3G WCDMA

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Hello. Welcome to another module on wireless communications in this massive open online course. And the previous modules we've looked at the basics of wireless communication systems also the basics of the 2G wireless communication system or standard that is GSM, the Global System for Mobile Communications. We now look at a more advanced standard that is a third-generation standard which is known as WCDMA which stands for wideband CDMA.

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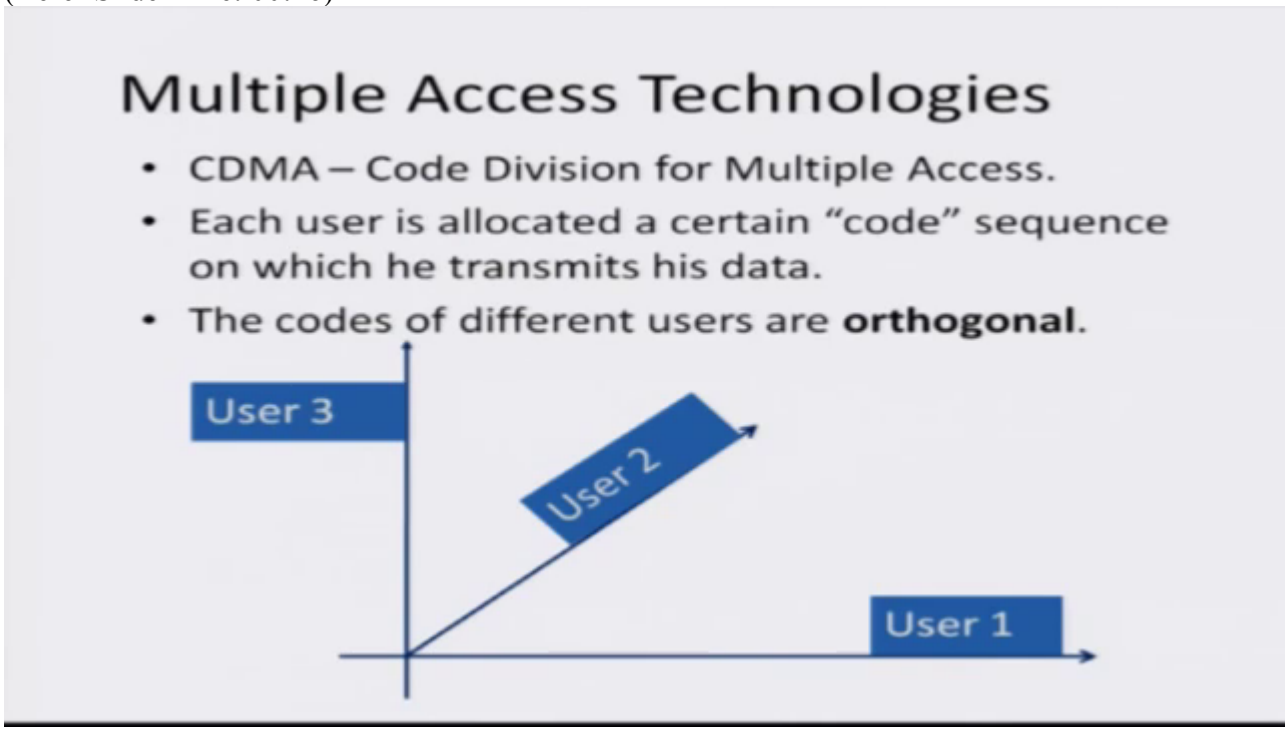

And CDMA is a very interesting multi-user technology. CDMA stands for Code Division for Multiple Access. As we have seen FDMA is based on division in frequency, TDMA is based on division in time while CDMA is based neither on division in time or division in frequency but where different users use different codes that is each users are assigned different codes and these codes are sort of the different languages in which these users speak to the base station.

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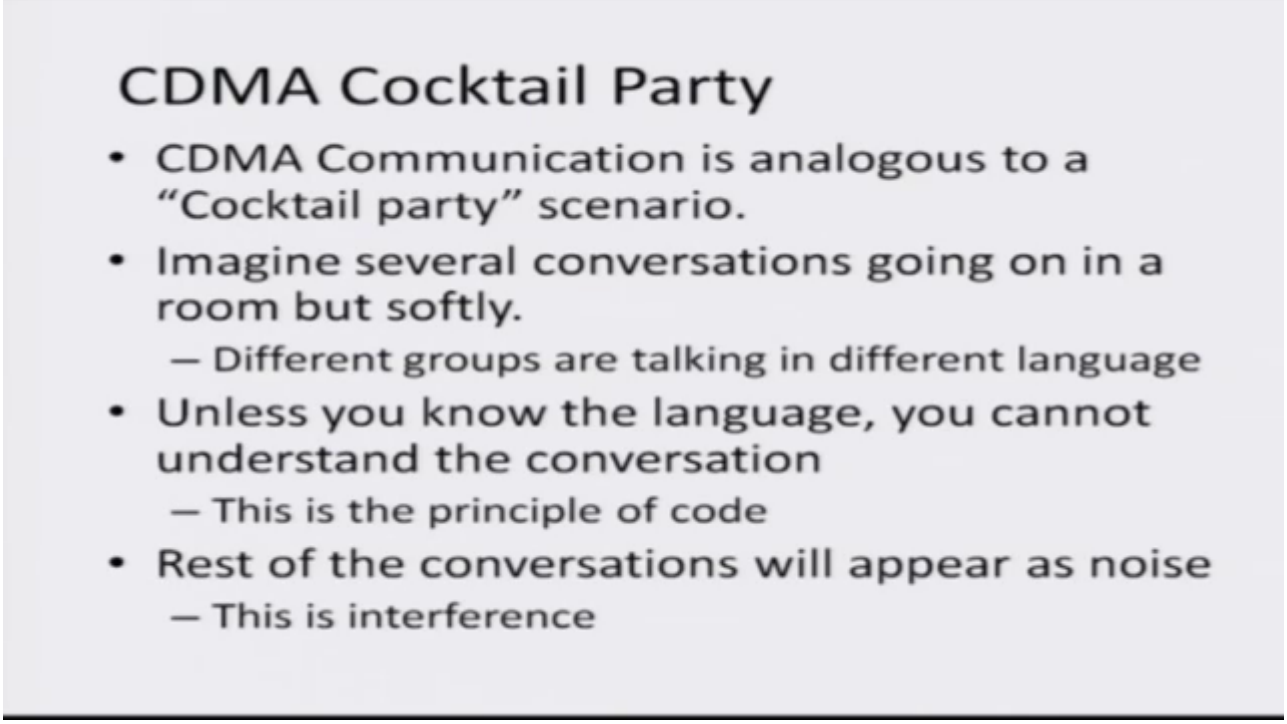

So you can think of CDMA as sort of a cocktail party. This is a very popular analogy used to analyze CDMA or understand CDMA. Let's say you have different groups of people are having conversations at a Cocktail party, but all these conversations are going on softly, let's of course, if the all the conversations are going very loudly then no one can hear anything, but if all the conversations are going on softly and each is using different language then you can make out what your friend or the person who is talking to you is conversing with you while the other conversations in languages which you don't understand appear to you is interference and that is precisely the backbone of CDMA where people use with the different devices, use different codes, these codes are akin to different languages and each user or each device speaks efficiently softly so that it does not swamp the conversation of the other devices, and since the other devices are on different codes they are like different languages which appear as interference and since they are soft this interference in turn does not swamp the communication of the particular device. And so it is a very interesting technology and has a lot of interesting properties which can be analyzed in detail but for this module since it's concerned with the basics we'll go over some of the basic overview features.

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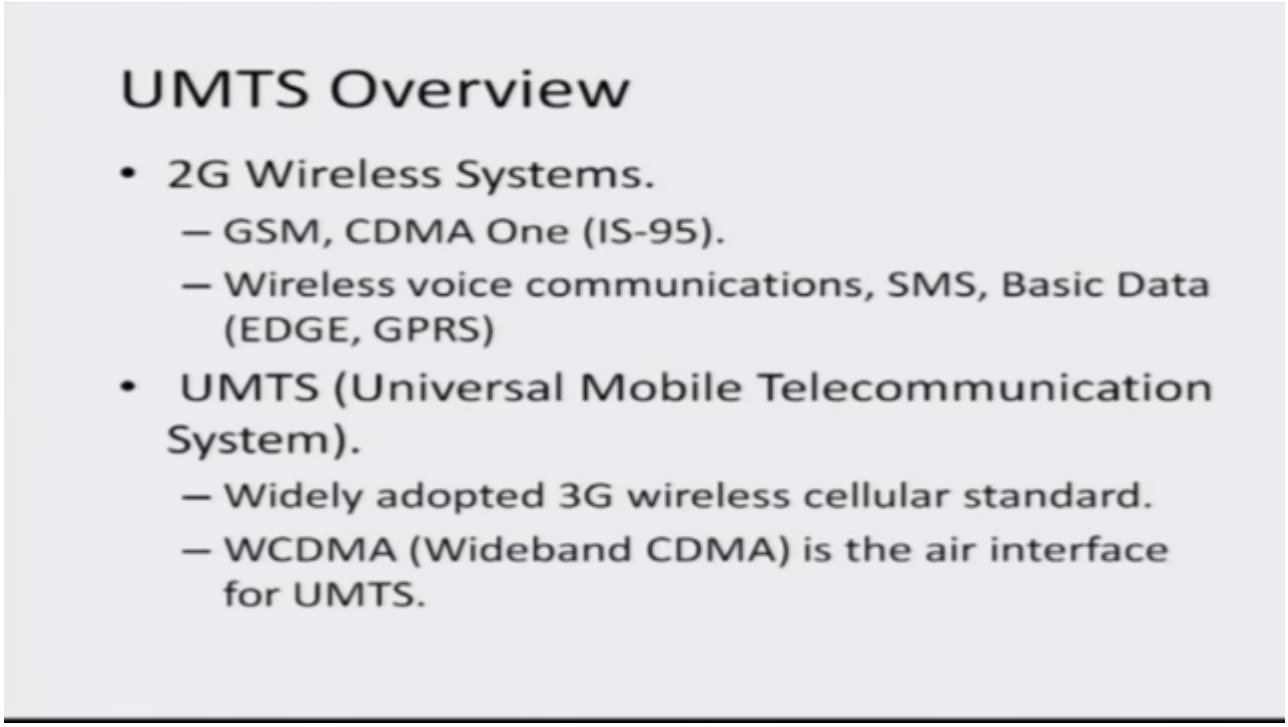

We have already seen that UMT 2G wireless systems consists of standards such as GSM and standard CDMA One or the IS-95 which support basic wireless communications, SMS features, basic data and such as for instance EDGE and GPRS the general packet radio service, etcetera; UMTS which is Universal Mobile Telecommunication System is a widely adopted 3G wireless cellular standard and the physical layer or the central technology of UMTS is what is known as WCDMA or wideband CDMA and that determines the air interface or of the signals are transmitted over the air.

