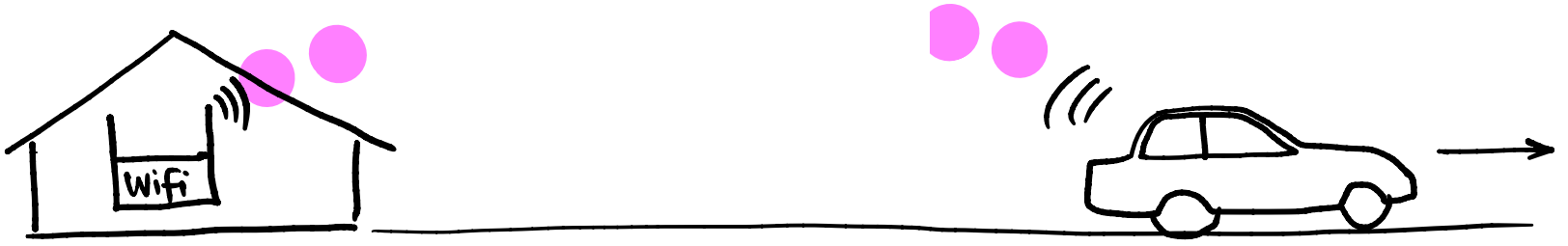
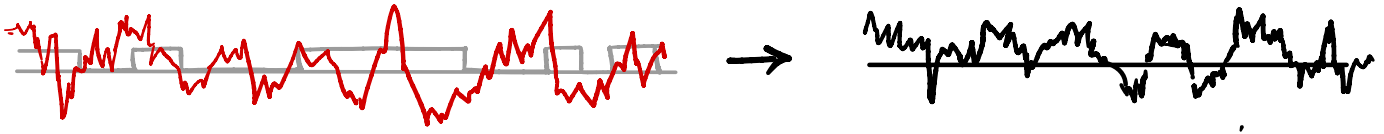
Cellular Networks

① Connecting over long distances



- Difficult because → Power attenuates with distance → bit errors

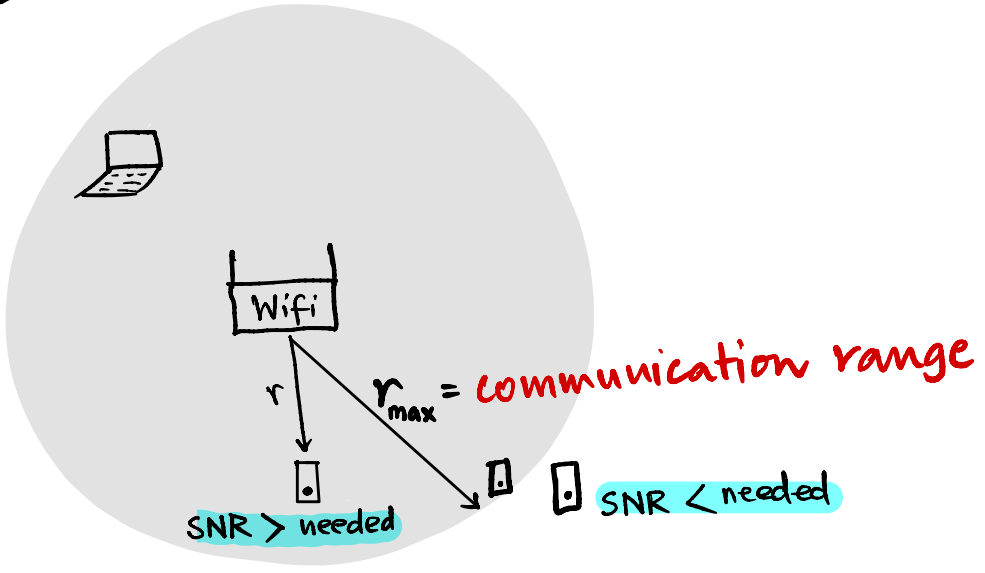
Recall :



- What matters is the ratio : $\frac{\text{Received power of signal (S)}}{\text{Power of (noise (N) + interference (I))}}$

$= \frac{S}{N+I}$ called SINR

② Communication Range



- Power attenuates $\frac{1}{r^2}$
- Received power $S = \frac{\text{Transmit power}}{r^2}$

