Analysis Cost 231 MultiWall Model on 4G LTE FDD 1800 and 900 Mhz Femtocell Network Planning

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Abstrak -Indoor 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 all users. Therefore, it is necessary to plan an indoor network 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) and conducted at Telkom Office. 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 for capacity and coverage is 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, Building 2 at -21.34 dBm, and Building 3 at -28, 07 dBm. While the scenario 2 for the 900 MHz frequency in Building 1 at -13.38 dBm, Building 2 at -14.52 dBm, and building 3 of -20.39 dBm

Index Terms— :Femtocell, RPS, COST 231Multiwall,4G LTE,FDD

I. Introduction

Requirement for data and voice communication is very necessary, not only outdoor users , but also necessary for indoor users eg offices, schools, shopping centers, etc.Indoor Building Coverage is a system with a transmitter and receiver are installed in the building.

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 indoors signal coverage because of the placement of femtocell base station placed in the room. The signal quality indoors is better because of the reduced distance between FAP (Femtocell Access Point) with the user. Based on this background, the authors took the research on the topic **"Analysis Cost 231 MultiWall Model on 4G LTE FDD 1800 and 900 Mhz Femtocell Network Planning".**

II. Basic Theory

A. Mobile Communication System [1]

Mobile communication system is a wireless telecommunications system that delivers good mobility to the user. The service area is divided into small areas called cells.

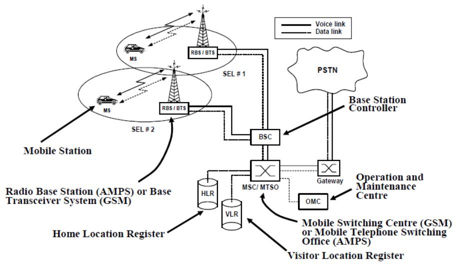

Fig 1. Cellular Communication System Architecture [1]

B. LTE (*Long Term Evolution*)[3]

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

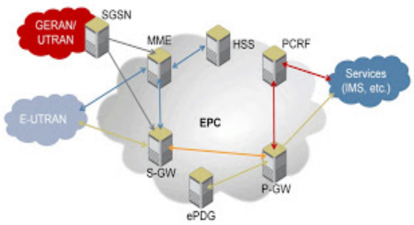

Fig 2. LTEArchitecture[1]

C. *Indoor Building Solution* (IBS)

Indoor Building Solution 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 customer inside the building.[5]

D. Femtocell

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

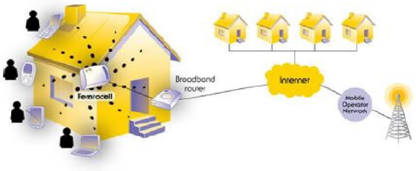

Fig 3. Femtocell Concept [5]

Femtocell architecture consists of three main things:
a. Femtocell Access Point (FAP) is a major node in the network-based femtocell.
b. Security Gateway (SeGW) is a network node that acts to secure the Internet connection between the femtocell users on the service provider's core network.
c. Femtocell Device Management System (FMS) is the part that ensures scalability femtocell network to multiple devices.

E. Indoor Propagation Network

Indoor network propagation model are:

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

$$LT = LFSL + LC \sum_{i=1}^{M} nwi.Lwi nf^{\left[\frac{nf+2}{nf+1}-b\right]} Lf \quad (1)^{[9]}$$

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.
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*

G. Link Budget Calculation

a. Propagation Line of Sight (LOS) is a power drop during the radio waves propagating in free space..

FSL = 32,45 + 20 log f (MHz) + 20 log d(km) (2)[3]

b. *Effective Isotropic Radiated Power* (EIRP).