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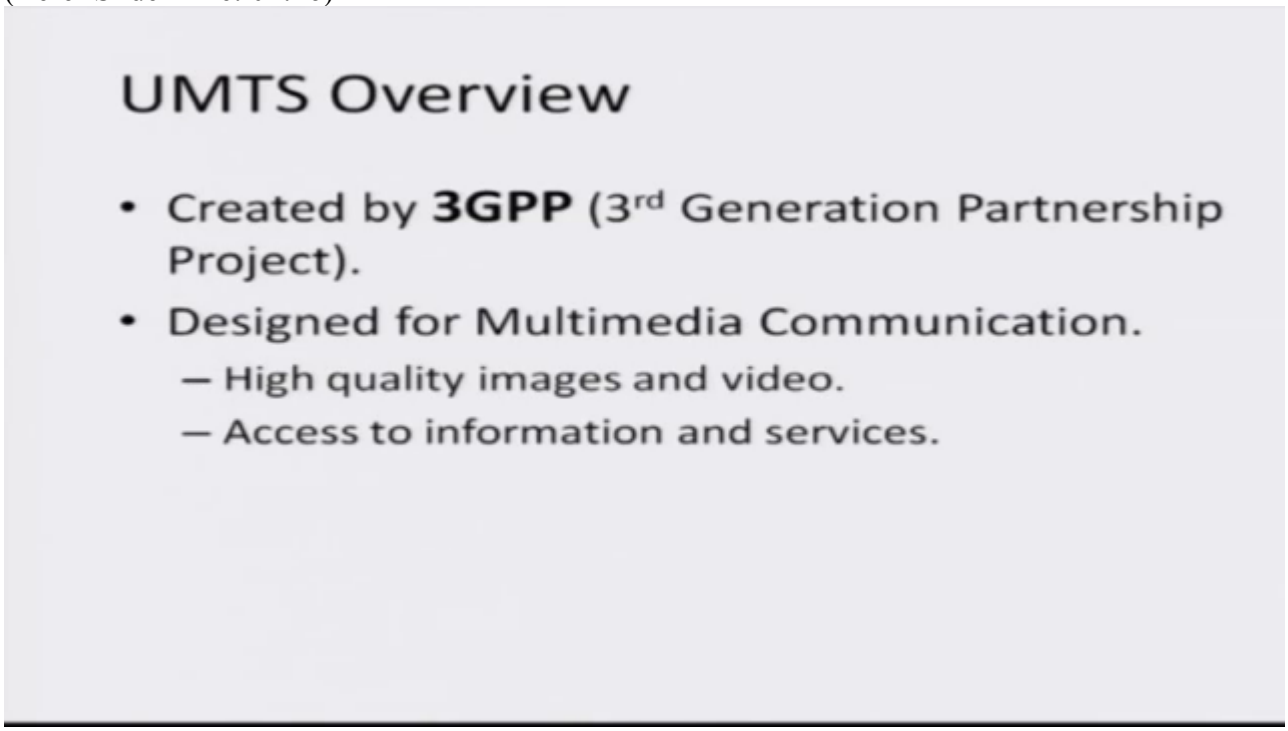

And this is created by this umbrella body which is termed as 3GPP or the third generation partnership project and it's designed primarily for multimedia communications as is not just

voice communication like the previous standards but also transmitting high-quality images, video and access to a variety of information and services.
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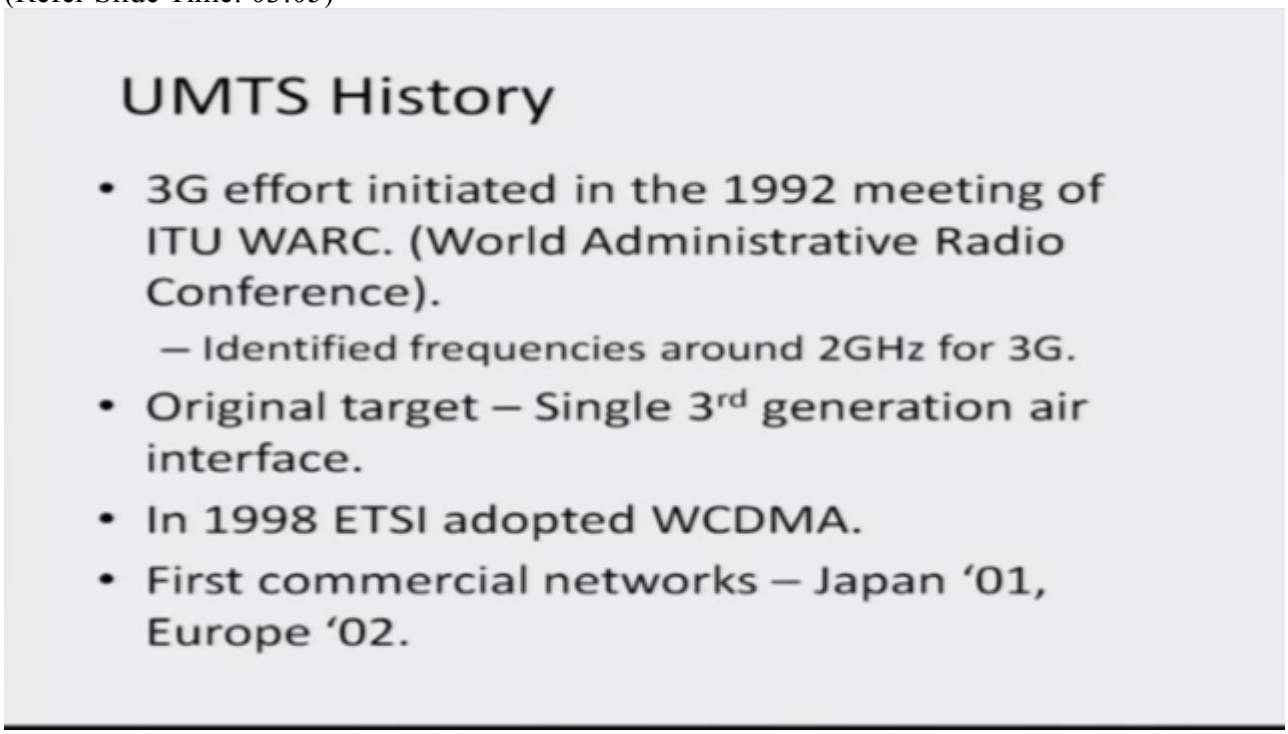

A brief history of WCDMA, it was -- the effort was initiated in 1992 in the world administrative radio conference and the original target was to again develop an advanced single third-generation air interface. In 1998 it was adopted by the ETSI or the European Telecommunications Standards Institute and the first commercial networks rolled out in Japan and Europe in around early 2000, 2001, 2002.
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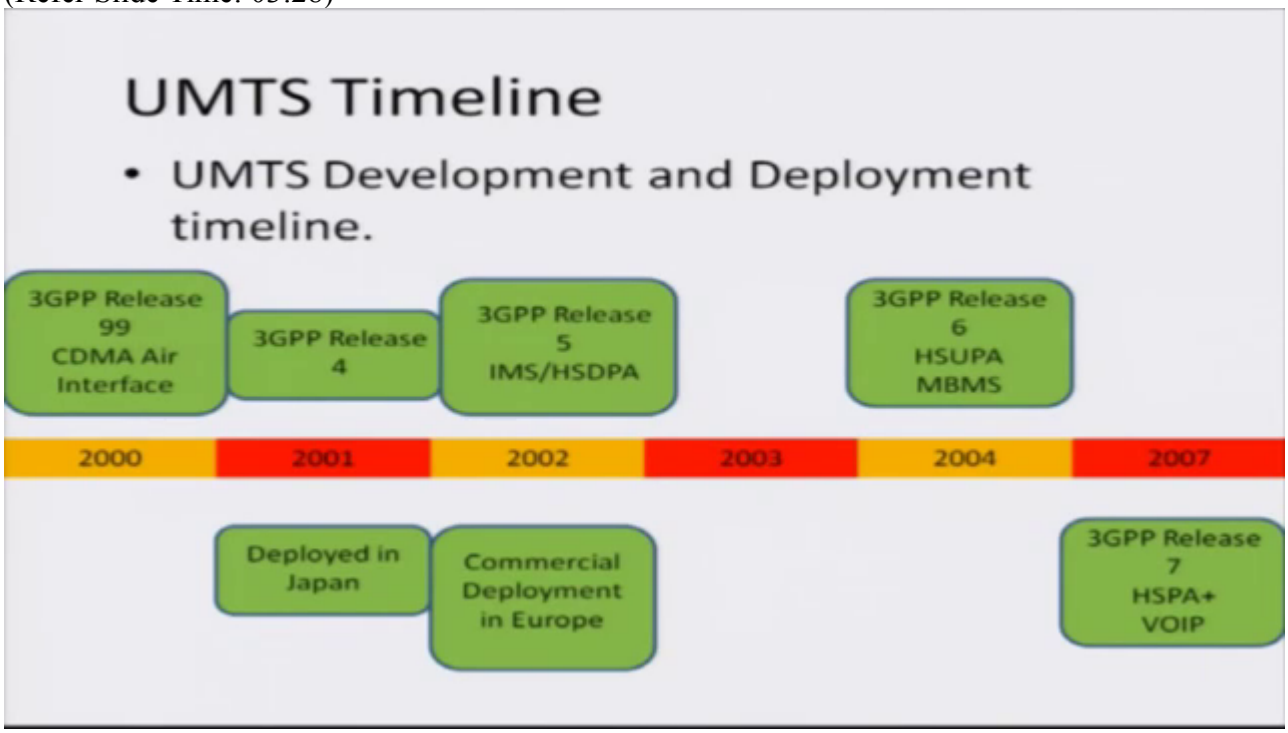