P_t = Transmitted power = 100

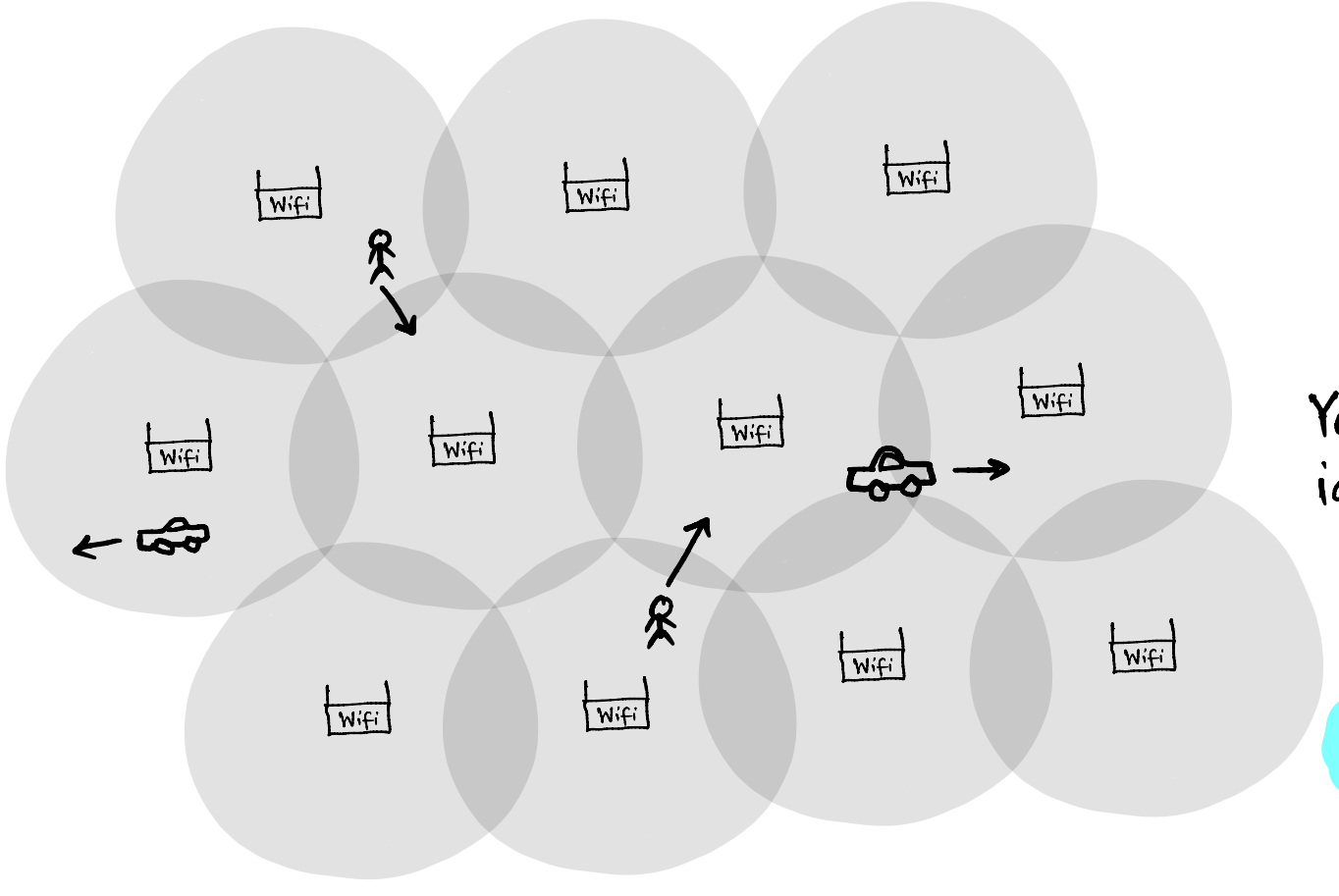
N = Noise power = 3

I = Interference = 0

SNR needed = 1.33

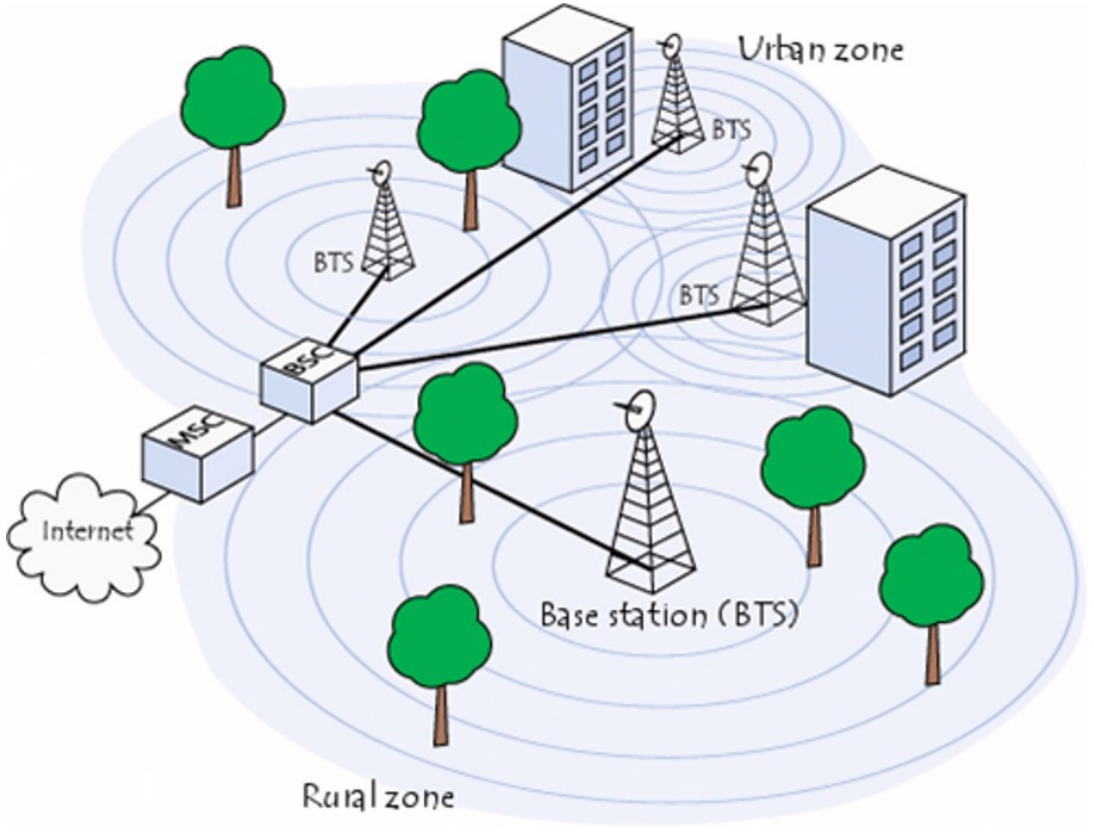
What is the communication range of wifi in this case ?

