Mobile Networks: From 4G to 5G

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Abstract. The implementation of 5G mobile network represents a significant increase in internet data rates, in the magnitude of about 20 times that of the currently fastest option, 4G LTE network. This, with the added benefits of lower latency, bigger capacity and reliability,, make the move from 4G to 5G mobile network a major improvement, and an inevitability. In this essay, we intend to present how the implementation of 5G is being made, the hardships and necessities of making a 5G environment, and the future of 4G LTE network.

Keywords: mobile networking, 4G, 5G, internet, LTE, mobile communication technology, latency, data rates, bandwidth.

1 Introduction

Getting ready for the fifth generation of mobile networks means having to make many changes to the general infrastructures that give availability of outdoors internet access, and given that 5G is a recent innovation, worldwide implementation is still far from complete.

Main topics to be presented in this essay:

- Infrastructure;
- Spectrum;
- Network efficiency;
- HETNET Architecture;
- D2D;
- Possible concerns.

This will be a basic overview of the differences between fourth (4G) and fifth (5G) generation of mobile networks, and how the change is being made across the world.

2 Infrastructure Differences Between 4G and 5G

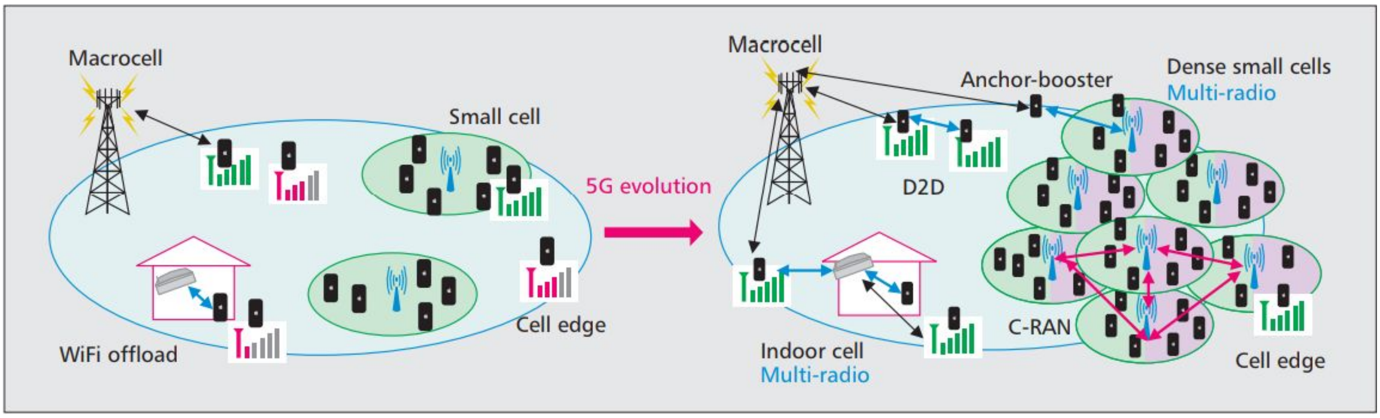

Fig 1. Diagram of an example infrastructure of the evolution from 4G LTE to 5G networks

Major differences. As the above diagram shows, there are major infrastructural differences between 4G LTE and 5G. There is a need to arrange densely packed cells (Multi-radio) in a 5G environment, this doesn't happen with 4G LTE, where small cells can be located much farther away.
5G also implements the following technologies:

HETNET(Heterogeneous networks) Architecture. A term used for modern mobile communication networks comprised of multiple clusters of cells.

- Macro cells(used to provide coverage)
- Pico/Micro cells (used to enhance capacity in busy areas)
- Femto cells (used at the office and at home)

D2D(Device to Device) communication. Enables the exchange of data traffic directly between user equipment without the use of base stations or the core network.

Supports new usages based on user proximity

- Social networking
- Peer-to-Peer content sharing
- Safe communications in the absence of network coverage
- Serves as another “cell tier” in the 5G HetNet clusters of devices cooperating with each other to increase network capacity
- Improved cellular coverage
- Reduced end-to-end latency
- Reduced power consumption

Multi-RATs(Radio Access Technologies ex: 5G,LTE,GSM). Expected to be used in 5G with overlapping coverage as part of a single multi-radio HetNet creating opportunities for combining and aggregating capacity across the different RATs and do so in a manner transparent to the end users.