And here is a brief timeline for the development of UMTS in 2000 3GPP released 99 was developed followed by the 3GPP release 4 in 2001 and the commercial deployments in Japan followed by in 2002 deployment in Europe and Release 5 what is known as HSDPA which increases the data rate further. It stands for high-speed downlink packet access. Around 2004 the uplink counterpart of that was or Release 6 was formalized and Release 7 further increase the data rate which is known as HSPA+ or high speed packet access plus, which supports again a variety of feature.
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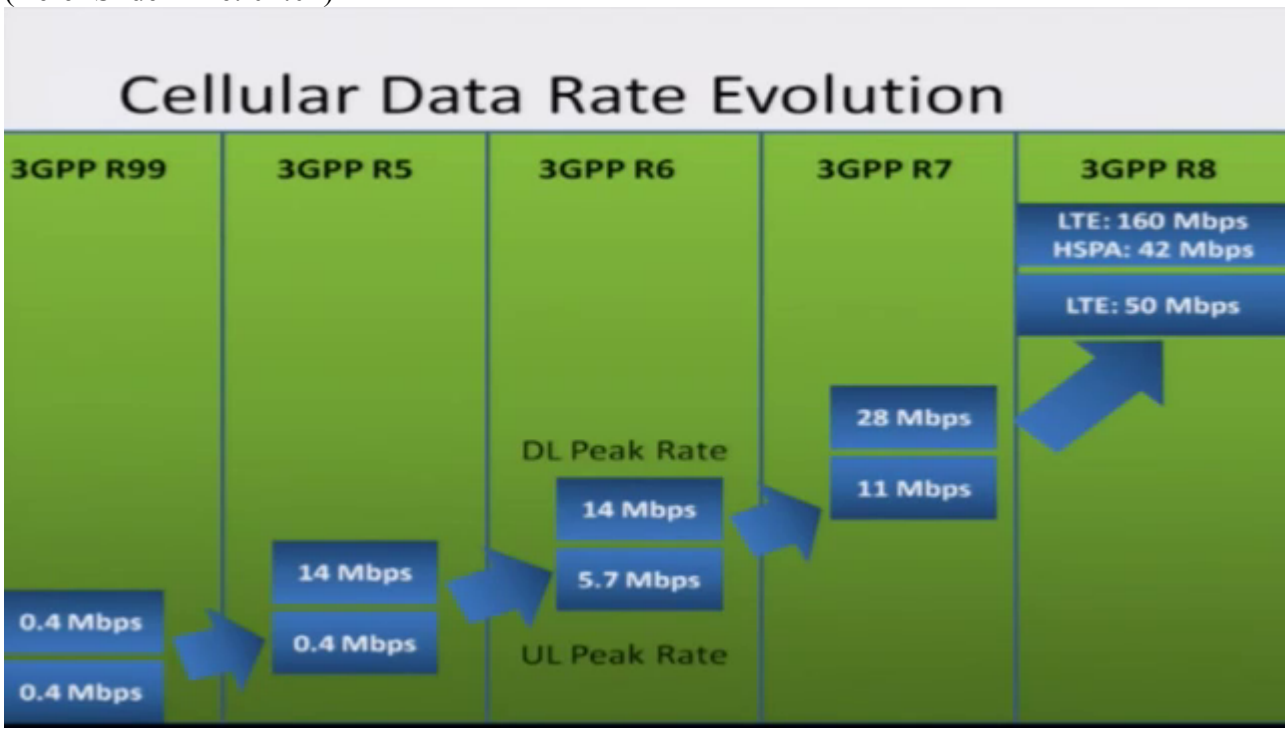

So this is again a brief graph showing the increase in data rate through the generations, the Release 99 or the initial version supported about 300 to 400 kilo bits per second further releases with HSDPA, HSUPA and HSPA went all the way from about 14 megabit per second to 28 megabits per second and this is followed by LTE or Long Term Evolution which can support a data rate of about 160 megabits per second. That is really a 4G wireless standard which we are going to look at in some of the later modules.
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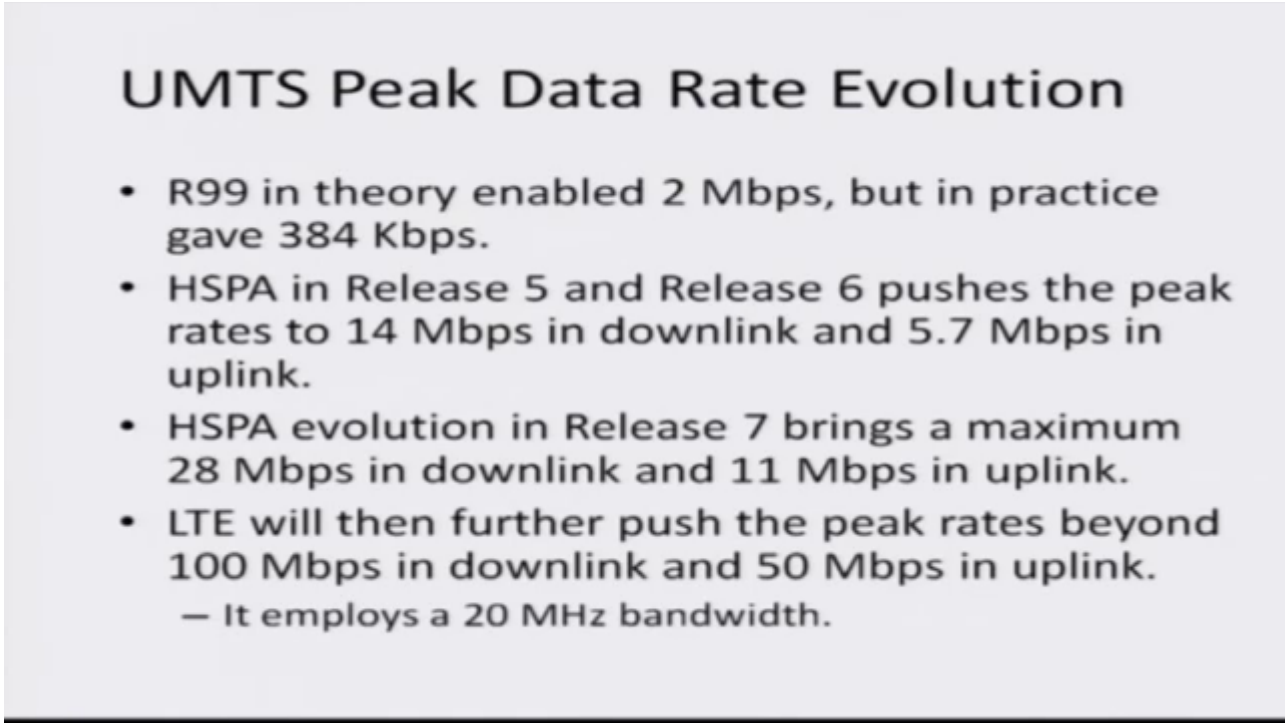

So therefore is also beneficial to understand how the data rate evolved across the various releases in the 3G. The R99 the initial release has about 400 kilobits per second while with HSDPA and HSUPA supported about 14 megabits per second and the downlink and 5 megabits per second in uplink respectively. The HSPA evolution or HSPA+ is capable of supporting about 28 or about 30 megabit per second in the downlink and 11 megabit per second in the uplink and LTE which is the ultimate evolution which is capable of supporting about 100 megabits per second in the downlink and 50 megabits per second in the uplink and it has a huge bandwidth of about 20 megahertz.

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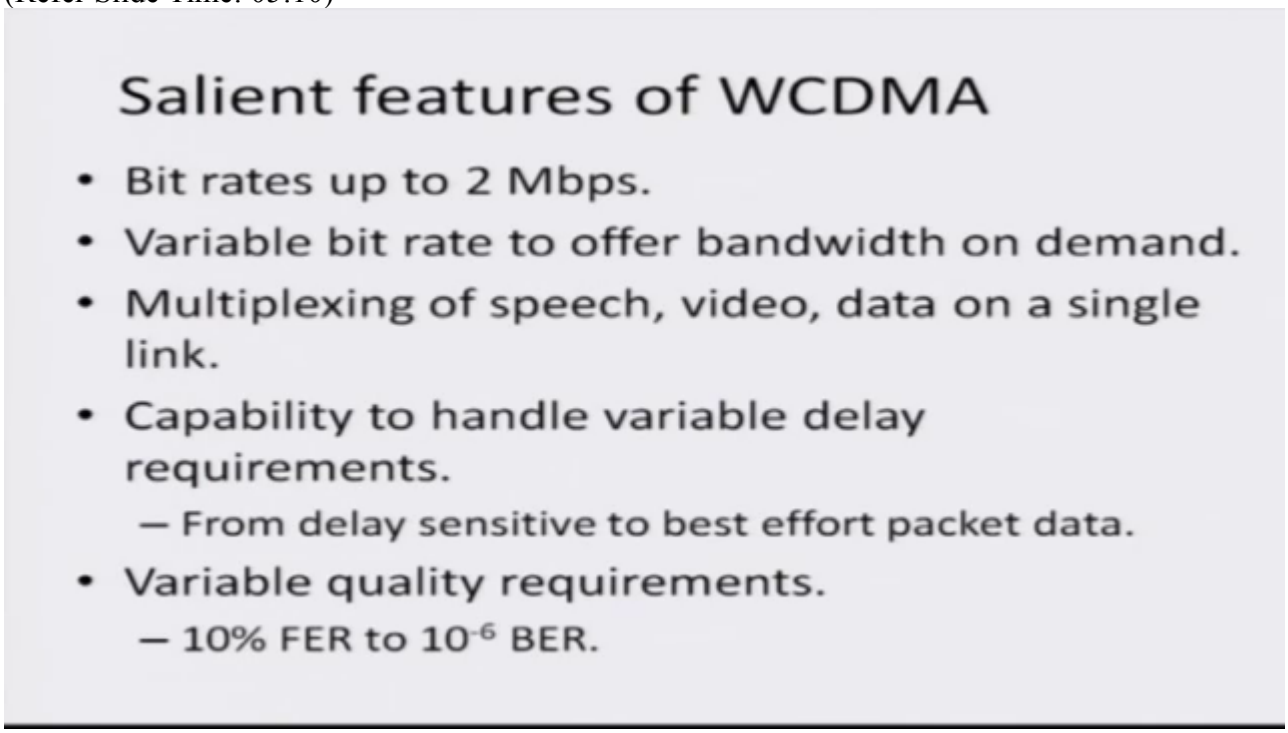

So some of the salient features of WCDMA, it can support bandwidths of very high bandwidths of two megabit per second which make not only voice calling but also video telephony possible. It enables to multiplex speech, video, data on a single link that is you can talk, you can communicate by video and you can also transmit data on your internet etcetera access internet on a single link and it handles a variety of delay requirements for instance for the internet which is you can sort of tolerate a certain amount of delay to voice which cannot tolerate any delay and it can is capable of achieving really low bit rate about 10 to the power of minus 6 which means that link is very reliable.
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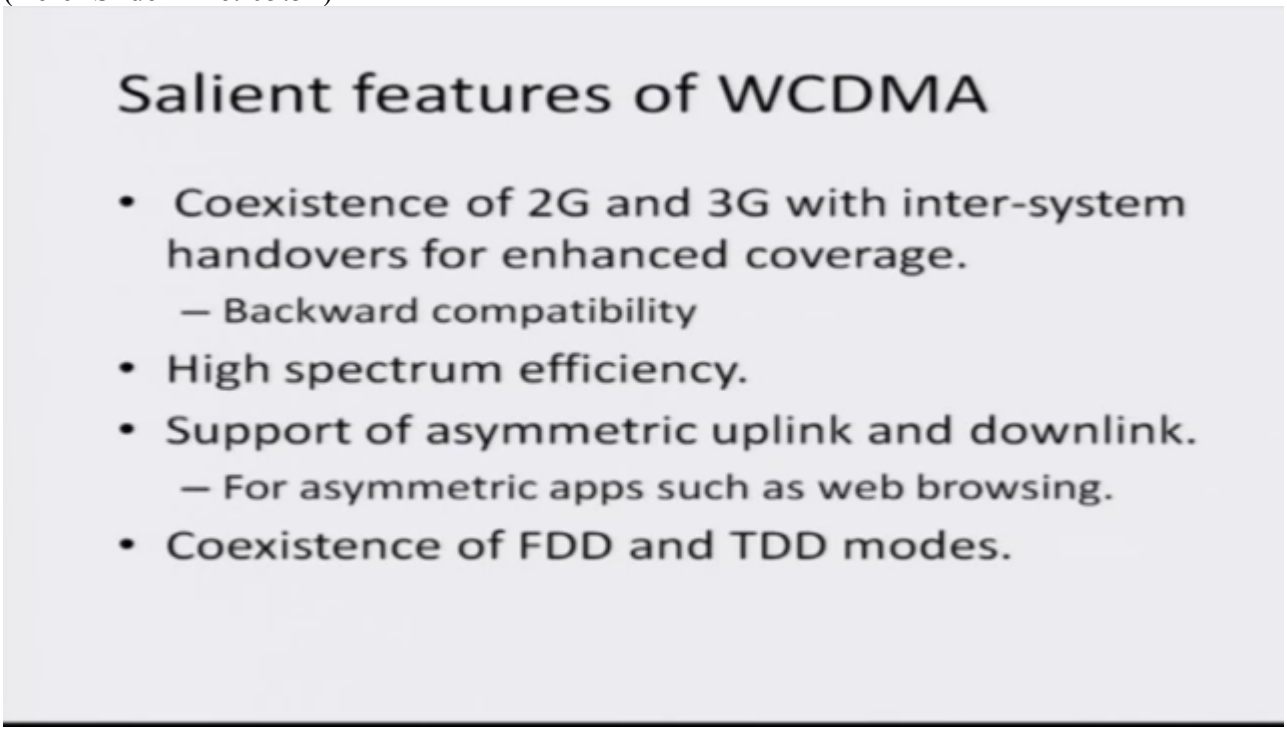

