Hybrid Spectrum Sharing in mmWave Cellular Networks

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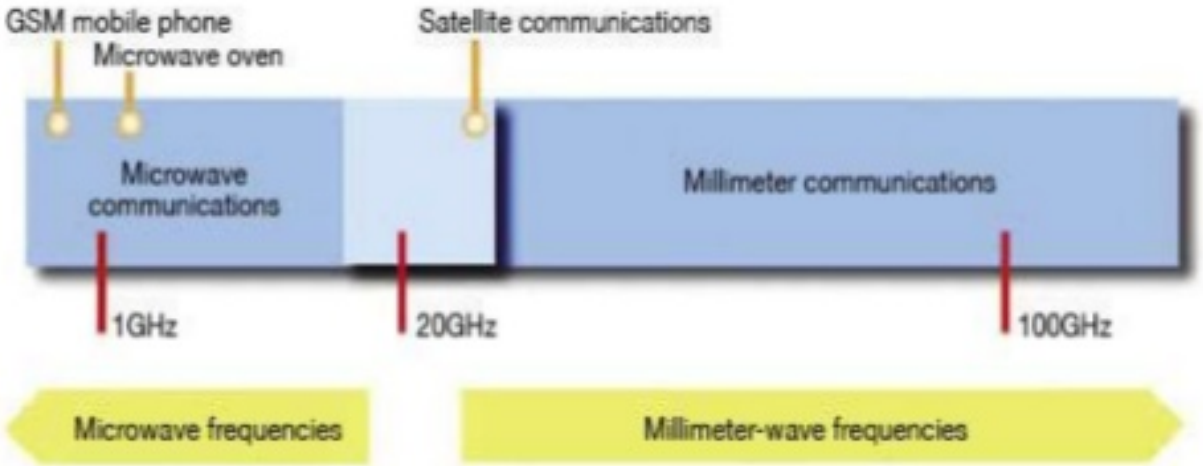
Introduction to mmWave

- Millimeter Wave is the band of spectrum between 30Ghz and 300Ghz.
- It can be used in a broad range of products and services like:-
  - High speed
  - Point-to-point wireless local area networks(WLANs)
  - Broadband access

Disadvantages of mmWave-

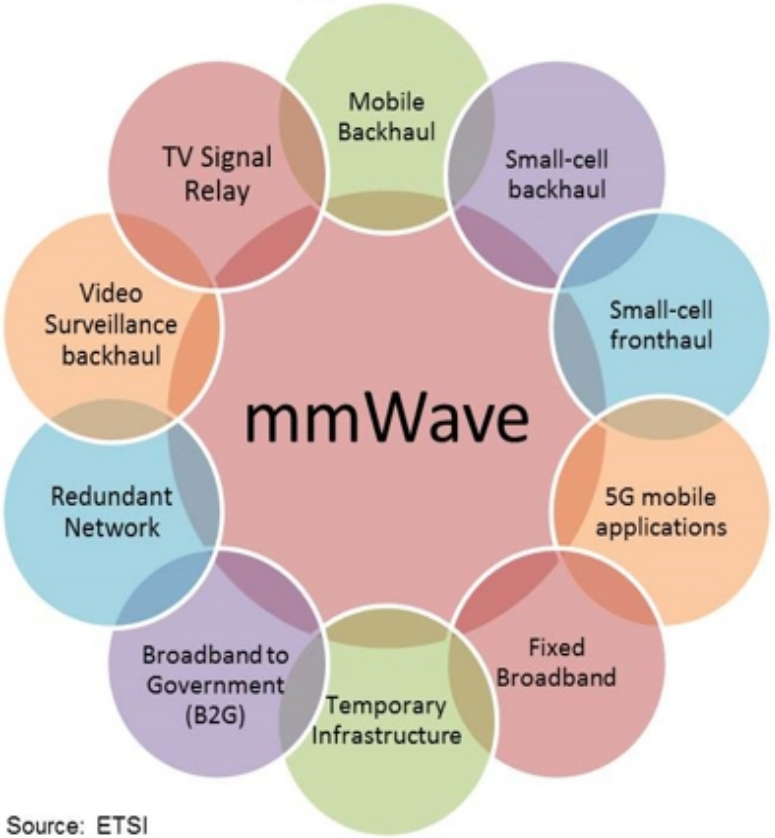
- It travels by line of sight due to its short range.
- Rain and Humidity can reduce signal strength.
- Have high atmospheric attenuation.