③ Why not blanket cover the city with Wifi?



Yes that's the idea with cellular networks ...

Except...

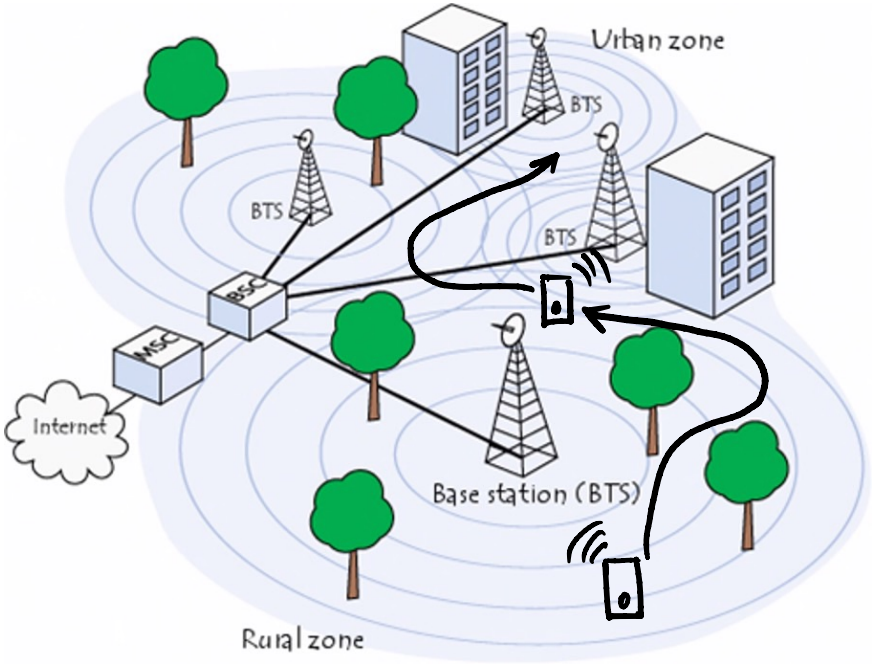


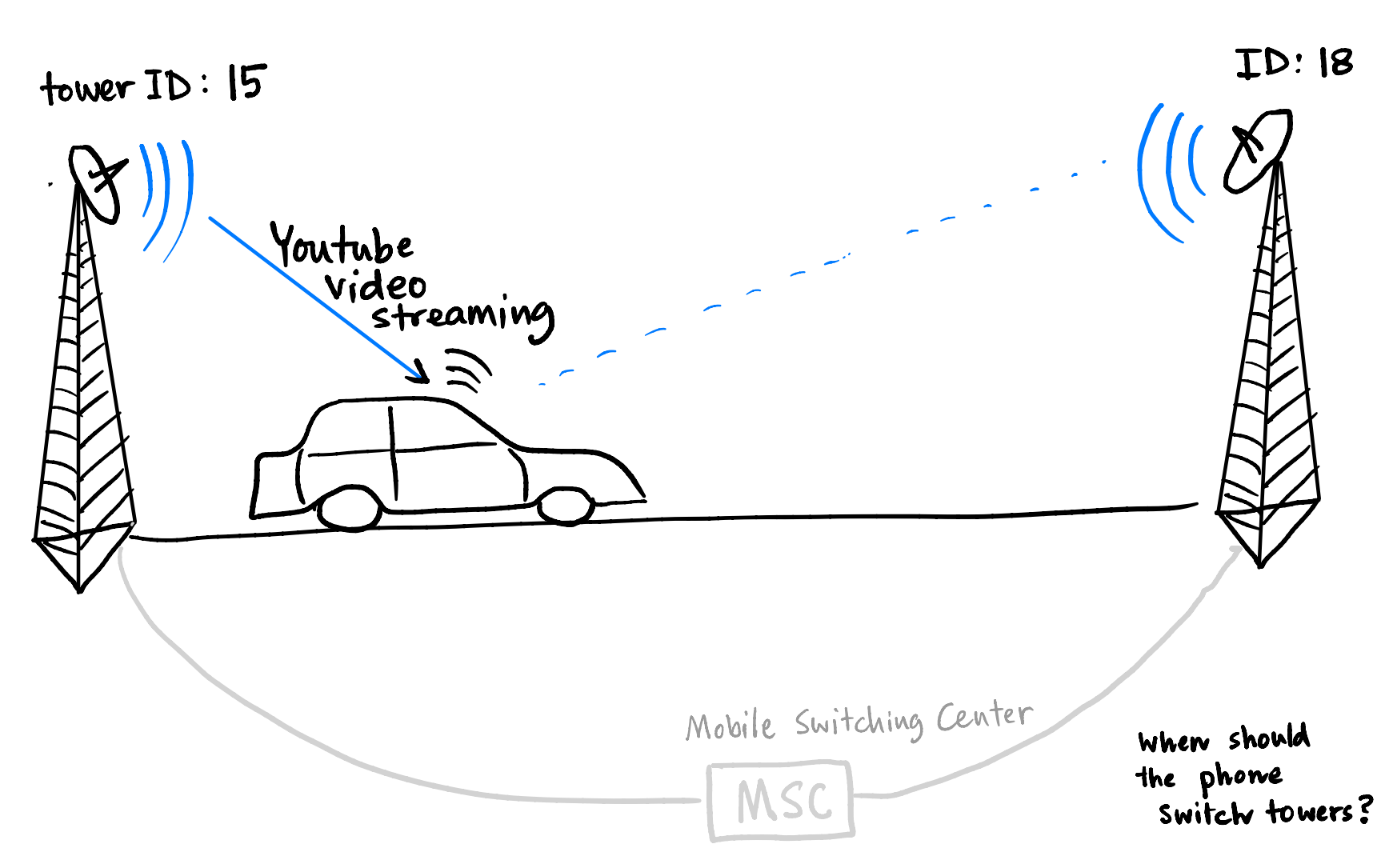
- Cell towers instead of Wifi boxes to send signals from a good height.
- All cell towers connected with wires
- Managed by a single administrator or company.