And some of the other features are WCDMA is backward compatible with other 2G services such as GSM. It has a very high spectrum efficiency that is in the given amount of spectral band or spectrum. It utilizes it very efficiently by transmitting at a large data rate. Supports symmetric uplink and downlink capacities and also supports both the modes of communication known as FDD and TDD. FDD stands for a Frequency Division Duplex and TDD stands for a Time Division Duplex.
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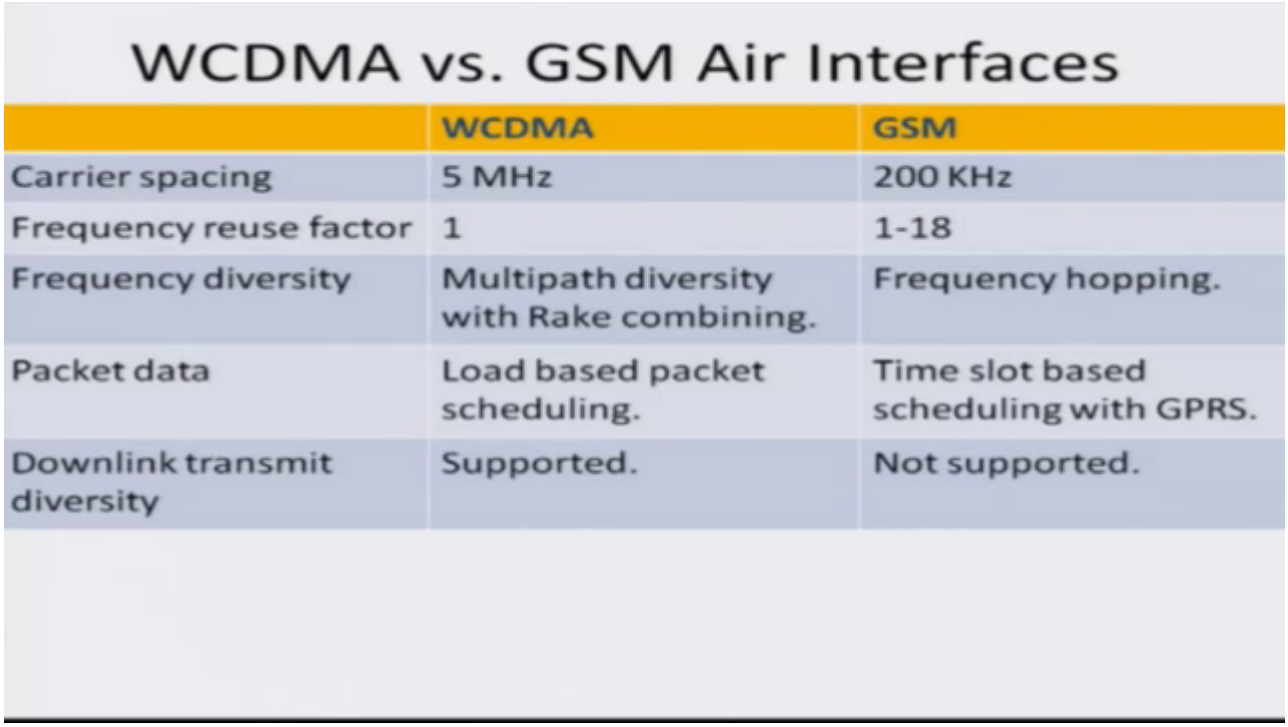

And these are some of the salient specs or comparison between WCDMA and GSM. As you can see GSM has a basic bandwidth of 200 kilohertz, while WCDMA has a significantly higher bandwidth of 5 megahertz and more importantly WCDMA has a frequency reuse actor of 1 which means it uses the frequency spectrum very efficiently while GSM has a frequency reuse factor of only somewhere between 1 and 18 which means it's very inefficient in frequency reuse. WCDMA supports packet data, it's supports transmit diversity which means it can use multiple antennas. This is one of the other advanced aspects of WCDMA where multiple antennas can be used to significantly enhance the reliability of the communication link. And this is something that we are going to look at also later when we talk about other advanced technologies.

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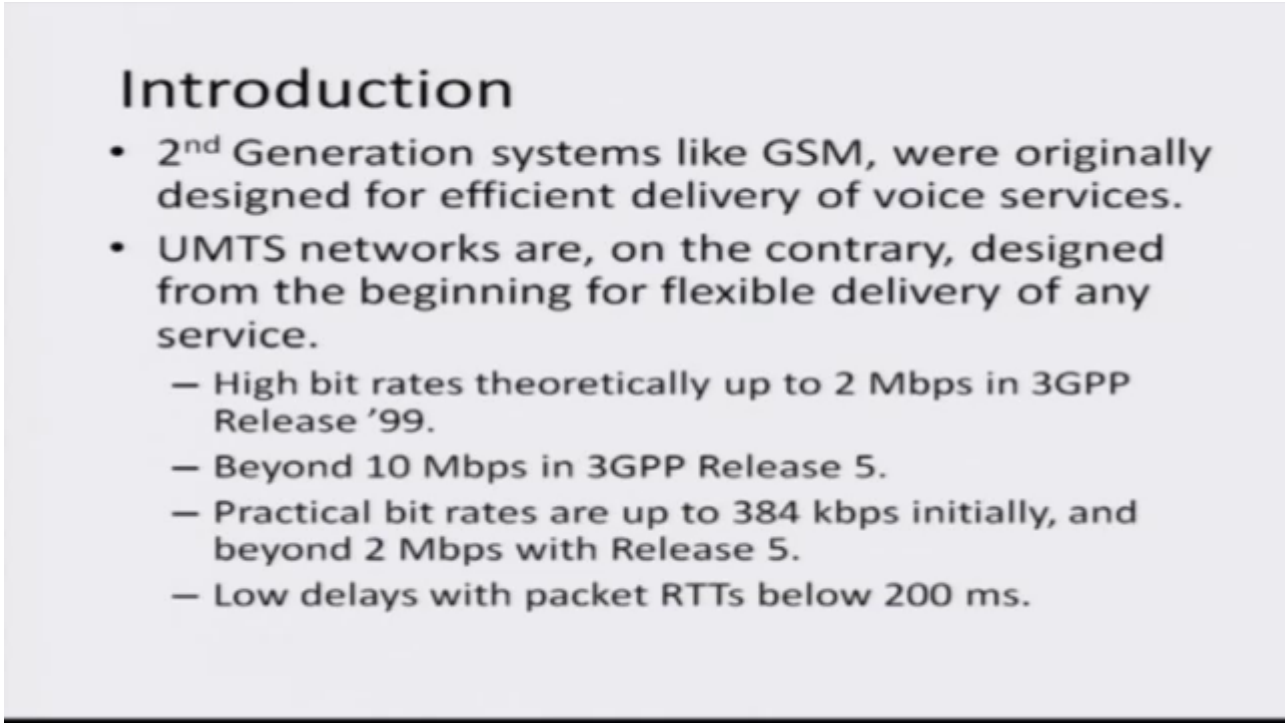

So CDMA as I already said in comparison to GSM which was originally designed for voice services CDMA or UMT was designed to provide high data rates about several megabits per second and in fact going beyond 10 megabits per second Release 5. And also the other important aspect is to improve the round-trip time. The round-trip time is sort of, for instance, it's the sort of time that takes to get a response back from the communication system. And this is very important for instance in live applications such as video conferencing and also online gaming where between the action of a particular user and the time you get a response it's important to minimize that delay and that is known as the round-trip time and WCDMA one of the main advantages it sort of minimizes the round-trip times significantly.

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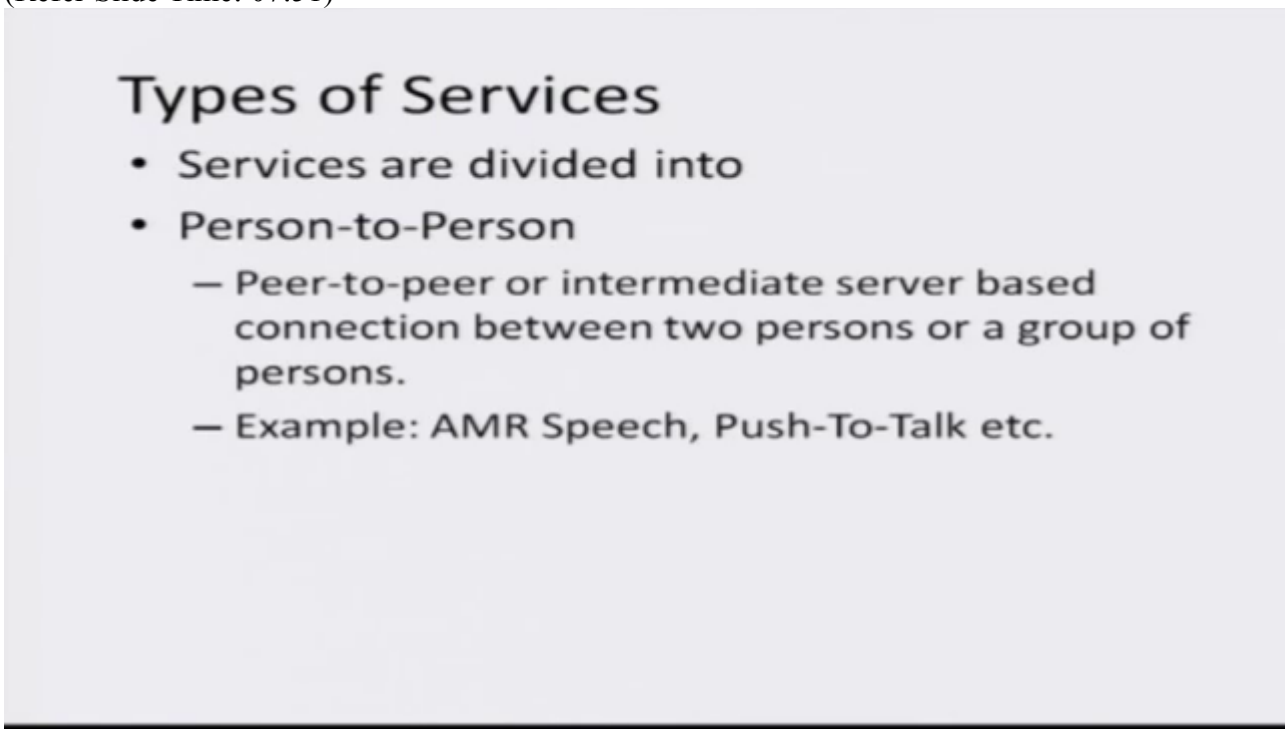

