October 25, 2024

CS 598 WSI (Fall 2024): Lecture 18 Scribe Notes

Key points in 5G technology

I. Virtualization
II. mmWave

Basics

Why do we need 5G?

- 4G: 100Mbps, Application that requires this high throughput - video streaming
- 5G: 3 new use cases
  (i) eMBB (enhanced mobile broadband)
  Throughput - 10 Gbps, Application - yet to be found
  (ii) URLLC (ultra reliable low latency communication)
  Latency ~1ms, but can be small volume of traffic
  Application - AR/VR/Gaming, control robots
  (iii) mmTC (massive machine type communication)
  Support 10k-100k devices, Application - IoT devices

- What is the difference between eMBB and URLLC (doesn't high throughput entail low latency)?
  => Not always, e.g., because if you have packets coming in a network queues at a higher rate than being sent out of it, that can reduce latency but throughput can be high

5G Spectrum

- 4G: < 2GHz
- 5G: < 1GHz (low band), 1-7GHz (mid band), > 20GHz (mmWave)
  It is not like the entire spectrum is for 5G, for example, in midband, there is also wifi (2.4GHz, 5GHz etc.)
  Most 5G operators work in mid band
  The higher you go, more bw, but more attenuation, less range, more prone to obstacles

  * 6G: 100GHz and above - terahertz communication

5G MIMO

- More antennas on base stations
- Things MIMO can do
  (i) Multiplexing (transmit to multiple devices at the same time)
  (ii) Diversity gain (for the same device you can get improved SNR)
  (iii) Interference management (nulling)

5G Frame structure

- gNodeB - 5G base station (like wifi access point)
- UE (user element) - client
- Frame - 10ms long, contains multiple UEs, consists of 1 ms subframes

X-axis: time Y-axis: frequency	t_1	t_2	t_3	…
f_1	UE1	UE1	UE2	…
f_2	UE3	UE1	UE2	…
…	…	…	…	…

PRB: Physical resource blocks

- Uses OFDMA, 15KHz subcarrier (wifi: subcarrier bw = 20M/64 = 330KHz, LTE: # of UE = 20M/15KHz = 1000 UE)
- 14 OFDM symbols in a subframe
- Allocate 7 OFDM symbols into 12 subcarriers for one UE
- Control can go anywhere, more flexibility in subcarrier size (15, 30, 60 KHz) and UE allocation can also go anywhere, need not be contiguous

Paper Discussion

Non-standalone mode

In cellular networks, the base station (RAN) talks to the UEs, and also to the core network component (handling access, billing, and other slow operations). In non-standalone mode, the core is LTE core, but the RAN is 5G radio.
* Typically 5G radio is put on a tower where there is also a 4G radio. Then the UE can choose which one (4G radio / 5G radio) to communicate with.
* In standalone mode, there is 5G core network, which is software driven

Experimental interpretations

- mmWave can give more throughput, but can have more fluctuations causing lower throughput as well
- mmWave requires directional transmission, if gets blocked, needs to recalibrate
  The base station decides if it wants to hand you off, can be arbitrary criteria (policy depends on provider)
- An experimental result suggests that it may be better to have multiple TCP connections in an app, as 5G mmWave performance in LoS gets better until it gets saturated with TCP connections
- Why is the min latency in LoS 50ms (not ~1ms)?
  => Because of 4G control panels, plus core network round trip
  => Solution: edge computing at the base station