"cellular" because hexagonal cells can fully cover 2D space.

④ "Connected by wires & single admin" : What's the big deal

A: Mobility and Handoff for continuous connectivity.

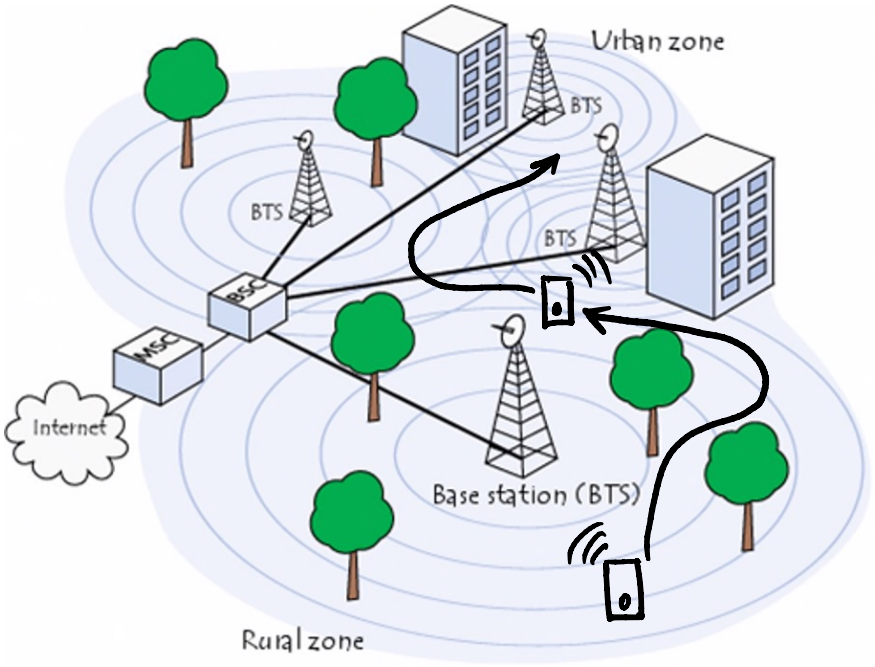



tower ID : 15
ID : 18
Youtube
video
streaming
Mobile Switching Center
MSC
when should
the phone
switch towers?

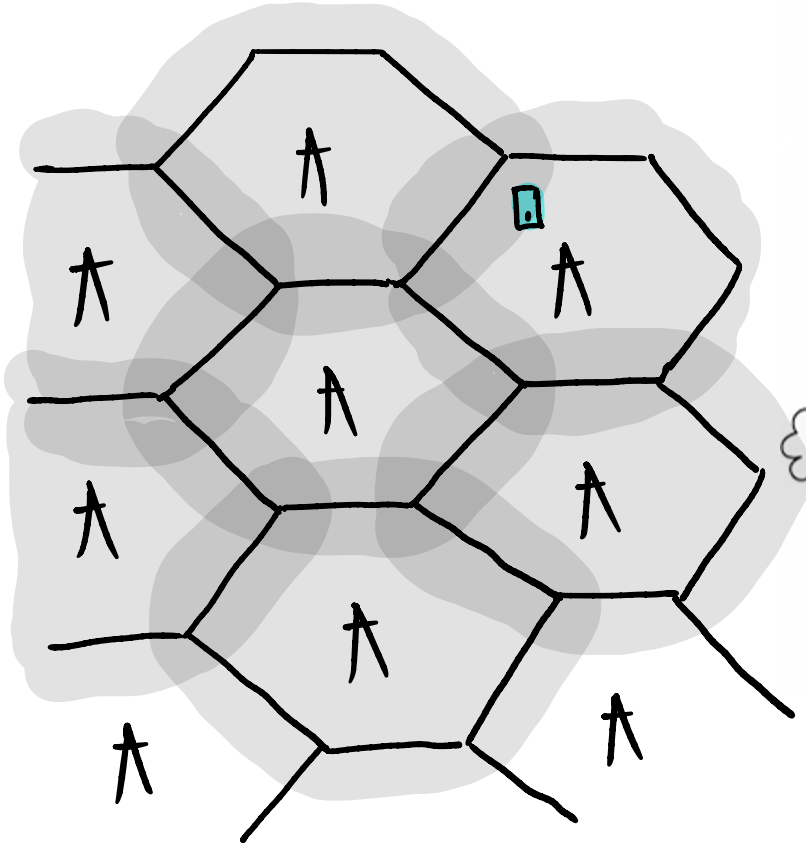
④ "Connected by wire & Single admin" : What's the big deal