And there are several types of services for instance, person-to-person such as peer to peer for instance these are the push-to-talk or the walkie talkie kind of services that are available.
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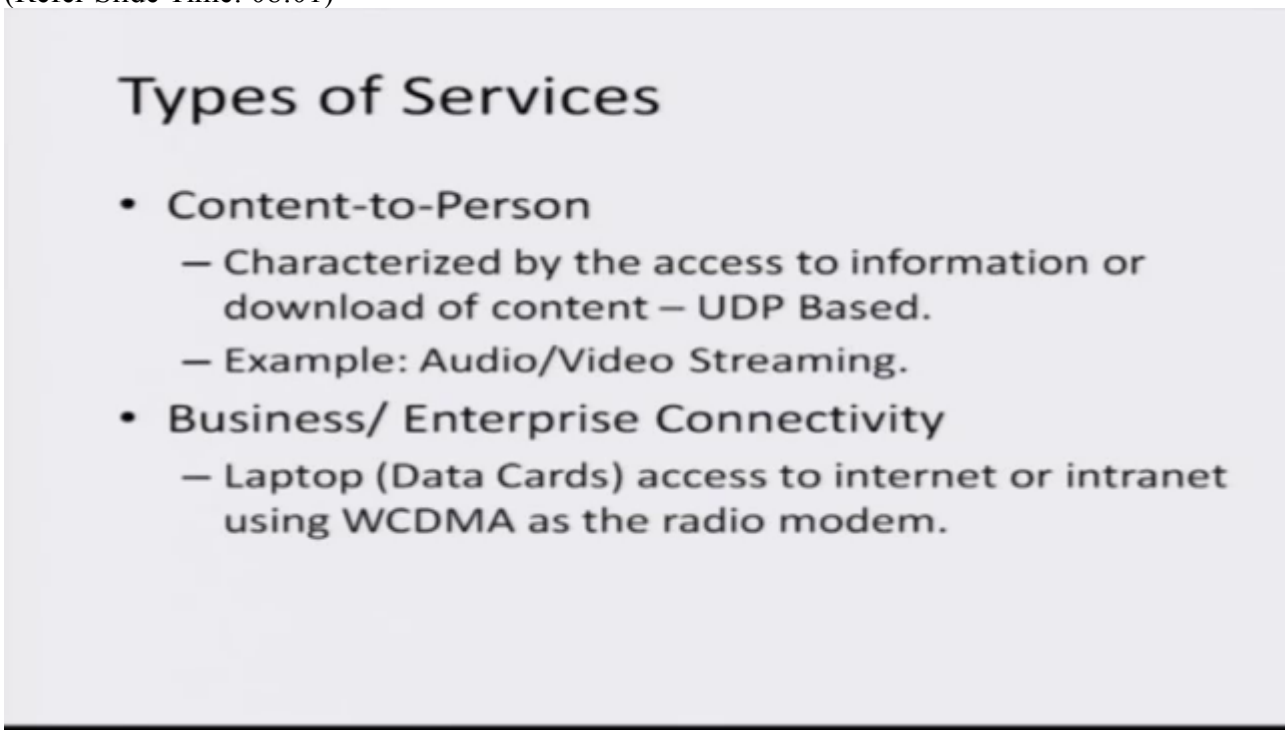

Content-to-person that is basically not just voice calling but transmit content such as video content which is hosted on a server such as music or live video streaming, streaming of movies, streaming of TV etcetera. Business and enterprise connectivity for instance providing dongles and data cards for laptops at the same time video conferencing facilities for businesses at a high data rate that is voice, simultaneous voice and video calling and sort of group voice and video calling that is video conferencing.
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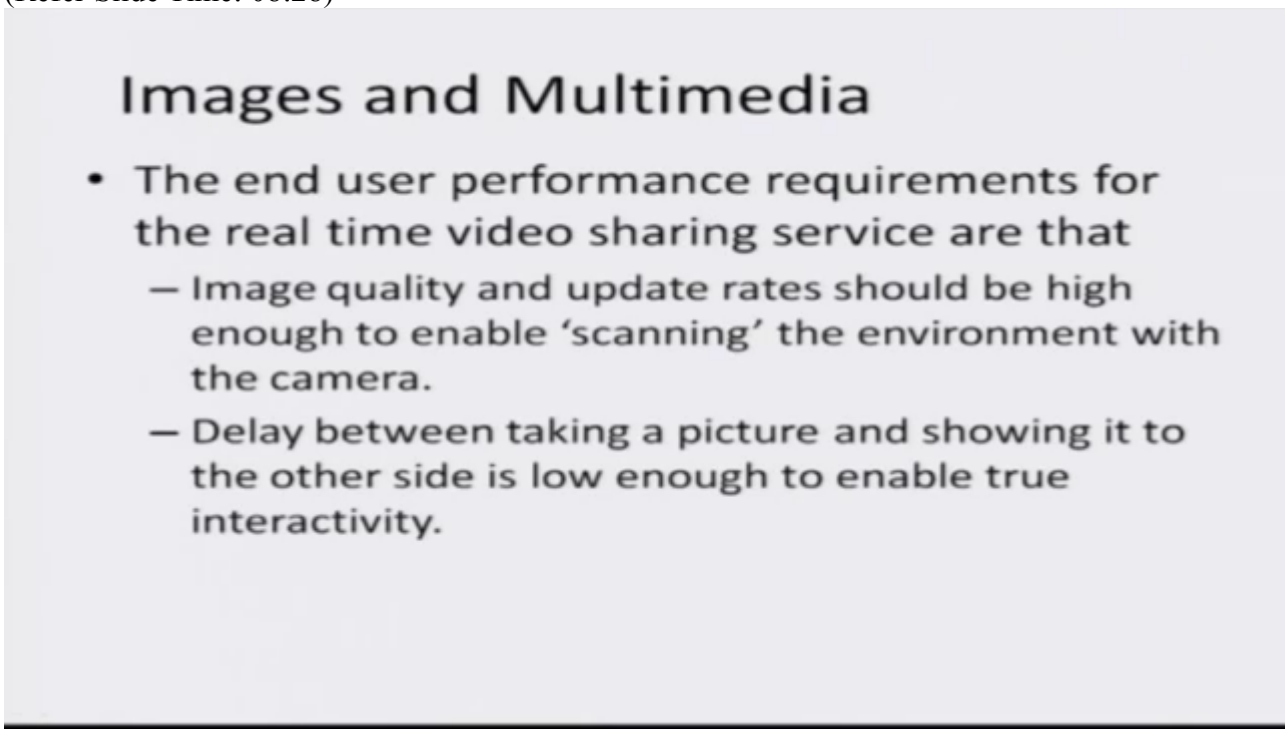

And also images to support transmission of high-quality images and multimedia content and minimizing the delay between taking a picture, scanning the environment and transmitting it to the other side and that's important to support image and multimedia transmission.
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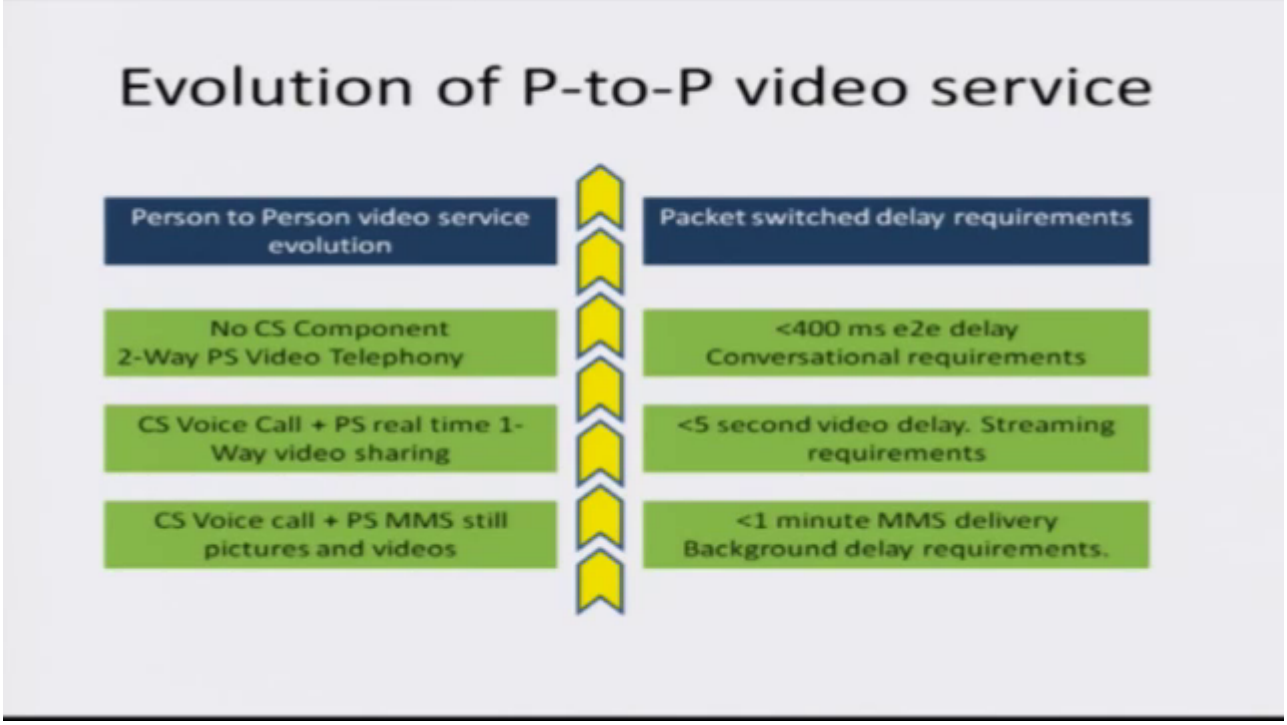

