LinkBudget & SINR MAP
(A Two-cell case)

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Contents

I. 주파수에 따른 Model’s SINR 계산

SINR(Signal to Interference plus Noise Ratio)

- SINR=S/(N+I)

- N = -174 + 10log(B) + F = -159.7 -> 1.07e-16(W)
  - B= 수신기의 대역폭 (Hz) -> 20MHz로 가정
  - F= 수신기 잡음 지수 (dB) –> 7dB로 가정

Linkbudget 가정값

수신 전력(dBm) = 전송 전력(dBm) + 이득(dB) - 손실(dB)

이득	G_{TX}	송신기 안테나 이득(dBi)	5[dBi]
	G_{RX}	수신기 안테나 이득(dBi)	5[dBi]
손실	L_{TX}	송신기 손실(동축, 커넥터 등) [dB]	이상적인 송수신기
	L_{RX}	수신기 손실(동축, 커넥터 등) [dB]	이상적인 송수신기
	L_{FS}	경로 손실 [dB]	
	L_{M}	기타 손실(페이드 마진, 바디 손실, polarization-mismatch 등) [dB]	10[dB]
	h_B	기지국 안테나 높이 :	50[m]
	h_M	이동국 안테나 높이 :	1[m]

Model's SINR 계산

- Hata model (800MHz, 1.9GHz)

$$L_{urban} = 69.55 + 26.16\log(f) - 13.82\log(h_{te}) - a(h_{re}) + [44.9 - 6.55\log(h_{te})]\log d$$

$$\alpha(h_{re}) = \begin{cases} 8.29(\log 1.54 h_{re})^2 - 1.1dB & \text{for } f_c \le 300MHz \\ 3.2(\log 11.75 h_{re})^2 - 4.97dB & \text{for } f_c \ge 300MHz \end{cases}$$

L_{urban}	도심지역에서 전파 손실 (dB)
f_c	전송 주파수
h_{te}	기지국(송신) 안테나 높이,30m-200m
h_{re}	수신기 안테나 높이, 1m-9m
d	기지국과 수신기 사이의 이격거리 (km)
$\alpha(h_{re})$	안테나 높이 교정 요소

Model's SINR 계산

- COST 231 Model (800MHz, 1.9GHz)

$$L_{P(COST)}(dB) = 46.3 + 33.9\log(f_c) - 13.82\log(h_b) - a(h_m) + (44.9 - 6.55\log(h_b))\log(d) + C_K$$

$$\alpha(h_{re}) = \begin{cases} 8.29(\log 1.54 h_{re})^2 - 1.1dB & \text{for } f_c \le 300MHz \\ 3.2(\log 11.75 h_{re})^2 - 4.97dB & \text{for } f_c \ge 300MHz \end{cases}$$

C_k: 3 도심지역

(Hata 모델과 Parameter와 Patameter의 단위 동일)

Model's SINR 계산

- SUI Model (28GHz)

$$PL_{SUI} = PL(d_0) + 10n\log_{10}\left(\frac{d}{d_0}\right) + X_{fc} + X_{hr} + S$$

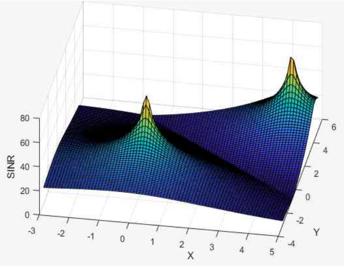
$$PL(d_0) = 20\log_{10}\left(\frac{4\pi d_0}{\lambda}\right), \quad n = a - bh_t + \frac{c}{h_t}, \quad X_{fc} = 6\log_{10}\left(\frac{f_{MHZ}}{2000}\right), f_c > 2GHz$$

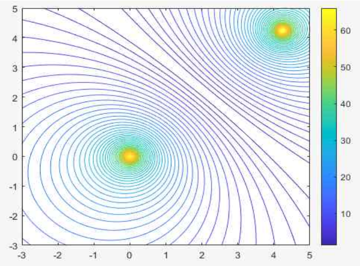
$$terrain\ type\ C{:}\ X_h = -20\log_{10}\left(h_r\ /\ 2000\right)$$

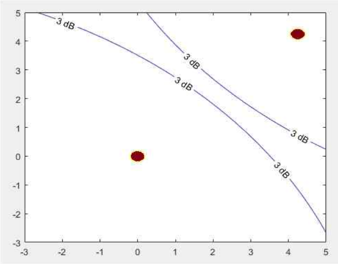
$$terrain\ type\ A\ and\ B{:}\ X_h = -10.8\log_{10}\left(h_r\ /\ 2000\right)$$

II. Model's SINR Map

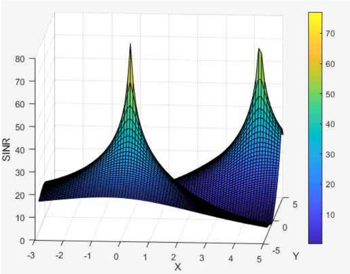
Hata model's SINR Map (800MHz)

