4G LTE RADIO NETWORK PLANNING

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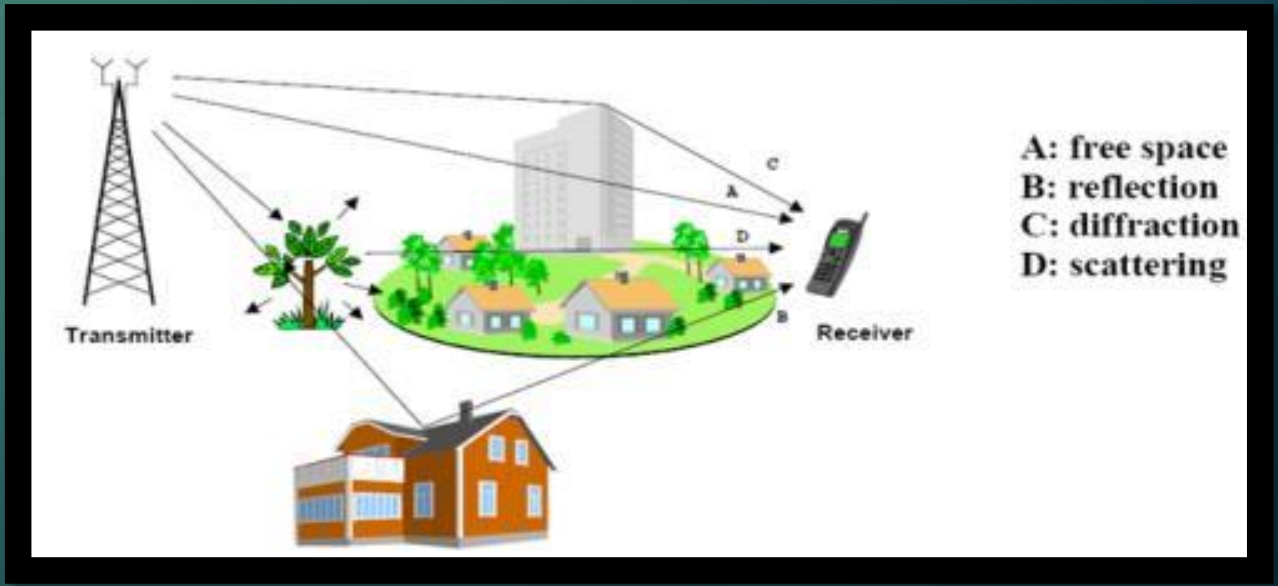
Why pathloss and linkbudget ?

- Mendapatkan kondisi terbaik dari suatu perencanaan.
- Mudah untuk melakukan perbaikan perencanaan

PATHLOSS

- Metode yang digunakan untuk mengukur suat loss yang disebabkan oleh cuaca, kontur tanah dll agar tidak mengganggu pemancar antar 2 buah antena yang saling berhubungan.
- Pelemahan – pelemahan sinyal bisa terjadi karena

a. Atenuasi
b. Refleksi
c. Difraksi
d. Scattering



Model Pathloss

- COST – 231
- OKUMURA-HATA
- ERCEG-GREENSTEIN (SUI)
- LONGLEY –RICE
- SAKAGAMI EXTENDED

COST – 231 HATTA

PL = 46,3 + 33,9log fc – 13.82 log hb – a(hr) + (44,9 – 6,55log hm) logd + CM

Parameter	Notasi	Spesifikasi
Frekuensi Pembawa	Fc	1500 – 2000 Mhz
Tinggi Antenna BTS	hb	4-50 m
Tinggi Antena MS	hm	1-3 m
Jarak BTS dengan MS	D	0,02 – 5 km

a(hr) = (1,1 log (f) – 0,7)hb – (1,56 log 9f) – 0,8) ; Small area
a(hr) = 3,2 (log 11,75hb)2 – 1.1 dB ; Large Area
CM = 0 ; Small Area
CM = 3 ; Large Area