Cloud RAN (C-RAN),this architecture creates a base station with distributed antennas, processing resources based on the varying traffic load within its geographical coverage.
The baseband signals from several hundred cells can be received and processed at a centralized server platform.
The technique relies on real-time lowlatency virtualization.
Evolution of C-RAN will include even more advanced techniques such as joint processing and demodulation of multiple signals and joint resource allocation across multiple RATs to further increase 5G capacity.

3 Network Efficiency

There are many differences between 4G networks to 5G networks, be it the different kinds of antennas, different radio spectrum frequencies, the amount of devices possible to connect to the internet, the delay, and of course the speeds.

3.1 Spectrum

While 4G networks use frequencies below 6GHz, 5G make use of extremely high frequencies in the 30 GHz to 300 GHz range, therefore 5G also uses shorter wavelengths, which means that antennas can afford to be much smaller than the existing antennas while still providing precise directional control while 4G LTE towers fire data in all directions wasting both energy and power sending radio waves to places not even requesting access to the web.
One base station can utilize more directional antennas, this means that 5G can support over 1000 more devices per meter in comparison to 4G LTE.
Summarizing, this means 5G networks can send ultrafast data to a lot more users with higher precision and lower latency in comparison to 4G LTE.

3.2 Difficulties and Concerns

While 5G is in most regards much better than 4G LTE, it has yet to be deployed worldwide because like every major technology development, it faces many obstacles, be it tech wise, financially or even legally.
Due to the type of signal a 5G cell tower transmits, the reach it has is limited to only devices in close proximity. Many of these 5G networks operate on high radio frequencies called millimeter waves, that while having the benefit of being able to carry enormous amounts of data are limited in range (most of the times limited to less than one square mile). Data sent through these types of 5G networks is also easily blocked by common objects like trees, buildings, and even the rain.
One of the downsides of 5G is that a big part of these high frequencies only work if there's a clean, direct line-of-sight between the antenna and the device receiving the signal, these frequencies are also easily absorbed by humidity, rain and other objects, meaning that it's impossible for them to travel as far. It's for this reason that we can expect a lot of antennas to be placed not far away from each other to support 5G, both small ones in strategic places and large ones positioned throughout a city. There will also be many repeating stations to push the radio waves as far as possible to provide long range 5G support.

Due to the limited scope 5G possesses fewer users can access 5G from a single cell tower, this also increases the amount of small antennae that will have to be erected to serve more customers, otherwise only a few very local devices are able to get on the network. Erecting this many antennae is a problem in itself due to the fact it's not a quick task to build such a huge number of them across the nation, plus providers are also running into other issues like local community regulations, municipality regulations, etc…

These issues can extend to things like zoning policies, lengthy permitting processes, unreasonable fees and aesthetic problems due to the fact 5G hardware needs to be installed on street lamps and utility poles. There is also the issue of safety, because 5G radio waves are operating at different radio frequencies than older ones like the ones corresponding to 4G and 3G networks.

And finally, quite possibly the biggest issue is the amount of money needed to be invested. Into the whole 5G infrastructure alone telecom companies are expected to invest as much as $275 billion before 2025.
A mobile network operator has to pay for all of the following, and more, during a 5G rollout before it can even reach customers:

- Spectrum licensing
- The physical hardware used in the 5G deployment
- Hiring technicians to install the necessary hardware
- Testing and retesting of the network
- Deployment fees demanded by regulators

3.3 Differences in Speed

5G has a minimum peak download speed of 20 Gbps while 4G LTE sits at just 1 Gbps. These numbers refer to devices that are not moving, like in a fixed wireless access (FWA) setup where there's a direct wireless connection between the tower and the user's device. Speeds vary once you start moving, like in a car or train.
However, these aren't usually referred to as the "normal" speeds that devices experience, since there are often many factors that affect bandwidth. Instead, it's more important to look at the realistic speeds, or the average measured bandwidth.
While not widely available yet, 5G has been tested several times already, and these tests have shown at least everyday download speeds of 100 Mbps, although different trials provided different results (for example, Verizon's at-home 5G service delivers data at 300Mbps up to 1Gbps).
Another difference between these networks is that 5G ones can more easily understand what type of data is being requested, being able to this way switch between a low power mode when not in intensive use (be it when it's not being used or supplying low rates to specific devices) or switch to a higher power mode when the demand is higher(for instance during HD video streaming).

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