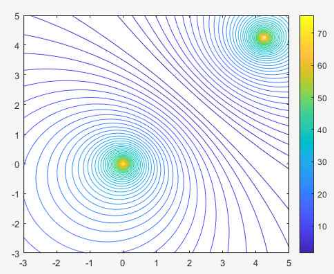


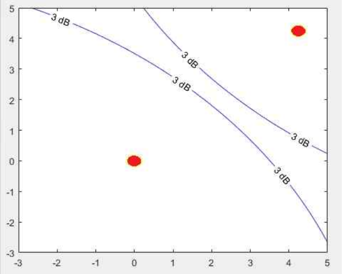




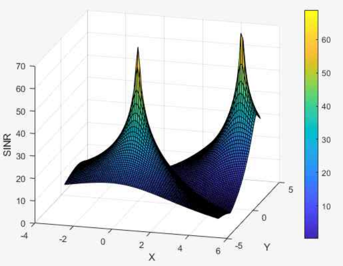
Hata model’s SINR Map (1.9GHz)

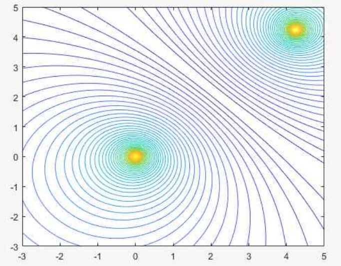


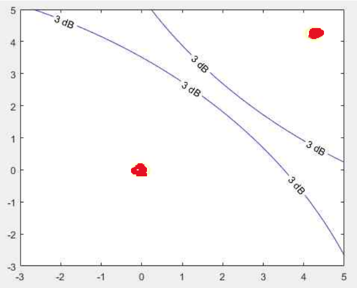




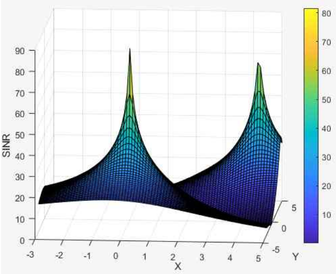
Cost 231 model's SINR Map(800MHz)

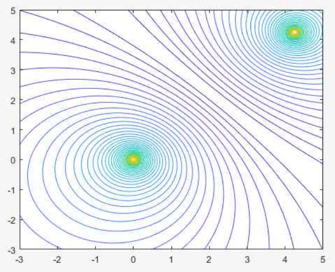


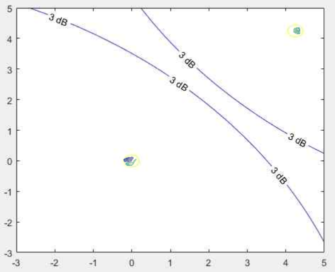




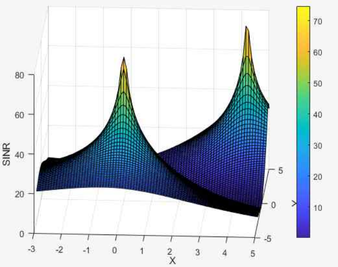
Cost 231 model's SINR Map (1.9GHz)

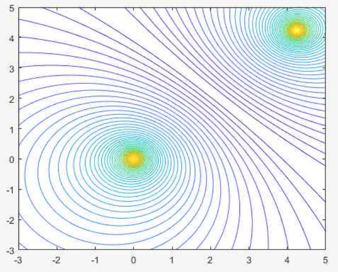


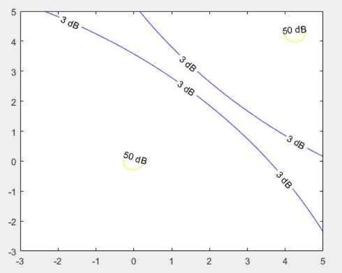




SUI model's SINR Map (28GHz)

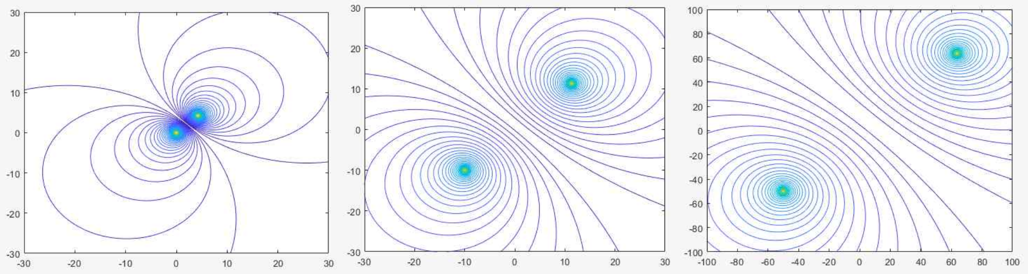






III. Conclusion

Conclusion

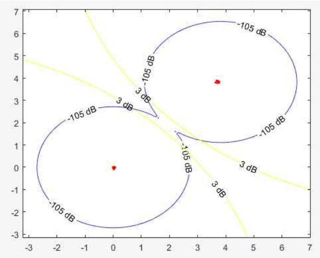


SINR	Signal strength	Description
>= 20 dB	Excellent	Strong signal with maximum data speeds
13 dB to 20 dB	Good	Strong signal with good data speeds
0 dB to 13 dB	Fair to poor	Reliable data speeds may be attained, but marginal data with drop-outs is possible. When this value gets close to 0, performance will drop drastically
<= 0 dB	No signal	Disconnection