And here is a brief list of the key characteristics of the different services for instance voice calls can tolerate a delay of about and still video transmission has background delay requirements about above 1 minute, but the moment you go to real-time video sharing the delay needs to drop below 5 seconds and for the circuit-switched for video telephony, video transmitting video along with voice the delay requirements need to be significantly lower about 400 milliseconds and lower.
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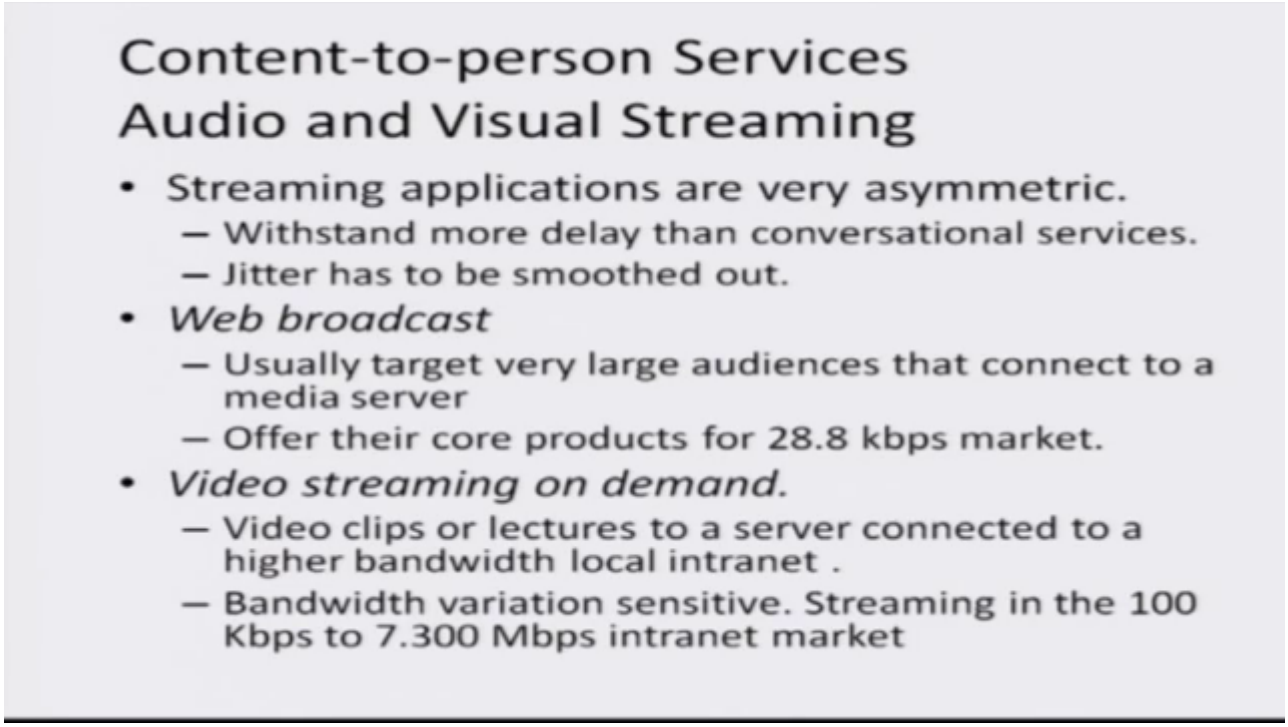

And there are various services such as the content person services such as streaming applications, web broadcast which target a large audiences which are broadcasting or for instances live news conferences, live conferences, live games, video streaming on demand such as streaming of video clips, highlights of games or lectures or movies etcetera, these are the different services.

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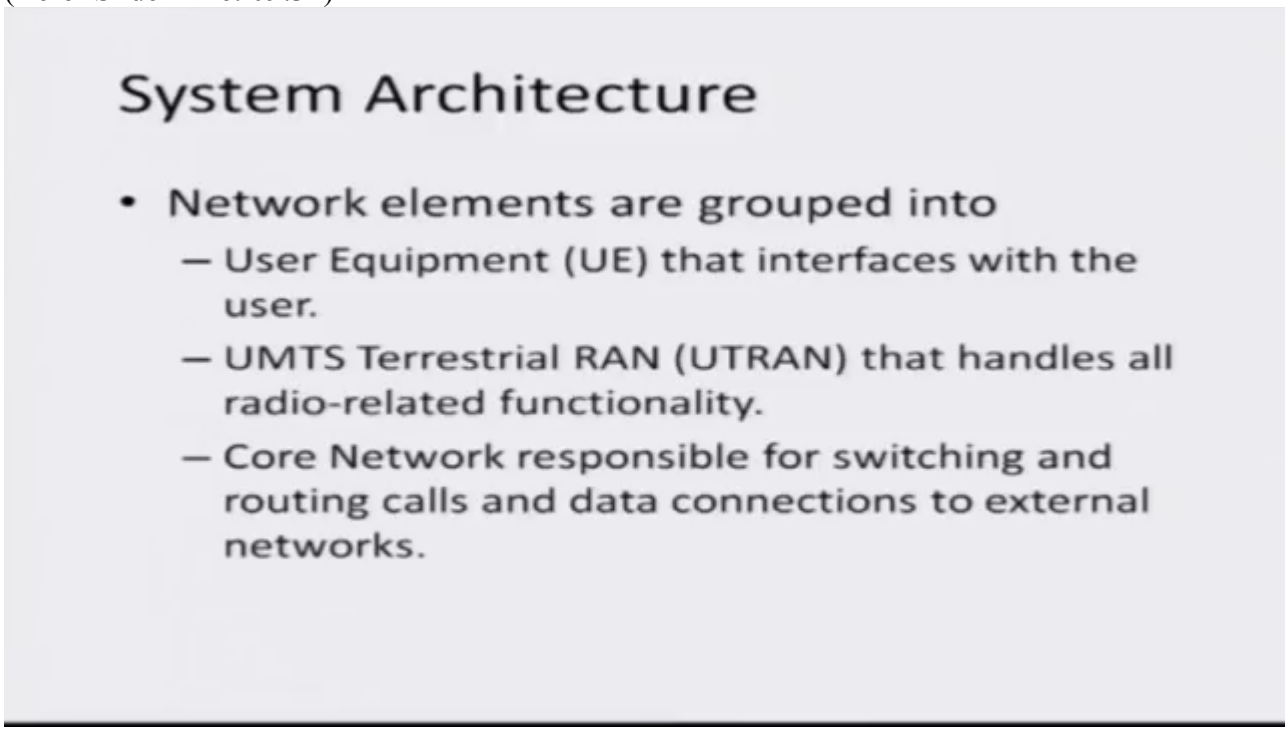

And just to give you a brief idea of the WCDMA Network. The WCDMA Network again is sort of similar to the GSM network it has three components. The user equipment which is your device along with the SIM, the terrestrial radio access network which s composed of the base station, the base station controller etcetera or it analogous component and the core

network which is responsible for the switching and routing calls to the other networks, other carriers, the landline network, the internet etcetera.

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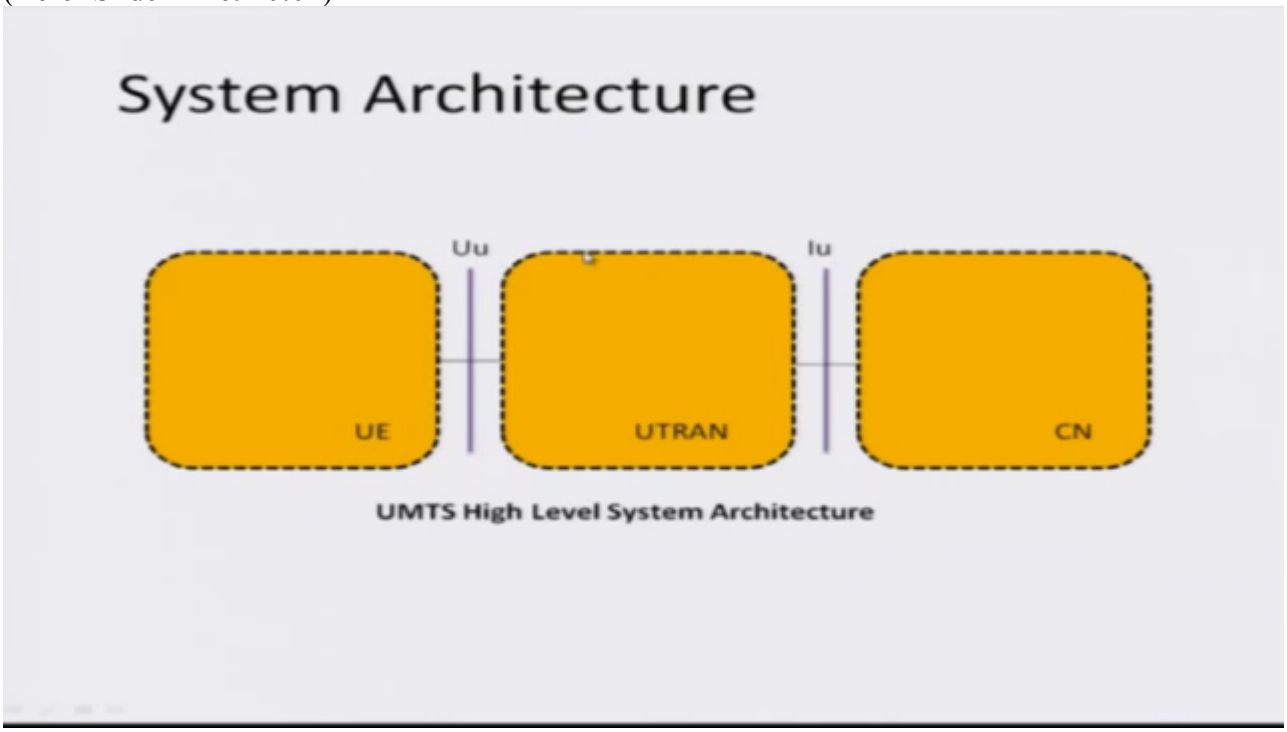

So this is a schematic. You have the user equipment, the core network at the end and the terrestrial radio access network in between.