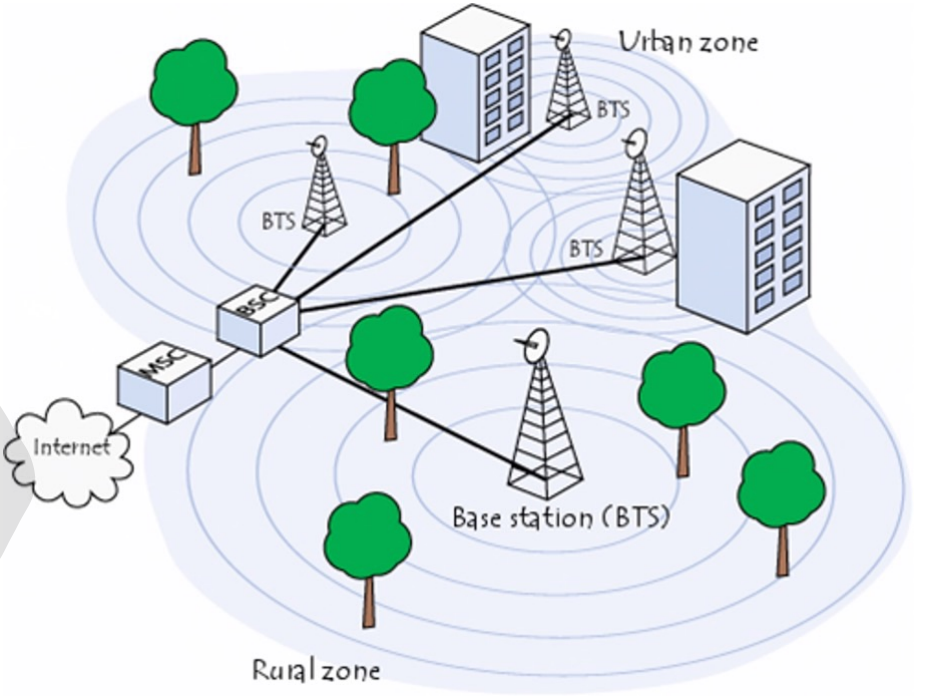
A: Mobility and Handoff for continuous connectivity.

B. Billing and Accounting

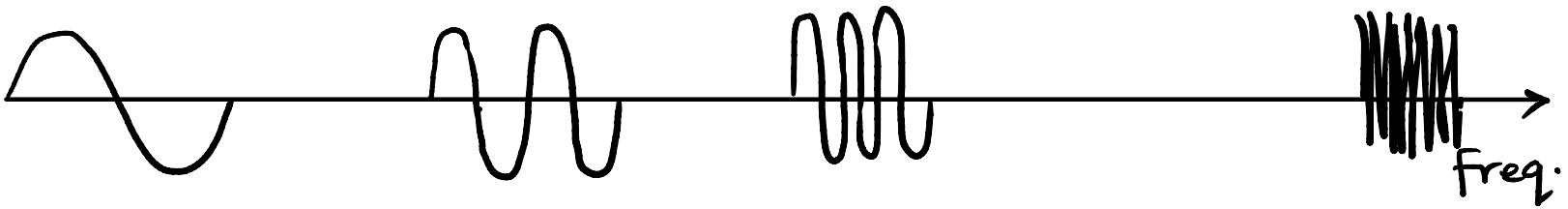


c. Scheduling





⑤ Understanding frequency and spectrum and Bandwidth

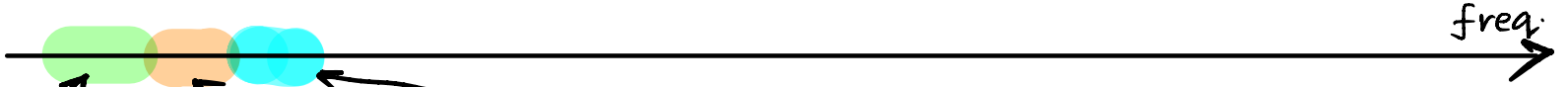


f = 1 (1 Hertz)

f = 2 (2 Hertz)

f = 3

f = 100 (100 Hz)