Conclusion

Model	주파수	두 안테나 사이 거리	HPA
Hata (최대거리: 5.06km)	800MHz	1km	-1.7851dBm = 0.66mW
		3km	14.328dBm = 27.09mW
		5km	21.8203dBm = 152.06mW
	1.9GHz	1km	8.0421dBm = 6.37mW
		2km	18.21dBm = 66.22mW
COST 231 (최대거리: 2.5918km)	800MHz	1km	0.4347dBm = 1.11mW
		3km	16.548dBm = 45.16mW
		5km	24.0402dBm = 253.52mW
	1.9GHz	1km	13.1697dBm = 20.75mW
		2km	23.336dBm = 215.58mW
SUI (최대거리: 969.12m)	28GHz	200m	9.29dBm = 8.49mW
		400m	20.5792dBm = 114.26mW
		800m	31.8678dBm = 1537.37mW

<SINR 3dB를 만족하며 거리에 따른 최적의 송신파워>



3dB를 만족하며 −105dBm의 수신 민감도를 고려한 2cell 구조

IV. Appendix

Matlab code

- 안테나 위치 및 송수신기 위치

```
tx1.x = 0;
tx1.y = 0;
tx2.x = 3*sqrt(2);
tx2.y = 3*sqrt(2);

tx_h = 50;
rx_h = 1;
```

Matlab code

- x, y범위 지정, d_1 d_2의 각 Tx에서 거리

```
[x, y] = meshgrid(-3:0.1:5);
d_1 = sqrt((x-tx1.x).^2 + (y-tx1.y).^2);
d_2 = sqrt((x-tx2.x).^2 + (y-tx2.y).^2);
d_close = d_1;
d_far = d_2;
for c = 1:1:81
    for r = 1:1:81
        if d_1(c, r)>d_2(c, r)
            d_close(c, r) = d_2(c, r);
            d_far(c, r) = d_1(c, r);
        end
    end
end
```

Matlab code

- Hata model 식

```
PL_hata_1 = 69.55 + 26.16*log10(fq) - 13.82*log10(tx_h) - 3.2 * (log10(11.75 * rx_h))^2 - 4.97 + (44.9 - 6.55 * log10(tx_h)) * log10(d_close);

PL_hata_2 = 69.55 + 26.16*log10(fq) - 13.82*log10(tx_h) - 3.2 * (log10(11.75 * rx_h))^2 - 4.97 + (44.9 - 6.55 * log10(tx_h)) * log10(d_far);
```

- COST 231 model 식

```
PL_cost_1 = 46.3 + 33.9 * log10(fq) - 13.82*log10(tx_h) - 3.2 * (log10(11.75 * rx_h))^2 - 4.97 + (44.9 - 6.55 * log10(tx_h)) * log10(d_close) + 3;

PL_cost_2 = 46.3 + 33.9 * log10(fq) - 13.82*log10(tx_h) - 3.2 * (log10(11.75 * rx_h))^2 - 4.97 + (44.9 - 6.55 * log10(tx_h)) * log10(d_far) + 3;
```

Matlab code

- SUI model 식

```
PL_sui_1 = 20*log10(4*pi*100*fq)-147.55+10*(3.6-
0.005*tx_h+20/tx_h)*log10(d_close/100)+6*log10(fq/2000)-20*log10(rx_h/2);

PL_sui_2 = 20*log10(4*pi*100*fq)-147.55+10*(3.6-
0.005*tx_h+20/tx_h)*log10(d_far/100)+6*log10(fq/2000)-20*log10(rx_h/2);
```

- 무한대 제거

```
rx_tx1 = 23.01 - PL_sui_1;
rx_tx2 = 23.01 - PL_sui_2;
rx_tx1(isinf(rx_tx1)) = C;
rx_tx2(isinf(rx_tx2)) = C;
z = rx_tx1 - rx_tx2;
```

Matlab code

- 3D

```
surf(x, y, z)
xlabel('X')
ylabel('Y')
zlabel('SINR’)
```

- 등고선

```
contour(x, y, z, 50)
```

- 3dB위치와 송수신기 위치

```
contour(x, y, z, [0 3 50], "ShowText", true, "LabelFormat", "%d dB")
```

V. Reference

Reference

- Park, Ju-Yong, Kim, Ki-Jung, Kim, Jeong-Su, & Lee, Moon-Ho. (2015). Cell Edge SINR of Multi-cell MIMO Downlink Channel. *The Journal of The Institute of Internet, Broadcasting and Communication*, *15*(4), 105–117. https://doi.org/10.7236/JIIBC.2015.15.4.105
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