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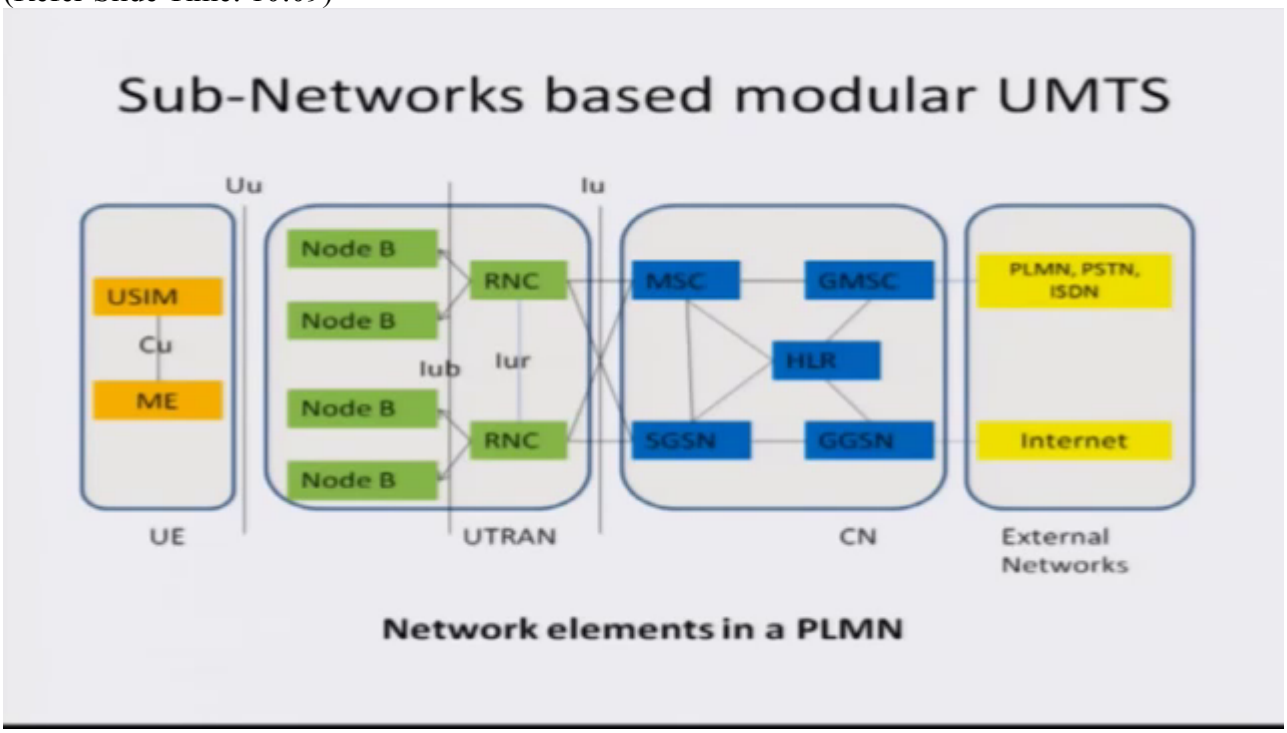

The user equipment consists of the SIM similar to GSM and the mobile equipment. The base station is known as the Node B and these base stations of the base station controller is also known as RNC or the Radio Network Controller. These are connected to the core network which consists of various gateways, which consists for instance can talk to other GSM based

cellular networks, other carriers or the landline network or also the internet that is interface with packet database networks etcetera.
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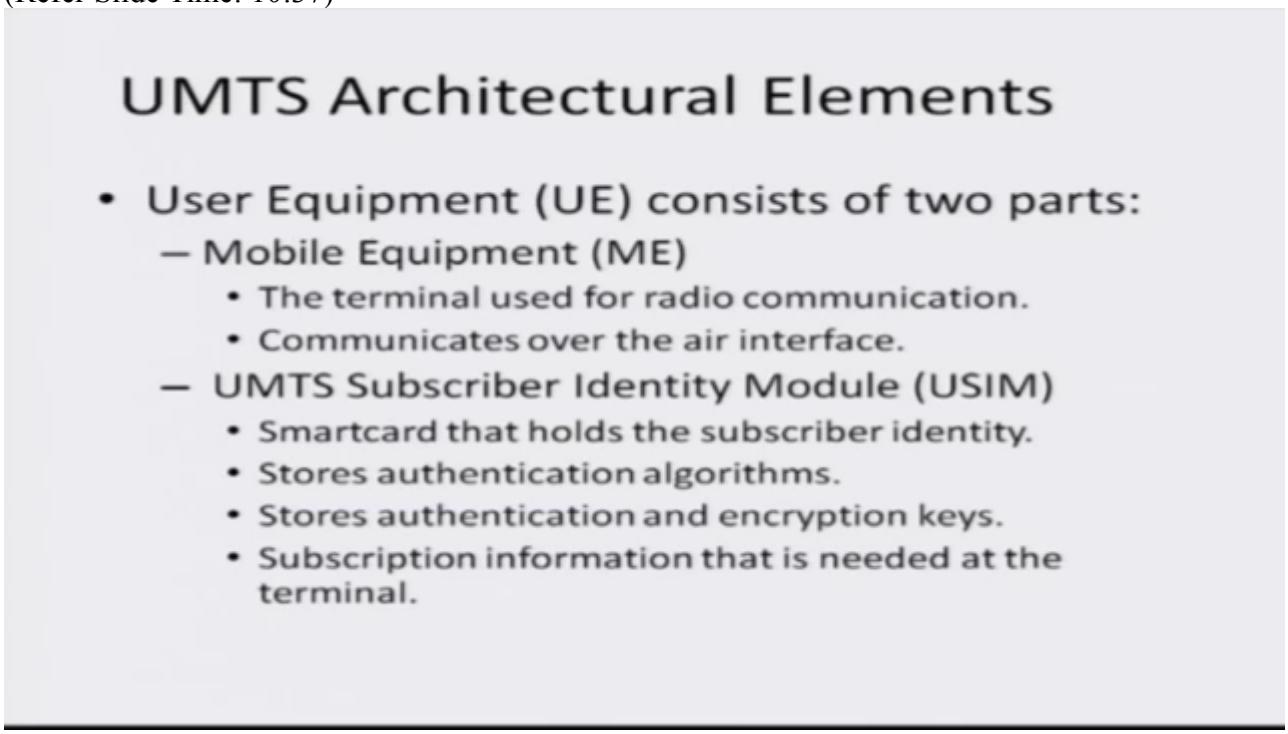

So these are the different aspects that is user equipment, the subscriber identity module that is similar to SIM that stores the authentication algorithms, the encryption keys, the subscription information, the service information, the identity etcetera.
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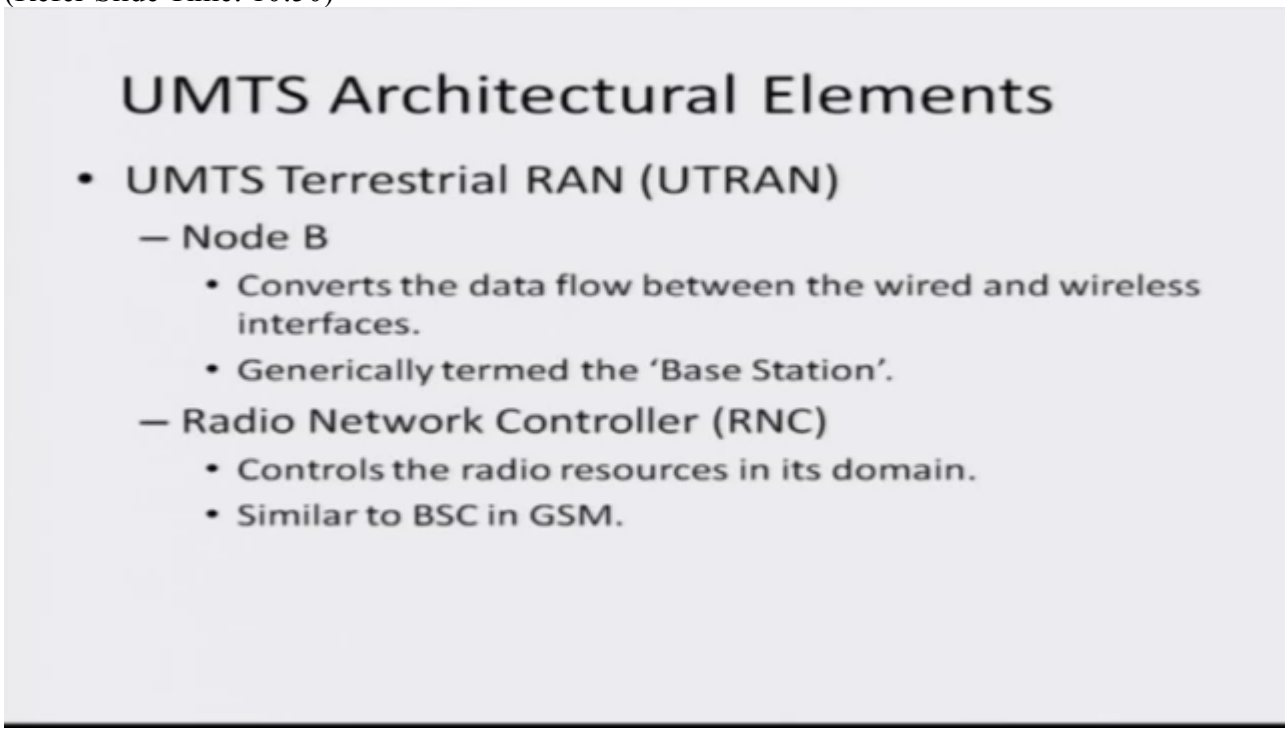

The radio access network which again is similar to the base station which is basically receives the signal from the user equipment or the device and relays it to the other aspects of

the network. And the radio network controller which controls this Node B's or these base stations and manages the handover and the frequency resources.
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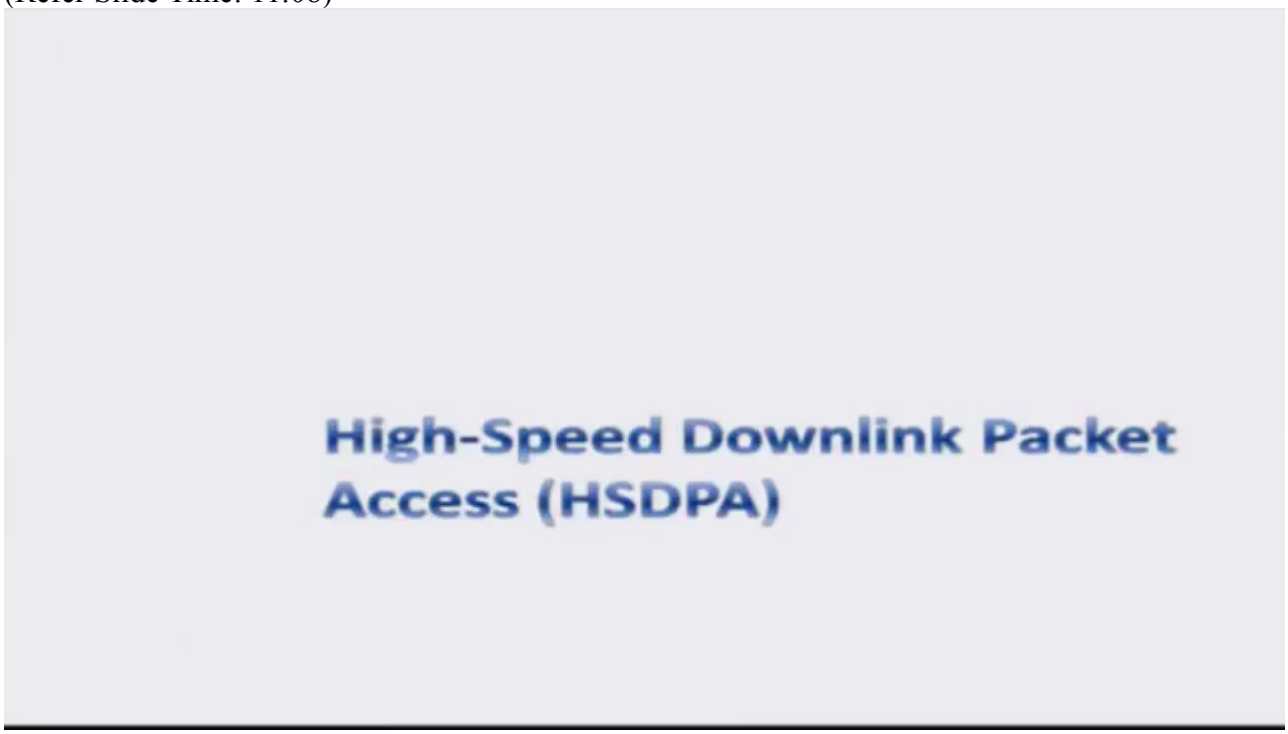