Millimeter wave frequency spectrum



Communication in Millimeter-Wave Frequencies

mmWave Applications/Use Cases



Source: ETSI

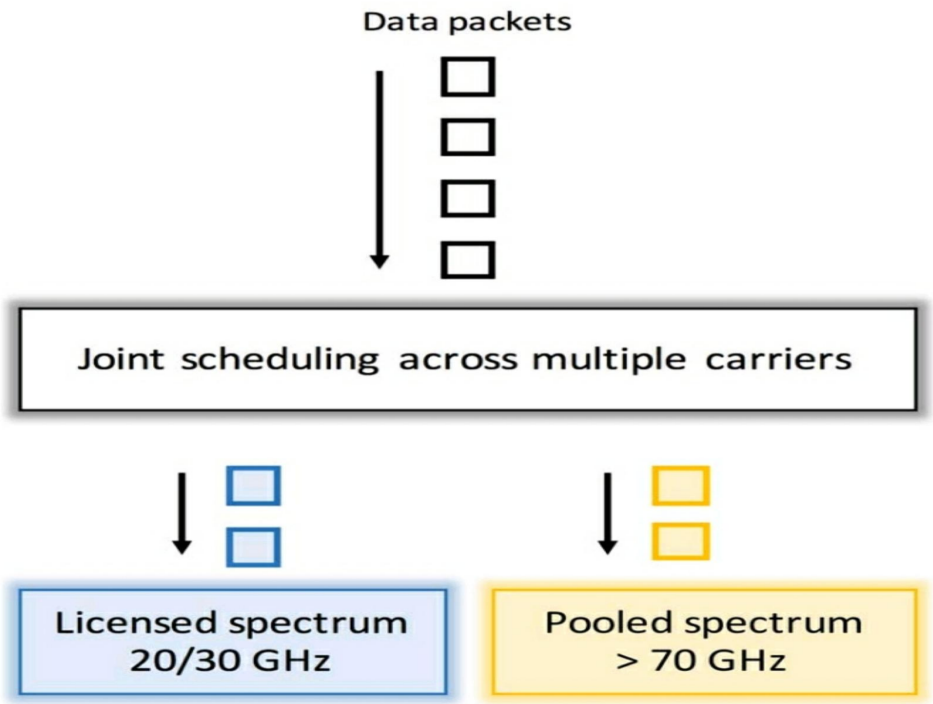
How does mmWave fit in 5G???

- 'Extremely high frequency' means extremely fast 5G speed
- High frequency means narrow wavelength.
- mmWave transmits large amount of data.
- Short transmission paths and high propagation losses.
- Build multielement dynamic beamforming antennas.

Spectrum Access Models

- **Exclusive/Licensed Model**
  Licensing is a way of ensuring that wireless operators do not interfere with each other's transmissions by having an authorized connection.
  The Sensus Flex Net is currently the only FCC(Federal Communication Commission) licensed communication network.
  It operates at 20/30 Ghz.

- **Licensed-exempt Model**
  Unlicensed wireless technologies don't require any permission.
  They are, by nature, vulnerable to interference.
  Wi-fi used is an example of unlicensed technology.
- **Spectrum Pooling**
  It is a spectrum management principle whereby
  licensed(primary) users put their unused spectrum into a pool
  from which secondary users can rent the spectrum.
  It operates at greater than 70Ghz.



Block diagram of the joint scheduling that allocates user packets in different bands.

Hybrid Spectrum Access Scheme

In this project, we introduce a new hybrid spectrum access scheme for mmWave networks, where data packets are scheduled through two mmWave carriers with different characteristics.
In particular, we consider the case of a hybrid spectrum scheme between a mmWave band with exclusive access and a mmWave band where spectrum ispooled between multiple operators.

Advantages of hybrid spectrum access with respect to traditional fully licensed or fully pooled spectrum access schemes.

- Coordination between different operators is not required.
- It does provide substantial gains.
- Use of spectrum sharing as a function of beamforming.
- Resource sharing in 5G mmWave cellular networks"
- Neutral small cells makes it easily accessible.

Our initial assessment shows that this approach provides advantages for the average user with respect to traditional fully licensed or fully pooled spectrum access schemes, in terms of increased throughput, spectral efciency, and better balancing of the available resources, which results in higher fairness.