EIRP = Ptx + Gtx – Ltx (3)[3]

c. *Receive Signal Level* (RSL)
RSL: received signal level at the receiver side.
RSL = EIRP – Lpropagasi + GRX – LRX(4)[1]

d. *SensitivitasReceiver* (SR)
$$SR = kTB + NF + SNR + IM \quad (5)[1]$$

H. Determining the Number of FAP

1. Based on Capacity,

a. Calculating Future Population

$$Future\ Population = P_0[1 + GF)]^n \quad (6)[9]$$

b. Calculating *Throughput*

Throughput = Bearer rate x Session time x Session duty ratio x [1/(1-BLER)] **(7)[9]**

c. Calculating *Single User Throughput*

Single User Throuhput =

$$\frac{[\Sigma\left(\frac{Throughput}{Session}\right) x\ BHSA\ x\ Penetration\ Ratio\ x\ (1+PAR)]}{3600} \quad (8)[9]$$

d. *Uplink Network Throughtput* (IP)

Uplink Network Throughput (IP) = Total User Number x UL Single Throughput **(9)[9]**

Information :

e. *Downlink Network Throughtput* (IP)

Downlink Network Throughput (IP) = Total User Number x DL Single User Throughput **(10)[9]**

f. Total FAP

$$FAP\ Amount = \frac{User\ Amount}{Number\ of\ Users\ per\ cell} \quad (11)[9]$$

2. Based on Coverage

a. COST 231 *Multiwall Model*

$$L_T = L_{FSL} + \mathrm{LC} \sum_{i=1}^{M} nwi.Lwi + nf^{\left[\frac{nf+2}{nf+1} - b\right]} Lf \quad (12)[9]$$

b. The covered area

$$L = 2,6\, d^2 \quad (13)[9]$$

c. Jumlah Femtocell

$$\textbf{FAP Amount} = \frac{(\textit{The area covered})}{(\textit{area of cell coverage})} \quad (14)[9]$$

II. 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

Collecting data in this research is to design and data preparation design results.Data preparation for designing the required data before you can design the indoor LTE network. Sample data is as follows building that will be analyzed, indoor base stations, and partition materials.The data is a result of design data associated with the design form of the calculation result. The data obtained through testing by using a calculation formula.

D. Planning Area Description

Planning area carried at Telkom Office located at Jalan Pemuda No. 74, a total area of 508.15 meter2 with a height of 3.5 meters from the ground which is divided into 3 separate buildings, namely plasa telecoms with an area of 85.62 meter^2, DCS building with an area of 85.93 meter^2, and building division access to the building area of 189.62 meter^2

II. DESIGN ANALYSIS AND SIMULATION RESULTS

A. RESULTS CALCULATION

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

1. *Link Budget*

Table 2. MAPL UplinkCalculation

	Transmitter	Value	*Calculation*
A	Max TX *Power* (dBm)	23	
B	TX Antena *Gain* (dBi)	0	
C	*Body Loss* (dB)	0	
D	EIRP (dBm)	23	d=a+b-c
	Receiver	Value	*Calculation*
E	*Noise Fig* (dB)	2	
F	*Thermal Noise* (dBm)	-137.445	KTB
G	*Receiver Noise Floor* (dBm)	-135.445	g=e+f
H	SINR (dB)	-7	
I	*Receiver Sensitivity* (dBm)	-142.445	i=g+h
J	*Load Factor*	0.7	70%
K	*Interference Margin* (dB)	1	
L	*Cable Loss* (dB)	0	
M	RX Antena *Gain* (dBi)	0	
N	*Fast Fade Margin* (dB)	0	
O	*Maximum Path Loss*	**157.445**	o=d-g-k+m-n

Table 3. 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 Fig* (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

Uplink MAPL Calculation acquired 157.445 dB and downlink MAPL calculations obtained 158.445 dB.

2. *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.

Table 4. Building 1 ObstacleTotal *Loss*

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

Table 5. Building 2 Obstacle Total *Loss*

Obstacle Type	dB	Amount	Total (dB)
Glass	0.8	8	6.4
Concrete	4	6	24
Wood Door	4	2	8
Obstacle Total *Loss*			**38.4**

Table 6. Building 3 Obstacle Total *Loss*

Obstacle Type	dB	Amount	Total (dB)
Glass	0.8	8	6.4
Concrete	4	10	40
Wood Door	4	4	16
Obstacle Total *Loss*			**62.4**

After getting the total value of the indoor attenuation of each building, then take into account the propagation permitted after passing loss.

