## Air Interface (The Radio Access Network)

In the OSI model, the air interface comprises layers 1 and 2 of the mobile communications system. It establishes a point-to-point link between the U.E and the base station. (cell tower)

**2G Networks Air Interface Technologies**

**GSM, CDMA, CDPD** (Cellular Digital Packet Data), **CSD** (Circuit Switched Data)

More efficient on the spectrum. 2G introduced data services for mobile, starting with SMS text messages. 2G technologies enabled the various mobile phone networks to provide the services such as text messages, picture messages and MMS (multi media messages). All text messages sent over 2G are digitally encrypted.

**2.5G Networks Air Interface Technologies**

**GPRS** (General Packet Radio Service), **HSCSD** (High Speed Circuit Switched Data), **EDGE** (Enhanced Data for GSM Evolution)

The three above technologies, are all apart of the GSM standard, but forks of the original method.

**/**CDMA2000** is also considered an 2.5G improvement over the base CDMA.

"2.5G" is used to describe 2G-systems that have implemented a packet-switched domain in addition to the circuit-switched domain. The first major step in the evolution of GSM networks to 3G occurred with the introduction of **General Packet Radio Service** (GPRS). **CDMA2000** networks similarly evolved through the introduction of 2.5G. It also expanded capacity and unique service such as caller ID,call forwarding, and short messaging

**3G Networks Air Interface Technologies**

**W-CDMA** (Wideband-CDMA), **TD-CDMA** (Time Division CDMA)

## Air Interface (The Radio Access Network) (cont)

Both of these at this point, have become apart of the **UMTS** (Universal Mobile Telecommunications System). They are still apart of the 3GPP group, so they are still technically "3G-GSM" technologies.

**CDMA2000** enters the 3G race with Qualcomm under the 3GPP2 banner.

**3.5 Networks Air Interface Technologies**

**3GPP** based: HSPA+, HSDPA, LTE (w/ E-UTRAN)

**3GPP2** based: CDMA2000

**IEEE** based: WiMAX, iBurst

At this point HSPA+ is a further improvement of W-CDMA, which was an improvemnt of GSM, so I'm not sure it even qualifies to still be considered GSM anymore. Both the 3GPP and 3GPP2 are working on extending the life and power of 3G technologies. The IEEE steps in and introduces the WiMAX standard which offers in theory 1Gbit/s.

**4G Network Air Interface Technologies**

3GPP based: **LTE** (w/ E-UTRAN)

IEEE based: **WiMAX**

Most notably here is the absence of CDMA2000, and the entry of the 3GPP2. They turned to fully support LTE Advanced here. 4G networks will be designed for multi-media, such as gaming, voice, video, cloud computing, and high definition television. WiMAX and LTE are the two largest 4G capable technologies. Sprint, in the US, was the first to deploy a WiMAX flavored 4G network. USB wireless modems were the first devices to be able to interface with the laid out 4G network, with cell phones coming 2nd..

## Air Interface (The Radio Access Network) (cont)

By the book, 4G-LTE should have a download rate of 100Mbit/s. While 4G-WiMAX should have a download rate of 120Mbit/s

HSPA+ is still relevant here as it allows for a comparable data speed, and allow for an easy transition towards 4G speeds. HSPA+ is not abandoned, but 3GPP favors LTE Advanced.

NOTE: That LTE + E-UTRAN is the air interface side of EPS. This means the user device, the cell tower, and the connection to the base station or other towers. Behind this is the SAE or System Architecture Evolution which involves the core. All of the together is what forms the EPS.

## The Legacy UMTS

**Universal Mobile Telecommunications System**

3GPP's term for their vision of the 3G (beginning in the year 2000) system and set of services for mobile and personal wireless access to public network services. Note that UMTS is the term for the entire system, which includes both the Radio Access Network (RAN) and the Core Network (CN). W-CDMA was the 3G radio technology used in the RAN side.

Built on an open standard interface, as defined by the 3GPP

Based on an evolution of the GSM MSC for circuit-switched capabilities in the Core Network side. Despite lofty goals, still heavily circuit switched based. The ATM protocol is used for the circuit switched voice and video traffic.

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Published 1st May, 2015.
Last updated 13th May, 2016.


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## GSM

**Global Systems for Mobiles**
One of the two major radio access technologies.
Used by AT&T, T-Mobile, and generally the rest of the world.
Developed by a consortium (3GPP), means that no one owns it, this means it's cheaper to implement.
At it's inception, GSM uses SIM cards for phones.
Upgraded to 3G-GSM. Can support simultaneous voice and data usage. CDMA and GSM are *both* multiple access technologies.
Original GSM was time switched. To get as many phone calls in a channel, it split the channel up into very very small time slices for each phone call.
Original CDMA was actually more powerful and flexible than original GSM. So in development, 3G-GSM uses CDMA methods.

## WCDMA or "3G-GSM"

**Wideband Code Division Multiple Access**
An improved version of the original GSM spec. No longer time multiplexed, but uses CDMA's code multiplexing. Requires wider channel bands, but allows for more data throughput.
Initially offering data speeds up to 384 Kbps.
WCDMA is the 3G technology used in the US by AT&T and T-Mobile
Later improved further by technologies like HSDA and HSPA+, which takes WCDMA a step further.
Despite the name similarity, WCDMA is not compatible with CDMA.