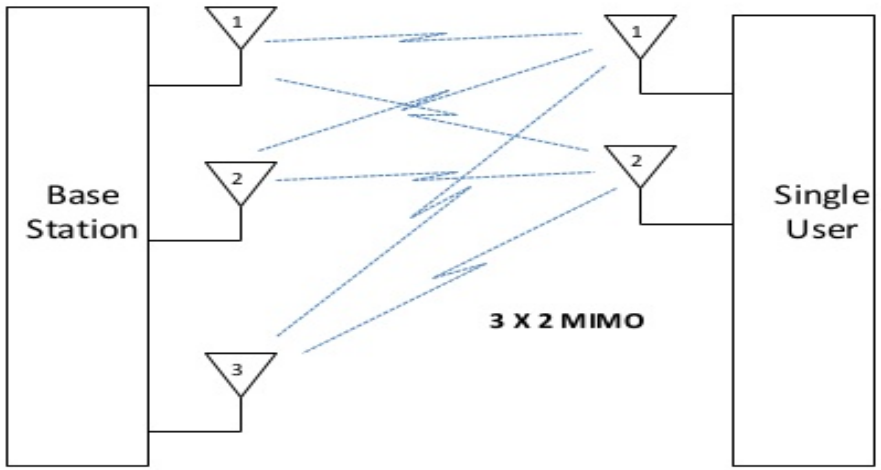
Realistic Approach-

- **Deployment Model:**
  For each operator m 1,...,M, the positions of the user equipments (UEs) and of the BSs(base stations) are modeled according to two Poisson Point Processes (PPPs), with densities UE and BS in some area A. This corresponds to considering an unplanned deployment, where base stations are not optimally located.

USPURTEK

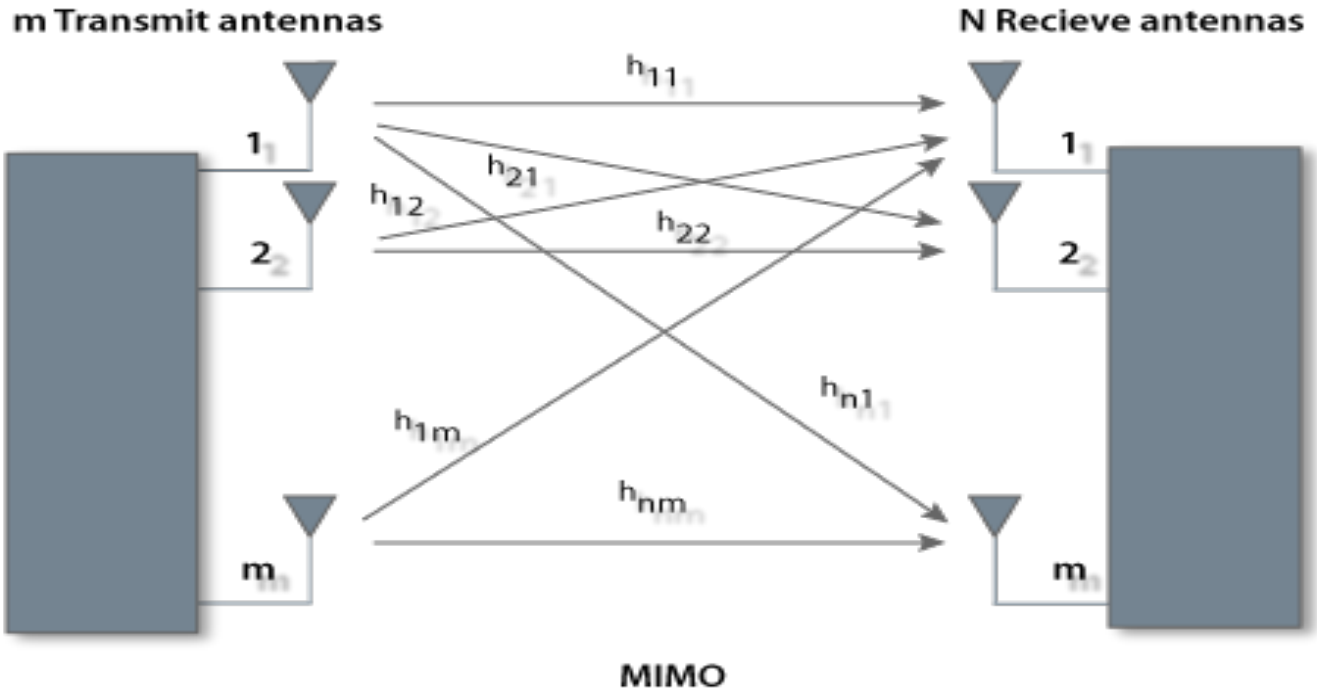
SU-MIMO

- ✓ Single User gets the benefit of full Throughput



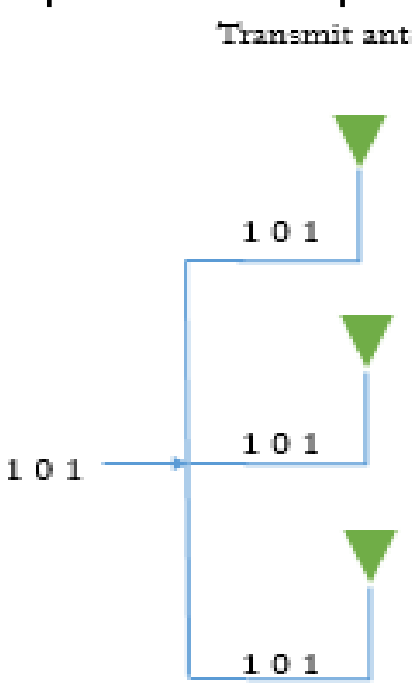
MIMO(multiple-input and multiple-output).