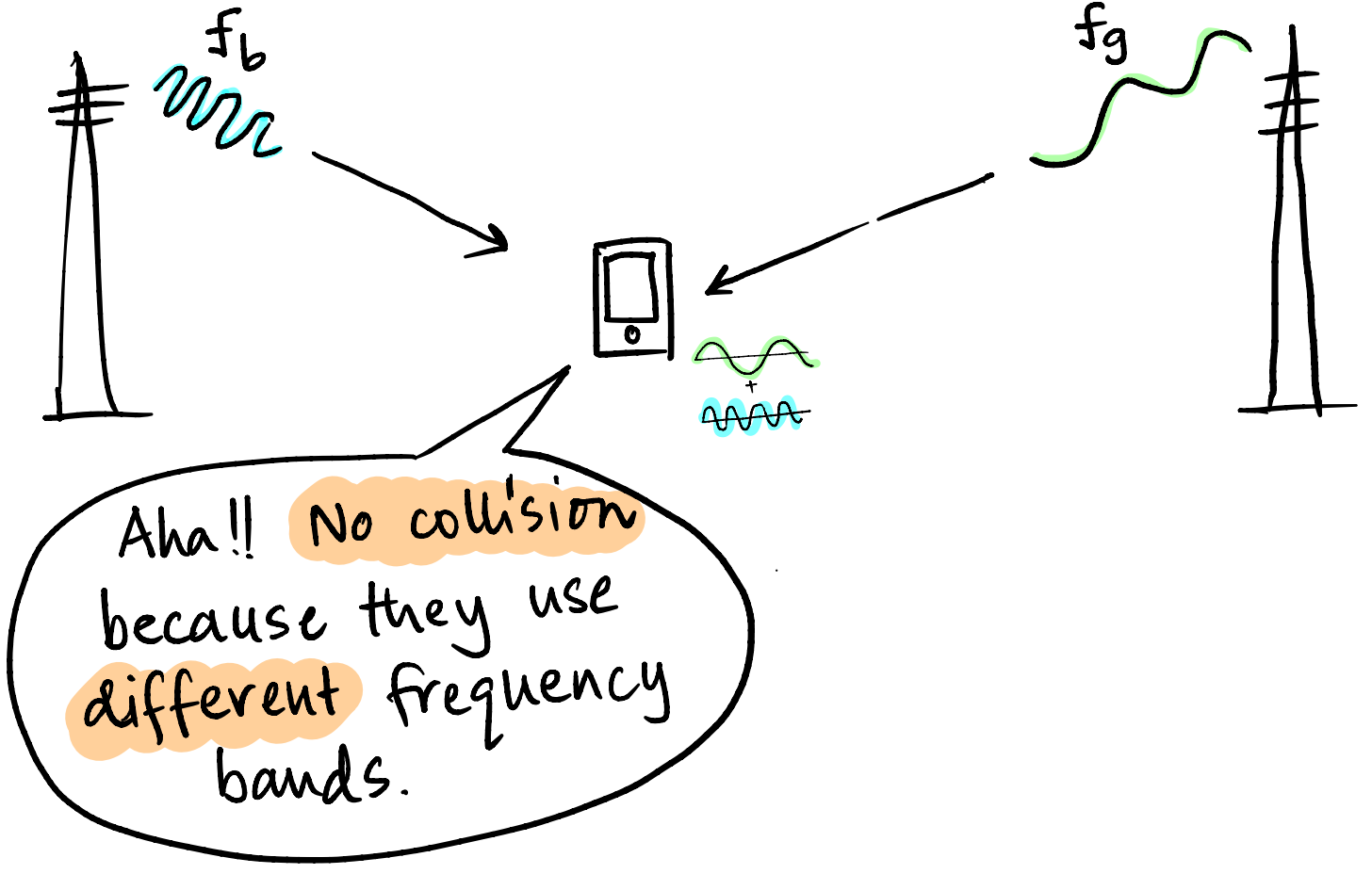
f_g = 1900 MHz to 1920 MHz

f_0 = 1920 MHz to 1940 MHz

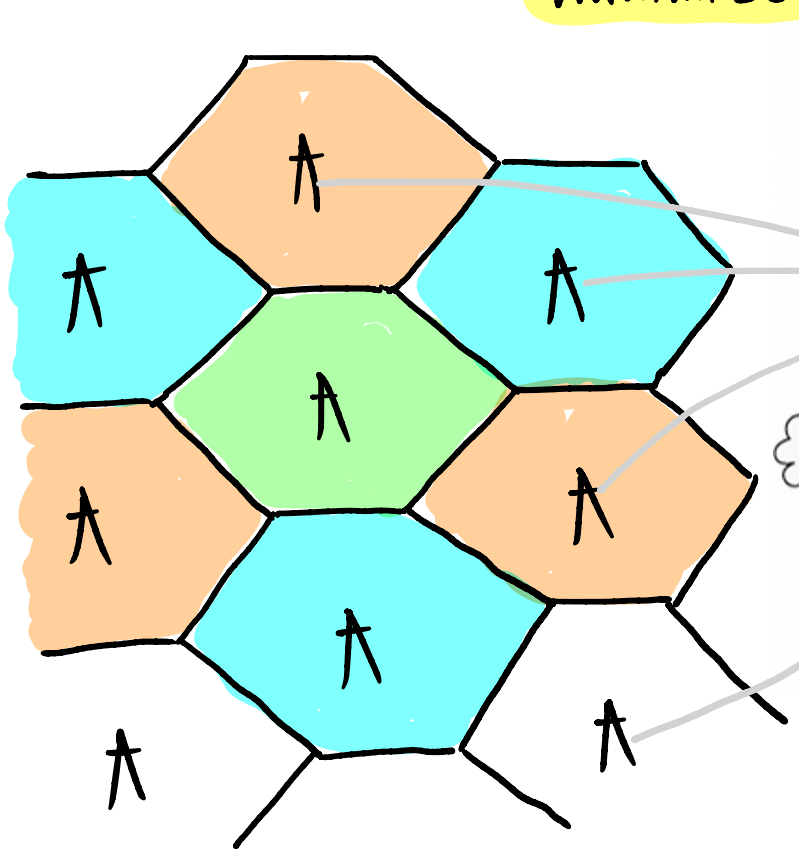
f_b = 1940 MHz to 1960 MHz

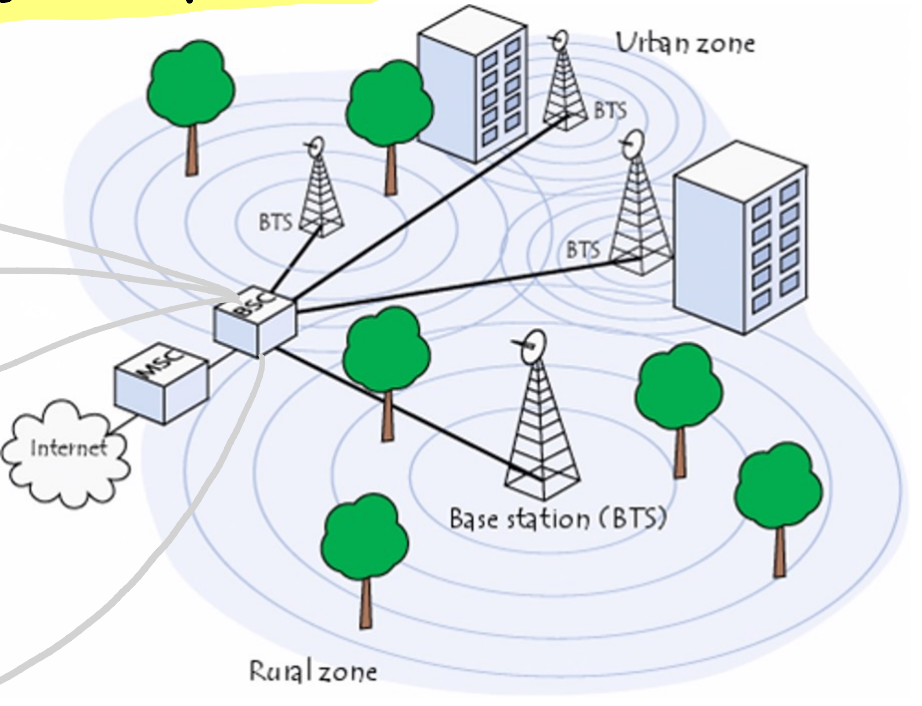
20 MHz Bandwidth

What happens if signal and interference are using different frequency bands?