Table 7. Propagation losses in Building 1

A	*Max Path Loss* (dB)	158.445.104
B	*Soft Handoff Gain*	0
C	Obstacle Total *Loss*	35.2
D	***Allowed Propagation Loss for cell range* (dB) / LT**	**123,245104**

Table 8. Propagation losses in Building 2

A	*Max Path Loss* (dB)	158.445
B	*Soft Handoff Gain*	0
C	Obstacle Total *Loss*	38.4
D	***Allowed Propagation Loss for cell range* (dB) / LT**	**120,045104**

Table 9. Propagation losses in Building 3

a	*Max Path Loss* (dB)	158.445
b	*Soft Handoff Gain*	0
c	ObstacleTotal *Loss*	62.4
d	***Allowed Propagation Loss for cell range* (dB) / LT**	**96,045**

B. ANALYSIS OF TOTAL FEMTOCELL ACCESS POINT (FAP)

1. Coverage Based Analysis

Coverage based analysis is carried out to determine the area that can be covered by FAP.

Table 10. Number of FAP Coverage Based on 1800 MHz

	1800 MHz		
	Building 1	Building 2	Building 3
The area planned	85,62 m^2	81,96 m^2	189,62 m^2
Coverage Cells	189540 m^2	91092 m^2	362,647 m^2
FAP Number	1	1	1

Table 11. Number of FAP Coverage Based on 900 MHz

	900 MHz		
	Building 1	Building 2	Building 3
The area planned	85,62 m^2	81,96 m^2	189,62 m^2
Coverage Cells	758160 m^2	364320,6 m^2	1450,38 m^2
FAP Number	1	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 12. Number of FAP Capacity Based