OKUMURA HATTA MODEL

PL = 69.55 + 26,16log fc – 13.82 log hb – a(hr) + (44,9 – 6,55log (hm) logd)

Parameter	Notasi	Spesifikasi
Frekuensi Pembawa	Fc	150 -1500 Mhz
Tinggi Antena BTS	Hb	30-200 m
Tinggi Antena MS	Hm	1-10 m
Jarak BTS dengan MS	D	1-20 km

a(hr) = (1,1 log (f) – 0,7)hb – (1,56 log (f) – 0,8) ; Small area
a(hr) = 3,2 (log 11,75hb)2 – 1.1 dB ; Large Area

LINK BUDGET

- COVERAGE PLANNING
- CAPACITY PLANNING

  Based Throughput

COVERAGE PLANNING

Comment Parameter	Unit	Uplink Calculations	Calculation
UE Tx Power	dBm	23	a
Body Loss	dB	2	b
eNB Gain	dBi	17	c
Feeder Loss	dB	2	d
TMA nsertion Loss	dBm	0,5	e
Thermal Noise	dB	-203,9772292	f
eNB Noise Figure	dB	4	g
SINR	dB	11	h
System Bandwidth	dB	69,54242509	i = 10*log(RB*12*15000)
Receiver Sensitivity	dBm	-119,4348041	j= f+g+h+i
Penetration Loss	dB	10	k
Fading Margin	dB	10	l
Interface Margin	dB	3	m
MAPL	dB	131,9348041	n=a-b+c-d-e+j-k-l-m

Comment Parameter	Unit	Downlink Calculations	Calculation
UE Tx Power	dBm	43	a
Body Loss	dB	3	b
eNB Gain	dBi	17	c
Feeder Loss	dB	2	d
TMA insertion Loss	dBm	0,5	e
Thermal Noise	dB	-203,9772292	f
UE Antena Gain	dBi	0	g
eNB Noise Figure	dB	6	h
SINR	dB	7	i
System Bandwidth	dB	69,54242509	j = 10*log(RB*12*15000)
Receiver Sensitivity	dBm	-121,4348041	k= f+h+i+j
Penetration Loss	dB	10	l
Fading Margin	dB	38	m
Interface Margin	dB	3	n
MAPL	dB	127,9348041	o=a+c-d-e+k-l-m-n

Downlink link budget LTE			
Comment Parameter	Unit	Downlink Calculations	Calculation
Tx RF Power	dBm	43	A
TX Diversity Gain	dB	3	B
Tx RF Line Loss	dBi	1	C
Tx Antenna Gain	dB	17	D
Tx AA Gain	dBm	0	E
EIRP	dB	62	f= a+b-c+d+e
Thermal Noise	dBm/Hz	-174	G
Subcarier Bandwidth	Hz	15000	h
Occupied Subcariers		600	i= 12*50
Noise Figure	dB	6	J
MCS	dBm	QPSK	K
SNR	dB	1.564	L
Fast Fade Margin	dB	4.5	M
Rx Diversity	dB	3	N
HARQ	dB	0	O
Rx Faded Sensitifity	dBm	-95.3	p = g + 10LOG (h*i) + j + l + m - n-o
Rx Antenna Gain	dB	7	Q
Rx RF Line Loss	dB	0	R
Effective Rx Faded Sensitivity	dBm	-102.3	s = p-q+r
Body, Vehicle, Building Loss	dB	10	T
Interference Margin	dB	2	U
Log Normal margin	dB	6.5	V
MAPL	dB	145.89	w= f -s-t-u-v

