STUDY FOR CELLULAR SATELLITE CAPACITY

SNR (Signal-to-Noise Ratio) quantifies how strong the received signal is compared to background noise:

$$SNR(linear) = \frac{P_{signal}}{P_{noise}}$$

$$SNR = 10\ log_{10}\left(\frac{P_{signal}}{P_{noise}}\right)$$

A higher SNR means:

- More reliable transmission
- Higher achievable data rates
- Better spectral efficiency (bits per Hz)

Shannon Capacity Formula

The Shannon capacity of a single-user wireless channel:

$$C = B \cdot log_2(1 + SNR)$$

C = channel capacity in bits per second (bps)

B = bandwidth in Hz

SNR = signal to noise ratio (linear)

Cellular antenna can range from 1.4 MHz to 20 MHz we will select 20 MHz to use more advanced antennas.

Let's assume we are using 4G for the network. The SNR range in 4G will be 15 dB to 30 dB. Let's assume SNR_{dB} it is 15 dB

$SNR\ (linear)$ = 31.6

Average user data requirement = 128 kbps

Then:

$$C_{antenna} = \ 20 \times 10^6 \cdot \log(1 + 31.6) \approx 100.6\ Mbps$$

Now divide by per-user data rate:

$$Capacity_{users} = \frac{100.6Mbps}{128kbps} \approx 786$$

This calculation shows the errorless and ideal condition. In a real world result will be different:

There are some factors that reduces the capacity:

- Protocol overhead (headers, control signals)
- Coding and modulation inefficiencies
- Variable channel quality (some users have worse SNR)
- Time wasted due to user switching and idle periods
- Backhaul or processing bottlenecks

So we apply a realistic "efficiency factor". It is accepted as 0.4 or 0.5 often

If we accept 0.4:

$$786 \cdot 0.5 = 393\ users\ (realistic\ max)$$

And finally, rounding down to ensure safety and stability, we choose:

300 users per antenna