Item	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

C. *RADIOWAVE PROPAGATION SIMULATOR ANALYSIS*

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

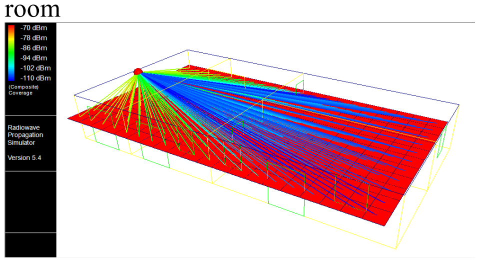

Fig 16. FAP display Simulation

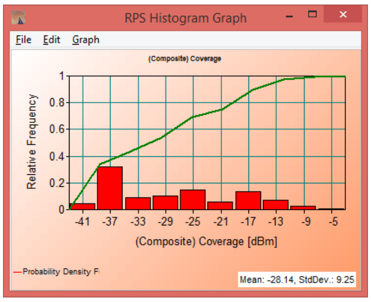

Fig 17. *Composite Coverage Result*

b. FAP is placed in the middle of the room

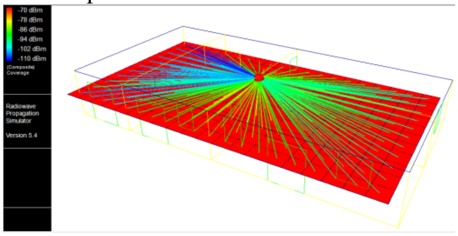

Fig 18. FAP display Simulation

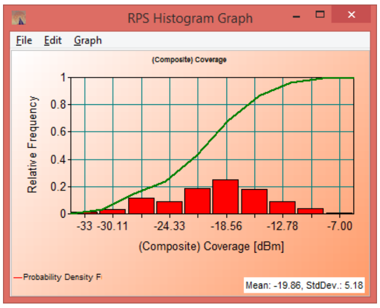

Fig 19. Composite Coverage Result

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

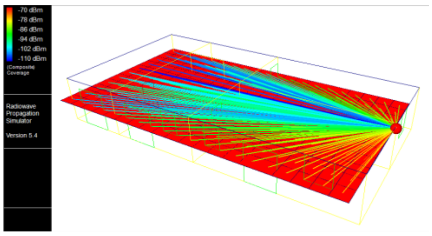

Fig 20. FAP display Simulation

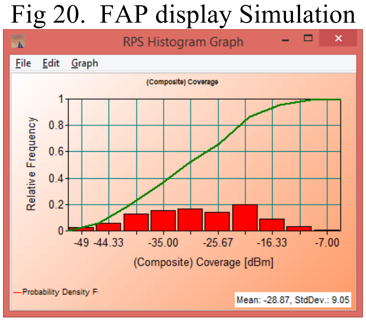

Fig 21. Composite Coverage Result

2. Building 2
   a. FAP is placed on the left side of the room

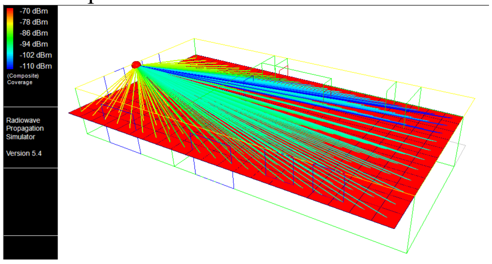

Fig 22. FAP display Simulation

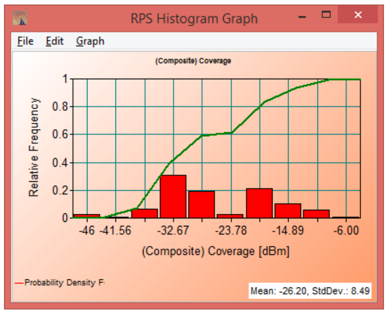

Fig 23. Composite Coverage Result

b. FAP is placed in the middle of the room

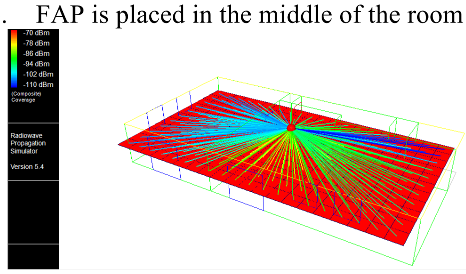

Fig 24. FAP display Simulation

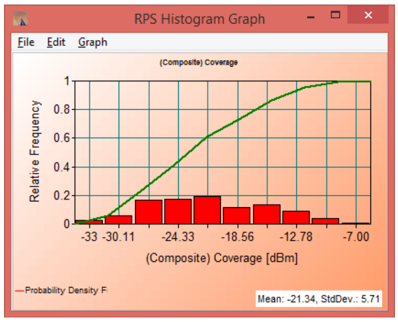

Fig 25. Composite Coverage Result

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

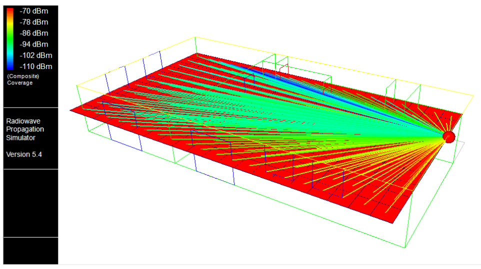

Fig 26. FAP display Simulation

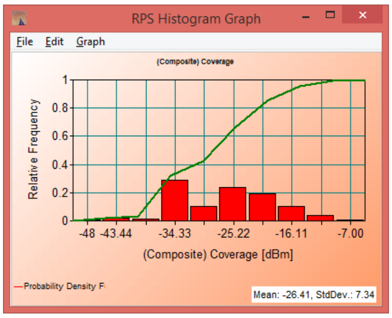

Fig 27. Composite Coverage Result

3. Building 3

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

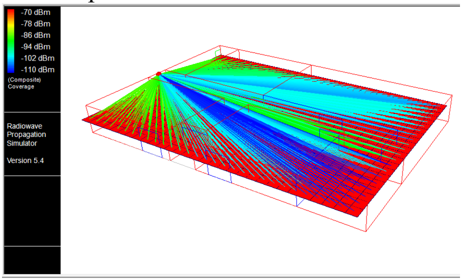

Fig 28. FAP display Simulation

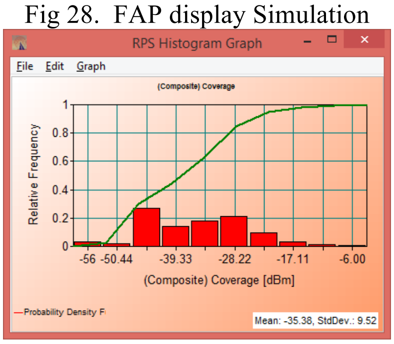

Fig 29. Composite Coverage Result

b. FAP is placed in the middle of the room

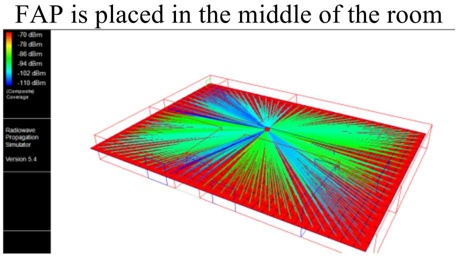

Fig 30. FAP display Simulation

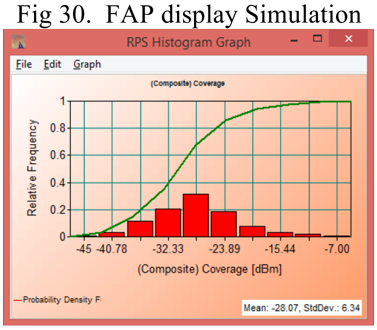

Fig 31. Composite Coverage Result

a. FAP diletakkan di sisi kanan ruangan

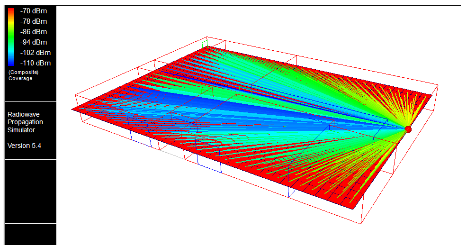

Fig 32. FAP display Simulation