And also a brief intro to the high speed downlink packet access, HSDPA.
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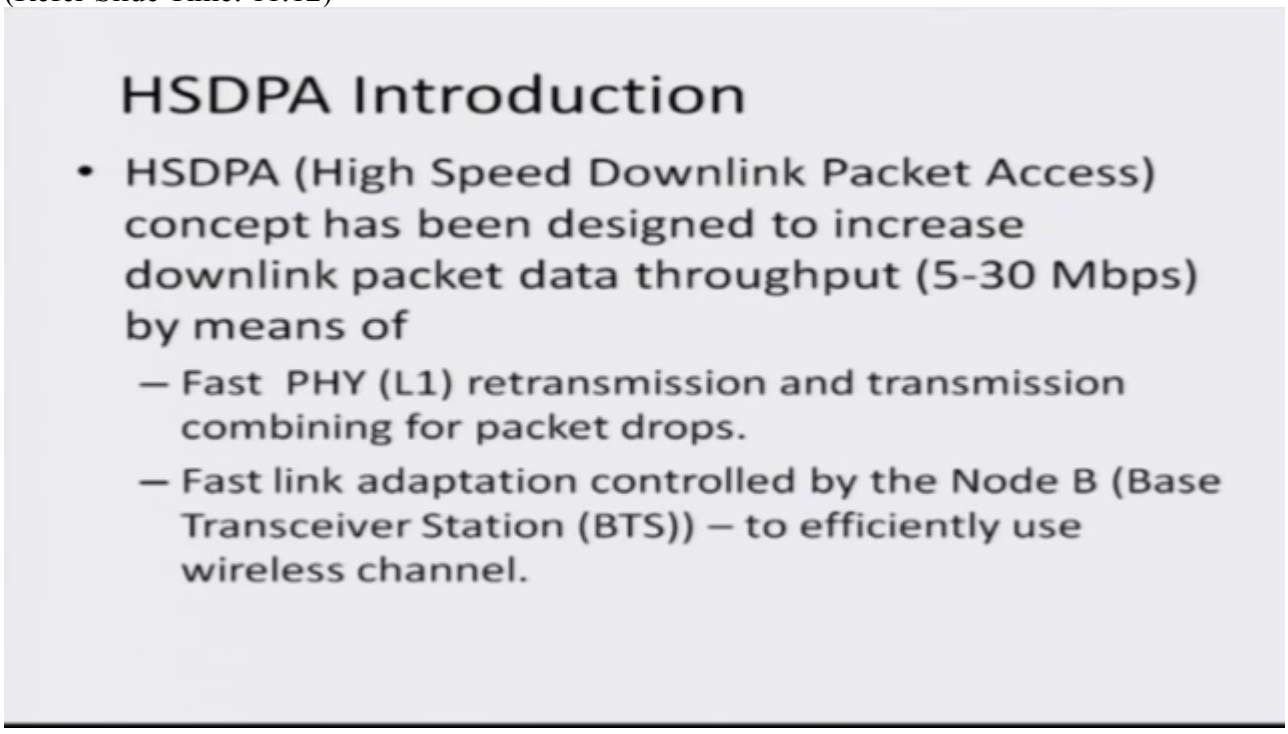

which has been designed to further increase the data rate from about two megabit per second in WCDMA to about 30 megabits per second and this is basically done with a lot a large number of smart schemes such as fast retransmission, link adaptation that is basically adapting the transmission strategy to the nature of the link to the strength of the signal.
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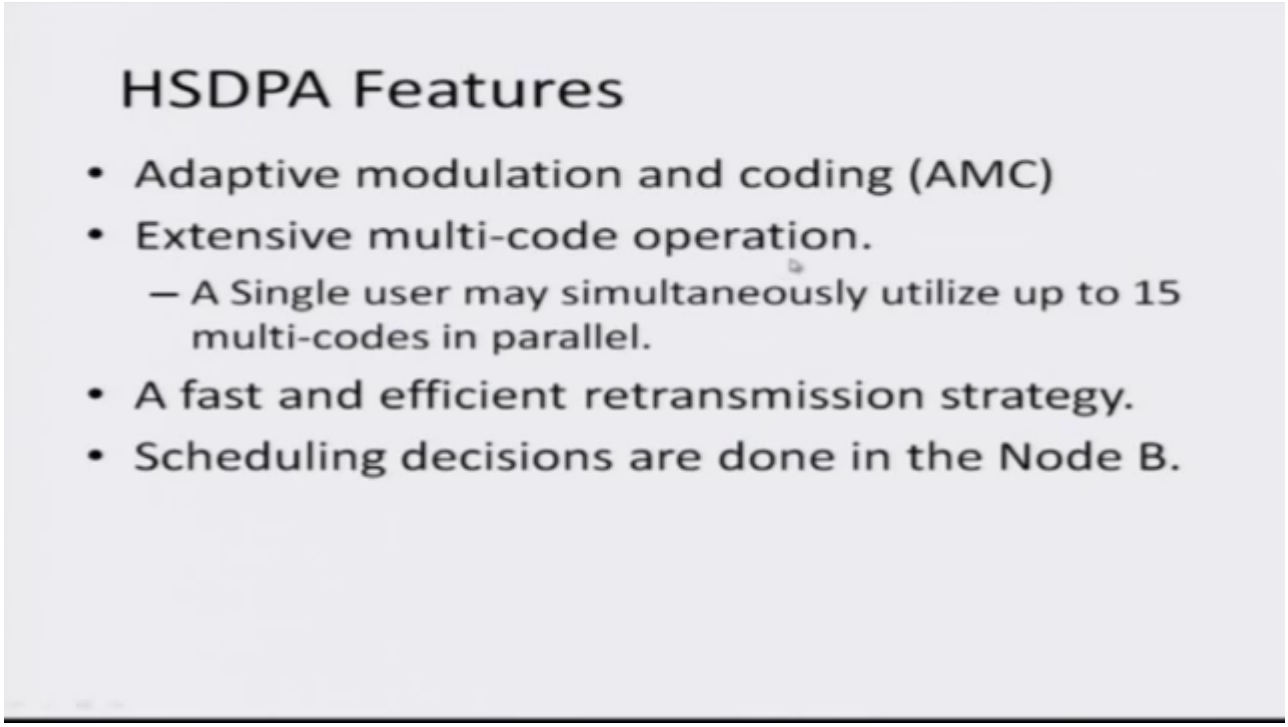

Adaptive modulation that is adaptively changing the signal strategy or the number of bits that are transmitted per symbol depending on the strength of the link, efficient retransmission and also scheduling decisions which means what kind of users have to be scheduled or what kind of users have to be provided service for instance let's say there are users who are using video some users are on voice, some users are on the internet or email or browsing applications, which users need how many resources, which users need to be scheduled, so making a lot of smart and intelligent decisions to schedule the users appropriately to increase the overall efficiency of the network. These are all features advanced -- some of the advanced features in HSDPA.

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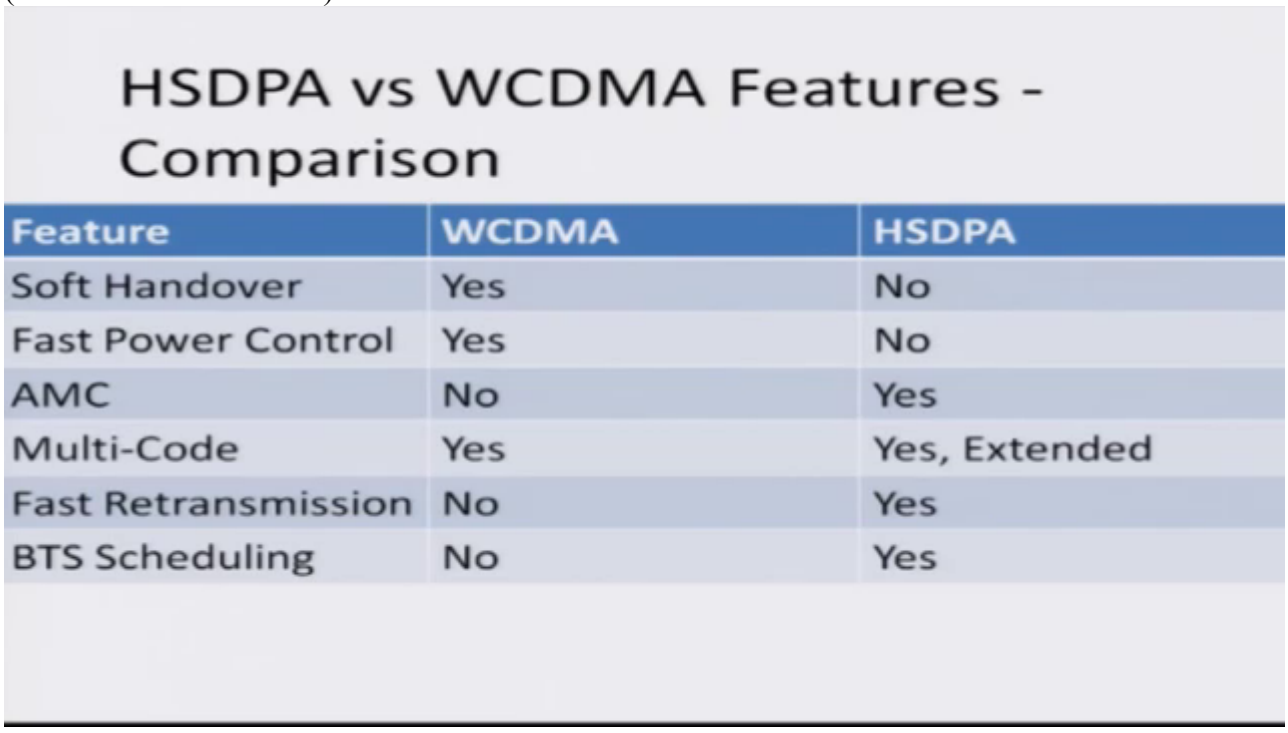

These are some of the table which summarizes some of the features that is a soft handover which increases the signal strength fast power control which increases the reliability, adaptive modulation and control, Multi code transmission, fast retransmission, again to retransmit drop packets thereby decreasing the time of delivery and scheduling appropriate users to increase overall efficiency. So that concludes this brief introduction to the third generation wireless communication standard that is WCDMA and its various features and some of the salient aspects. Thank you.