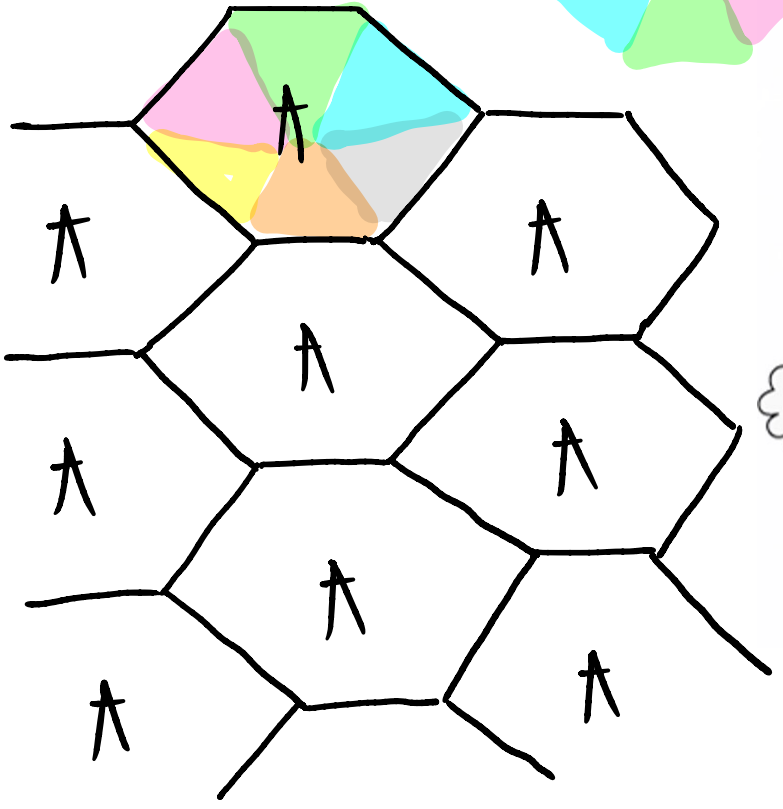

f_b
f_g
Aha!! No collision because they use different frequency bands.

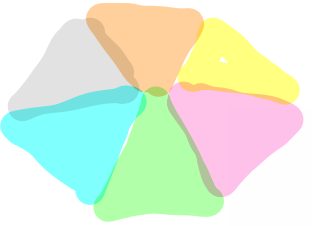
c. Scheduling : Optimally assign frequency bands to each cell to minimize interference.