## The Basic Differences

As CDMA looks to be slowly going away, this isn't so much of an issue anymore, but this is a good reference for the differences between the two fundamental cell phone RAN methods.

**GSM BASED**
AT&T / T-MOBILE
Uses SIM cards to store subscriber data. This means that the data on the card is verified by the core system, behind the RAN network. This means you can swap SIM cards on unlocked GSM phones. 3G-GSM phones, can allow simultaneous talking and usage of data. Back in the day, GSM based technologies held a superior battery life. Nowadays this isn't too much of an issue anymore.

**CDMA BASED**
SPRINT / VERIZON
Does not use SIM cards. (before LTE) This means that the phone is checked against a list of 'allowed' phones on the network. No such thing as an 'unlocked' CDMA phone. If you have Verizon, you must a 'white listed' verizon phone. Despite Sprint and Vz just now getting into the LTE (GSM based) market, they still have a ton of CDMA legacy equipment. So this means they still use the "White Listing" approach of checking the phone against a list of approved phones. In the US CDMA does not allow talking and data usage at the same time. Before new technology came about, battery life for CDMA devices was lesser than that of GSM devices..

## The Basic Differences (cont)

Also, because the rest of the world and AT&T/T-Mobile used GSM, CDMA was massively outnumbered. Meaning if you traveled abroad, your CDMA device would be shiny brick.

## The Evovled Packet System

You should note here that the term LTE is tossed around, but it actually involves many networks put together. Two major projects involved. The Radio Access side, and the Core Access side.
**Long Term Evolution (LTE)** is the Radio access project, and the
**System Architecture Evolution (SAE)** is the Core Access project.
These two projects produced two tangible networks.
The LTE project produced the **E-UTRAN (Evolved- Universal Terrestrial Radio Access Network).**
The SAE project produced the **EPC (Evolved Packet Core).**
Both of these networks are separate, but must be made to interface with each other.
The **E-UTRAN** will pass calls into the **EPC**, which is made up of many components.
This end to end network is the **EPS or Evolved Packet System**, which many people just mistakenly call LTE.

## CDMA

**Code Division Multiple Access**
One of two major radio systems used.
Used by Sprint, US Cellular, and Verizon.
Developed and "owned" by Qualcomm.
Traditionally CDMA does not use SIM card technology, but because 4G LTE



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## CDMA (cont)

is used "on top" of CDMA technology, LTE does introduce SIM cards to CDMA. Phones are tracked by their ESN (electronic serial number) so they do not require SIM cards. Once activated, a CDMA phone is tied directly to that carrier's network.
Crams many phone calls into one radio channel. This is done by "Code Division". A call's data is encoded with a unique key. The receiver has the matching key to 'decode' the call from everyone else's call from the channel.
"3G GSM" variant is actually a version of CDMA, which is called Wideband CDMA.

## HSDPA and HSPA+

**High-Speed Downlink Packet Access" and** High-Speed Packet Access**
Often referred to as 3.5G. As of 2013 HSDPA deployments can support down-link speeds of up to 99.3 Mbit/s at a maximum, with ideal conditions. In real life use, most speeds hover around 22~30Mbit/s
HSPA+ is replaced by LTE's E-UTRAN. Because E-UTRAN and LTE are tied so closely, most just refer to it as jointly, LTE

## Groups and Standards

**3GPP** The 3rd Generation Partnership Project is a collaboration between groups of telecommunications associations. The initial scope of 3GPP was to make a globally applicable third-generation (3G) mobile phone system specification based on evolved Global System for Mobile Communications. It has since expanded to include GSM, UMTS (including HSPA+), EDGE, and LTE.

## Groups and Standards (cont)

**3GPP2** Despite the completely ripped off name, this group has/had nothing to do with 3GPP. In practice, 3GPP2 is the standardization group for CDMA2000, the set of 3G standards based on the earlier cdmaOne 2G CDMA technology. That's pretty much it.
**IEEE**
Institute of Electrical and Electronics Engineers. Needs no introductions, made up of engineers and scientists who get together to create and work on standards. They proposed the WiMAX and iBurst Standards as 3.5 and 4G cell technologies. WiMAX being the current only competitor to LTE.

## Voice and Data Transmission

Today, Verizon and other wireless providers transmit voice calls over the traditional circuit-switched networks, and subscribers use the newer IP-based 4G LTE network to access the Internet and other "data" services. The VoLTE, service enables wireless operators to use the data network to transmit voice services in the same way they transmit data.Basically, it chops up voice calls into packets, just like emails Facebook messages, and Skype calls. Of course with the advent of VoLTE, voice can now be unified with data, allowing ALL carriers to use voice and data at the same time.. Traditional voice networks (over a 2G network) transmit voice calls using an 8kbps codec. Verizon says it's using a 13kbps codec that also uses more-modern compression methods. The result is a call that's noticeably clearer than a typical cell phone call.

## Connecting Other Networks

Obviously the EPS system is entirely packet based, but other systems, especially legacy ones, are still circuit based.

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