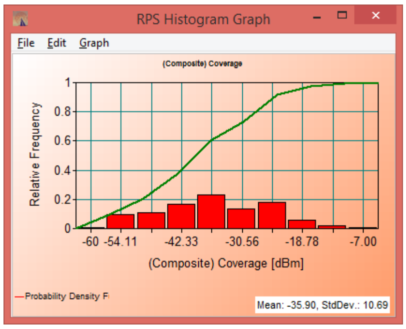

Fig 33. Composite Coverage Result

FAP placement of the whole scenario already have an indicator of average power levels below -70 dBm. However, the most appropriate to be implemented is scenario 2, the beam has the smallest attenuation compared to scenario 1 and scenario 3.

D. PHYSICAL CELL IDENTITY (PCI) ALLOCATION

PCI is naming that is used to identify cells in LTE. Number of PCI on LTE at 504 units consisting of 168 (Secondary Synchronization Signal (SSS) ID group and 3 Primary Syncronization Signal (PSS) ID per group. PCI allocation in this research are 492-501 (located at 164-167 SSS). While the rest of the PCI numbering used for macro cell.

Table 13. PCI Allocation

FAP Number	PCI Number
1	492
2	495
3	498

III. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusion

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

1. Maximum Allowable Path Loss is 157.445 dB for uplink and 158.445 dB for downlink
2. The second scenario is selected in this reserach. The second scenario resulting composite value coverage for the 1800 MHz frequency in Building 1 at -19.86 dBm, in Building 2 at -21.34 dBm, and at

Building 3 of -28.07 dBm.While the value of the second scenario composite coverage for the 900 MHz frequency in Building 1 at -13.38 dBm, in Building 2 at -14.52 dBm, and the Building 3 at -20.39 dBm.

3. The allocation of numbering PCI is 3 PCI ie 492, 495, and 498. This corresponds to the number of FAP because there is no division of sectors in each FAP.

B. Recomendations

1. Not only use the 1800 MHz and 900 MHz but also 2300 Mhz or 850 Mhz. Bandwidth variation not only uses 5 MHz.
2. Selection of partition and building materials more varied so that the simulation results will design more in line with real conditions.

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