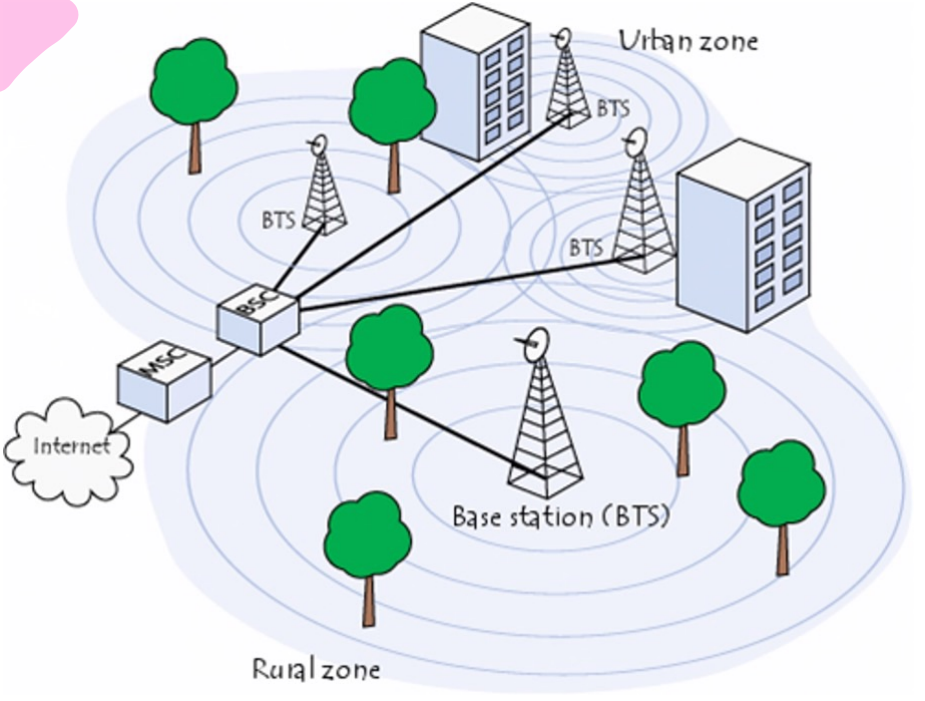




c. Scheduling

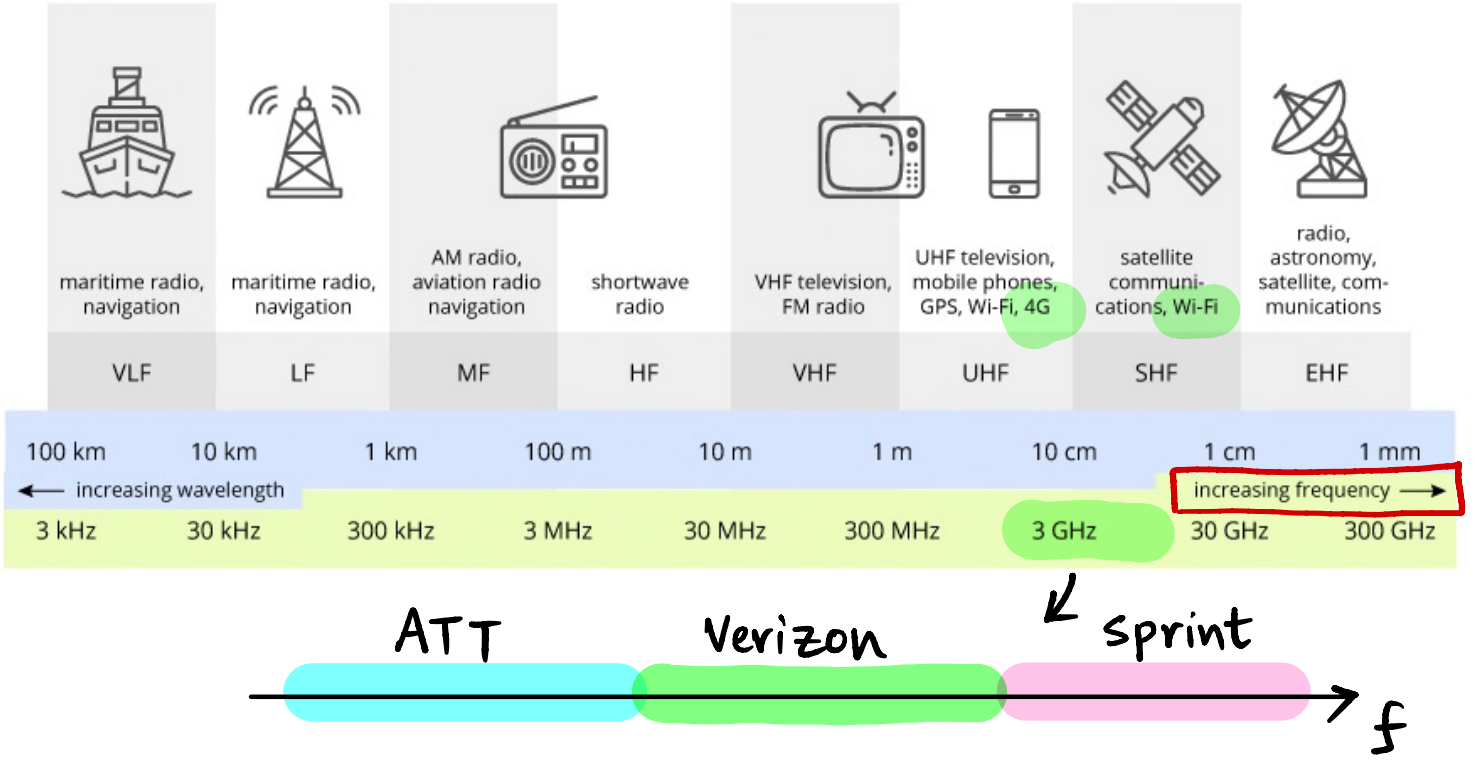






⑥ How to meet tremendous demand data & net. speed?

↳ Everyone needs spectrum or bandwidth ...
but where is free spectrum. It's so crowded!



⑦ Generations of cellular technology : 1G/2G/3G/4G/5G

6 minutes to download a movie with 4G.
15 seconds to download same movie with 5G

Features	1G Analog	2G Dig.	3G	4G MIMO	5G
Start/Devlopment	1970/1984	1980/1999	1990/2002	2000/2010	2010/2015
Technology	AMPS, NMT, TACS	GSM	WCDMA	LTE, WiMax	MIMO, mm Waves
Frequency	30 KHz	1.8 Ghz	1.6 - 2 GHz	2 - 8 GHz	3 - 30 Ghz
Bandwidth	2 kbps	14.4 - 64 kbps	2 Mbps	2000 Mbps to 1 Gbps	1 Gbps and higher
AccessSystem	FDMA	TDMA/CDMA	CDMA	CDMA	OFDM/BDMA

→ smaller range

→ More bandwidth

phone call → Data

Next generation : 5G + IoT

- Every medicine bottle has a tag ... connected to 5G
  Possible to track the medicine. Drones. Whales ...
- Every object starts getting connected. WOW !!

(8) Cellular Network and Society

(a) Radiation of nearby cell towers :

(b) Distracted driving → accidents → deaths

(c) Cellular network talk time = money in some countries

(d) Education over cell phones for everyone .

Coming up next lecture:

Internet