Uplink link budget LTE			
Comment Parameter	Unit	Uplink Calculations	Calculation
Tx RF Power	dBm	23	a
TX Diversity Gain	dB	0	b
Tx RF Line Loss	dBi	0	c
Tx Antenna Gain	dB	7	d
Tx AA Gain	dBm	0	e
EIRP	dB	30	f= a+b-c+d+e
Thermal Noise	dBm/Hz	-174	g
Subcarier Bandwidth	Hz	15000	h
Occupied Subcariers		120	i= 12*10
Noise Figure	dB	4	j
MCS	dBm	QPSK	k
SNR	dB	-4.6	l
Fast Fade Margin	dB	4.5	m
Rx Diversity	dB	3	n
HARQ	dB	0	o
Rx Faded Sensitifity	dBm	-100.5	p = g + 10LOG (h*i) + j + l + m - n-o
Rx Antenna Gain	dB	17	q
Rx RF Line Loss	dB	1	r
Effective Rx Faded Sensitivity	dBm	-126.5	s = p-q+r
Body, Vehicle, Building Loss	dB	10	t
Interference Margin	dB	2	u
Log Normal margin	dB	6.5	v
MAPL	dB	134.0	w= f -s-t-u-v

- $EIRP = Ptx + Gtx_{DG} - Ltx + Gtx + Gtx_{AA}$

Ptx	= Daya *Transmitter* (43 dBm)
Gtx_{DG}	= *Gain diversity transmitter* (3 dB)
Ltx	= *Loss Line* (1 dB)
Gtx	= *Gain antenna transmitter* (17 dB)
Gtx_{AA}	= *Gain adaptive array* (0 dBm)

Sehingga didapatkan persamaan seperti berikut :

EIRP = 62 dBm

- $RX_{FS} = kT + 10Log(SC_{Bw} \times SCo) + NF + SNR + FF - G_{RXDG}$

kT = *Thermal Noise* (-174 dBm)

SCBW = *Subcarrier Bandwidth* (15kHz)

SCo = *Occupied Bandwidth* (600)

NF = *Noise Figure* (6 dB)

SNR = *Signal to Noise ratio* (1.564 dB)

FF = *Fade Margin* (4.5 dB)

GRXDG = *Rx Diversity Gain* (3 dB)

$RX_{FS} = -174 + 10Log(15000 \times 600) + 6 + (1.564) + 4.5 - 3 - 0$

RX_{FS}= - 95.3 dBm

- $Thermal\ Noise = 10\ Log\ (k.T)$

k = konstanta boltzman (1.38×10^{-20}) mWs/K

T = Suhu (290 K)

$$Thermal\ Noise = 10\log(k.T)$$

$$Thermal\ Noise = 10\log(1.38\ \times\ 10^{-20}.290)$$

$Thermal\ Noise = -174\ \text{dBm/Hz}$

- *Occupied Subcarrier (SCo)*

SCo=Resource Block ×Subcarrier Per Resource Block

SCo=50 ×12

SCo=600

Channel Bandwidth Mhz	1.4	3	5	10	15	20
Subcarrier Bandwidth, Khz	15	15	15	15	15	15
Subcarrier per Resource Block	12	12	12	12	12	12
Number of Resource Block	6	15	25	50	75	100

Tabel Kanal AWGN

MCS index	Downlink			Uplink		
	Modulation	Coding Rate	SNR,dB	Modulation	Coding rate	SNR,dB
0	QPSK	0.1172	-6.475	QPSK	0.1000	-7.231
1	QPSK	0.1533	-5.182	QPSK	0.1250	-6.164
2	QPSK	0.1885	-4.131	QPSK	0.1550	-5.113
3	QPSK	0.2452	-2.774	QPSK	0.2050	-3.701
4	QPSK	0.3008	-1.649	QPSK	0.2500	-2.658
5	QPSK	0.3701	-0.469	QPSK	0.3100	-1.480
6	QPSK	0.4385	0.561	QPSK	0.3650	-0.544
7	QPSK	0.5137	1.564	QPSK	0.4300	0.440
8	QPSK	0.5879	2.479	QPSK	0.4900	1.263
9	QPSK	0.6631	3.335	QPSK	0.5550	2.085
11	16QAM	0.3691	4.140	16QAM	0.3075	2.794
12	16QAM	0.4238	5.243	16QAM	0.3525	3.789
13	16QAM	0.4785	6.285	16QAM	0.4000	4.771
14	16QAM	0.5400	7.403	16QAM	0.4500	5.748
15	16QAM	0.6016	8.478	16QAM	0.5025	6.727
16	16QAM	0.6426	9.168	16QAM	0.5350	7.313
17	64QAM	0.4277	9.168	16QAM	0.5700	7.931
18	64QAM	0.4551	9.846	16QAM	0.6300	8.963
19	64QAM	0.5049	11.060	16QAM	0.6925	10.010
20	64QAM	0.5537	12.250	16QAM	0.7525	10.994
21	64QAM	0.6016	13.398	64QAM	0.5017	10.994
22	64QAM	0.6504	14.534	64QAM	0.5417	11.961
23	64QAM	0.7021	15.738	64QAM	0.5850	12.995
24	64 QAM	0.7539	16.934	64QAM	0.6283	14.017
25	64 QAM	0.8027	18.067	64QAM	0.6700	14.991
26	64QAM	0.8525	19.196	64QAM	0.7100	15.920
27	64QAM	0.8887	20.032	64QAM	0.7417	16.652
28	64QAM	0.9258	20.866	64QAM	0.7717	17.343

