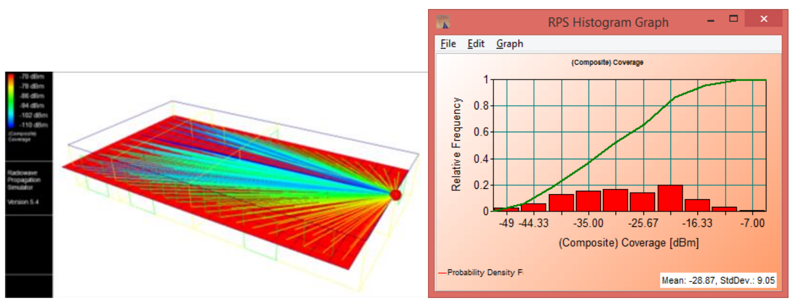

FIGURE 5 FAP display Simulation and Composite Coverage Result

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

Based on the research results, it can be concluded that:

1. Maximum Allowable Path Loss is 158.445 dB for downlink
2. The scenario resulting composite value coverage for the 1800 MHz frequency in Building at -19.86 dBm, While the value for the 900 MHz frequency in Building at -13.38 dBm.

B. Recomendations

1. We can use anothe Frequency 2300 Mhz or 850 Mhz.
2. Bandwidth variation not only uses 5 MHz.

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