"MIMO" specifically refers to a practical technique for sending and receiving more than one data signal simultaneously over the same radio channel by exploiting multipath propagation.

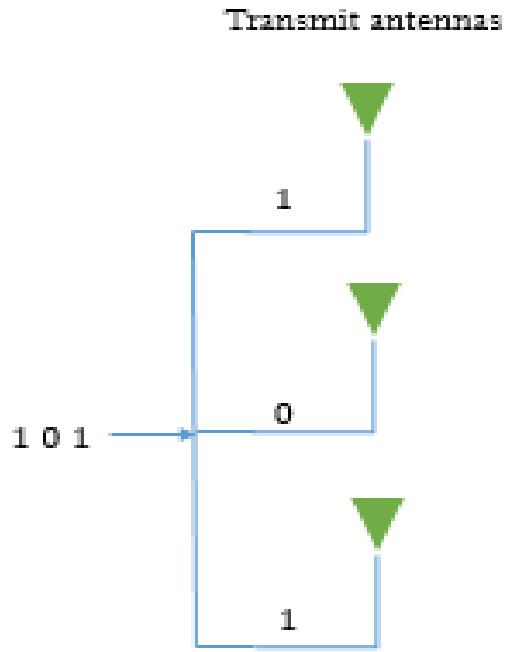


The two main formats for MIMO are:-

- Spatial Diversity.
- Spatial Multiplexing.



MIMO with Diversity
(Transmit diversity)
Improves reliability



MIMO with
Spatial Multiplexing
Increases data rate

By increasing the number of receive and transmit antennas it is possible to linearly increase the throughput of the channel with every pair of antennas added to the system. This makes MIMO wireless technology one of the most important wireless techniques to be employed in recent years.

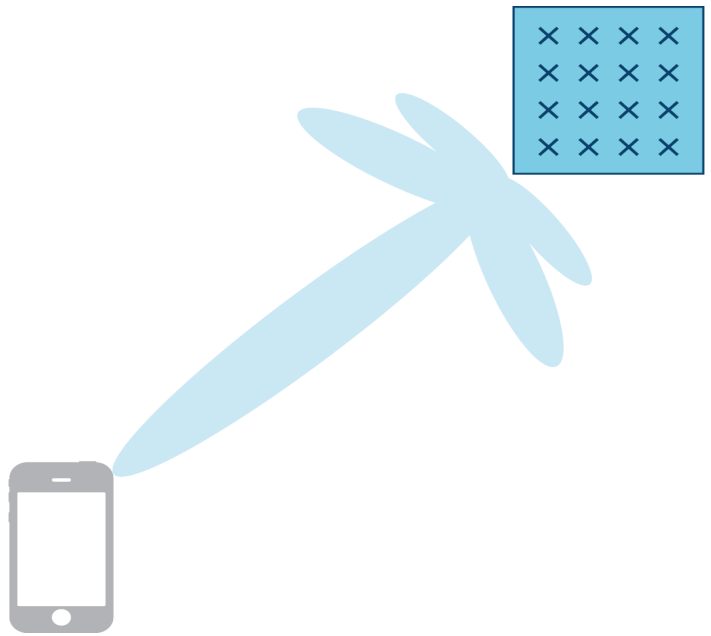
- **Rate and scheduling model-**
  Let $H^{(c)}{}_{ij}$ denote the MIMO channel matrix from BS $_i$ to UE $_j$ at carrier c.We assume beamforming with single-stream transmissions (i.e., no spatial multiplexing) to any one UE. We let w(c) RX_{ij} and w(c) TX_{ij} denote the RX and TX beamforming vectors that would be used if BS i were serving UE j. RX_{ij}=TX_{ij}+$H^{(c)}{}_{ij}$

MIMO channel Model:-

Each link is independently determined to be in one of three states: line-of-sight (LOS), non-line-of-sight (NLOS) or outage (out) with a probability that depends on the link distance d. For links in outage, there is no connection between the BS and the UE.
For LOS and NLOS links, the omni-directional path loss follows a distance-dependent attenuation given by:
PL(d)[dB]= α**+**β**10log10(d)+**ξ
where $\xi \epsilon$ N(0,σ^2) is the log-normal shadowing, depend on the carrier and on the LOS or NLOS link state.

MIMO Beamforming:

They are used to create a certain required antenna directive pattern to give the required performance under the given conditions.



References-

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2. H. Kim, G. de Veciana, X. Yang, and M. Venkatachalam, Distributed -optimal user association and cell load balancing in wireless networks, IEEE/ACM Trans. Netw., vol. 20, no. 1, pp. 177190, Feb. 2012.
3. https://en.wikipedia.org/wiki/MIMO


Thank
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