- *Effective Rx Faded Sensitivity* (RX_{EFS})

$RX_{EFS} = RX_{FS} - G_{RX} + L_{RX\_LL}$

RX_{FS} = Rx *Faded Sensitivity* (-102.8 dBm)

G_{RX} = *Gain Antenna Receiver* (7 dB)

L_{RX_LL} = RF *Line Loss Receiver* (0 dB)

〚RX〛_(EFS) = -95,3- 7+ 0

〚RX〛_(EFS) = -102.3 dBm

- $MAPL = Tx_{EIRP} - RX_{EFS} - L_{BV} - M_{interference} - M_{SF}$

T_{XEIRP} = *Effective Isotropic Radiated Power* (62 dBm)

R_{xEFS} = *Effective Rx Faded Sensitivity* (-102.3 dBm)

L_{BV} = *Body, Vehicle, Building Loss* (10 dB)

$M_{interference}$ = *Margin Interference* (2 dB)

M_{SF} = *Log Normal Margin* (6.5 dBm)

MAPL = 62-(-102.3)-10-2-6.5

MAPL = 145.89 dBm

- $Lu = 46.3 + 33.9\log(f) - 13.82\log(\mathrm{Hb}) - \mathrm{a}(\mathrm{Hm}) + [44.9 - 6.55\log(\mathrm{Hb})]\log(d) + CM$

Lu =46.3+33.9 log(f)-13.82 log(Hb)- a(Hm)+ [44.9-6.55 log(Hb)]logd+Cm

145.89 =46.3+33.9 log(1800)-13.82 log(40)- 4.37+ [44.9 - 6.55log(40)]logd+0

145.89 =46.3+110.35-22.14- 4.37+ 34.41 logd+0

145.89 = 130.14 + 34.41log d

log⟦d ⟧ = (130.14-145.89)/(-34.41)

log⟦d ⟧ = 0.45

d =2.82 km

- $Jumlah\ e\ Node\ B = \frac{Luas\ Area\ perencanaan}{Luas\ Hexagonal}$

Luas Hexagonal=1.95 × d^(2)×2.6

Luas Hexagonal=1.95 ×2.82×2.6

Luas Hexagonal=40,31 km2

Jumlah e Node B= (63,462)/40,31

Jumlah e Node B= 1,54 sites

CAPACITY PLANNING, Based On THROUGHPUT

Network Througput Based

Traffic Parameters	Uplink				Downlink				UL	DL
	Bearer Rate (Kbps)	PPP Session Time (s)	PPP Session Duty Ratio	BLER	Bearer Rate (Kbps)	PPP Session Time (s)	PPP Session Duty Ratio	BLER	Through put/Sess ion (Kbit)	Through put/Ses sion (Kbit)
VoIP	26.90	80	0.4	1%	26.90	80	0,4	1%	869.49	869.5
Video Phone	62.53	70	1	1%	62.53	70	1	1%	4421.31	4421.31
Video Conference	62.53	1800	1	1%	62.53	1800	1	1%	113690.9	113690.9
Real Time Gaming	31.26	1800	0.2	1%	125.06	1800	0,4	1%	11367.3	90952.7
Streaming Media	31.26	3600	0.05	1%	250.11	1800	0,05	1%	5683.6	864016.4
IMS Signalling	15.63	7	0.2	1%	15.63	7	0,2	1%	22.1	22.1
Web Browsing	62.53	1800	0.05	1%	250.11	1800	0,05	1%	5684.5	22737.3
File Transfer	140.69	600	1	1%	750.34	600	1	1%	85266.6	454751.5
Email	140.69	50	1	1%	750.34	15	1	1%	7105.6	11368.8
P2P File Sharing	250.11	1200	1	1%	750.34	1200	1	1%	303163.6	909575.8

Trafic Model For Various Environment

User Behaviour	Dense Urban		Urban		Suburban		Rural	
	Penetration Ratio	BHSA	Penetration Ratio	BHSA	Penetration Ratio	BHSA	Penetration Ratio	BHSA
VoIP	100%	1.4	100%	1.3	50%	1	50%	0.9
Video Phone	20%	0.2	20%	0.16	10%	0.1	5%	0.05
Video Conference	20%	0.2	15%	0.15	10%	0.1	5%	0.05
Real Time Gaming	30%	0.2	20%	0.2	10%	0.1	5%	0.1
Streaming Media	15%	0.2	15%	0.15	5%	0.1	5%	0.1
Signalling	40%	5	30%	4	25%	3	20%	3
Web Browsing	100%	0.6	100%	0.4	40%	0.3	30%	0.2
File Transfer	20%	0.3	20%	0.2	20%	0.2	10%	0.2
Email	10%	0.4	10%	0.3	10%	0.2	5%	0.1
P2P File Sharing	20%	0.2	20%	0.3	20%	0.2	5%	0.1

Throughput

$$Thr_{session} = R_{bearer} \times t_{session} \times D \times (1/(1 - BLER)$$

$Thr_{session}$ = Banyaknya bit yang diterima oleh tiap *user equipment* (UE) per-sesi suatu layanan

R_{bearer} = Laju data pada *layer* aplikasi (*bearer rate*)

$t_{session}$ = *Session time,* durasi suatu layanan

D = *Duty Ratio,* laju transmisi data per-sesi suatu layanan

$BLER$ = *Block Error Rate,* laju error layanan karena kapasitas penuh/*blocking*

Single User Throughput

$$Thr_{SU} = \frac{Thr_{session} \times BHSA \times R_{penetration} \times R_{PAV}}{3600\ s}$$

Thr_{SU} = Rata-rata banyaknya bit yang diterima oleh tiap UE per-layanan

$Thr_{session}$ = Banyaknya bit yang diterima oleh tiap UE per-sesi suatu layanan

$BHSA$ = *Busy Hour Service Attempt*, percobaan untuk mendapatkan suatu layanan oleh UE pada jam sibuk

$R_{penetration}$ = *Penetration Ratio*, yaitu seberapa bagus suatu layanan dapat mempengaruhi *subscriber*

R_{PAV} = *Peak To Average Ratio*, Asumsi prosentase beban lebih jaringan terbesar yang bisa terjadi pada area tertentu (di modul ini hanya menggunakan area urban dan suburban)

Network Throuhput

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

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

- Total user number = Forecasting number of users in an operator
- UL Single user throughput = Total uplink throughput of a single user in desired service area
- DL Single user throughput = Total downlink throughput of a single user in desired service area

Up and Down Cell capacity

DL Cell Capacity + CRC = (168 – 36 – 12) x (Code bits) x (Code Rate) x Nrb x C x 1000

UL Cell Capacity + CRC = (168 – 24) x (Code bits) x (Code Rate) x Nrb x C x 1000

Amount Of eNodeB

$$Number\ of\ Site = \frac{Network\ Throughput}{Site\ Capacity}$$