Principles of Modern CDMA/MIMO/OFDM Wireless Communications

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Lecture - 01
Evolution of Wireless Communication Technologies

Hello. Welcome come to this MOOC massive open online course, on the principles of CDMA, MIMO and OFDM Wireless Communications systems.

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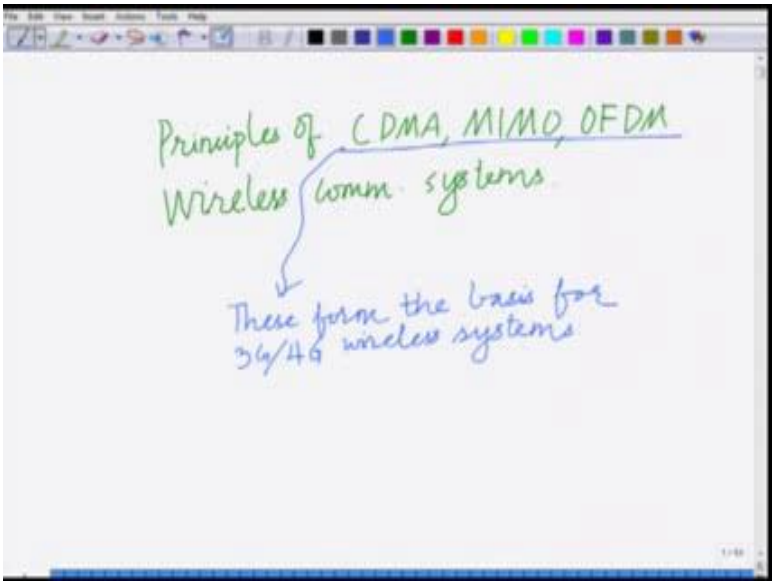

This is a massive open online course, on the Principles of CDMA, MIMO and OFDM Wireless Communication Systems. And these, that is CDMA, MIMO and OFDM technologies, which we are going to talk about extensively in this course. These form the basis for the current 3G, 3rd generation and 4th generation Wireless Communication Systems.

These are the basic technologies, for 3G; that is the 3rd generation and 4th generation wireless communication systems. In fact, these are also going to be extensively used in the upcoming fifth generation wireless communication systems. To better understand the impact of these technologies; that is CDMA, MIMO and OFDM technologies. Let us

briefly look at the evolution of the wireless communication system. That is how of the wireless communication systems and standards evolved over the different generations of wireless technologies.

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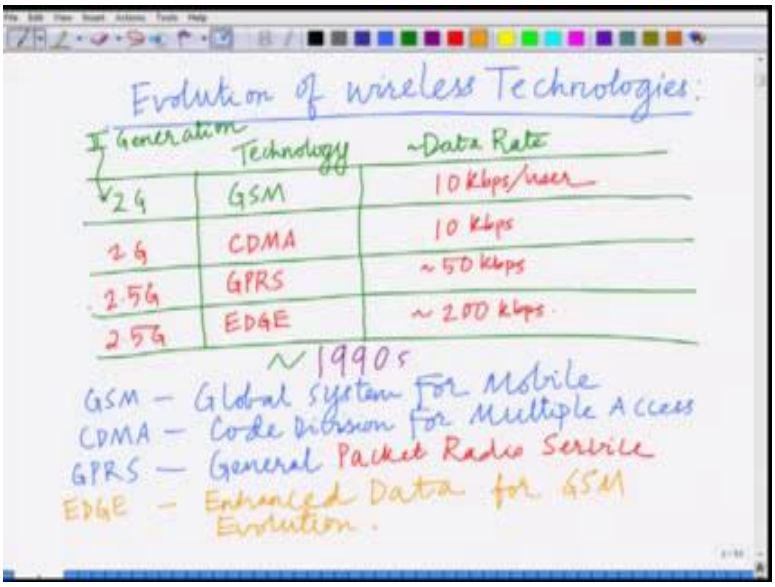

To begin with we have; let us talk about the evolution of wireless. Let us talk about the Evolution of Wireless Technologies. We have let us start with, our basic second generation wireless technologies. We have 2G where 2G represents, second generation. And 2G one of the fundamental technology of 2G is GSM, I am going to explain this acronyms shortly, which as a data rate this is the technology or standard and this is the approximate data rate. 2G as a data rate of approximately 10 kilo bit per second per user and another computing 2G standard for another standard in second generation was CDMA; which also had basic 10 kbps kind of a data rate. And moving on slightly ahead 2G evolved into 2.5G that is 2.5 generation wireless communication in 2.5G. We have technologies such as, GPRS; which enabled data rate of around 50 kbps and also another 2.5G or sometimes also called 2.75G standard is edge, which had slightly higher data rate of around 200, approximately 200 kbps.

These are the basic 2G technologies; which you can see have, this are the beginnings of the digital wireless communication revolution. And, if you are looking at the time scale,

these are around approximately around the 1990s. These were deployed in various countries and across several continents and approximately, starting with the early 1990s and evolved fully by the late 1990s.

And to explain these acronyms, we are going to look at several acronyms as we progress through this course. GSM, which is the most popular wireless communication standard; this stands for the Global System For Mobile Communications. CDMA stands for Code Division For Multiple Access. GPRS stands for the General Packet Radio Service and EDGE, which is a 2.5G standard, stands for Enhanced Data for GSM Evolutions. These are the various standard that is GSM, which is the Global System For Mobile. We have CDMA that is Code Division For Multiple Access. GPRS, which is a General Packet Radio Service and EDGE, which stands for Enhanced Data for GSM Evolutions and this is the basic scenario of the 2G wireless setting.

And moving on this 2G wireless communication systems evolved into the 3rd generation wireless communication system. 2G give way to 3G wireless of the 3rd generation wireless communication systems. We have 3G or the 3rd Generation Wireless Communication Systems. And I am going to make a small list of these, 3rd generation wireless communication systems.

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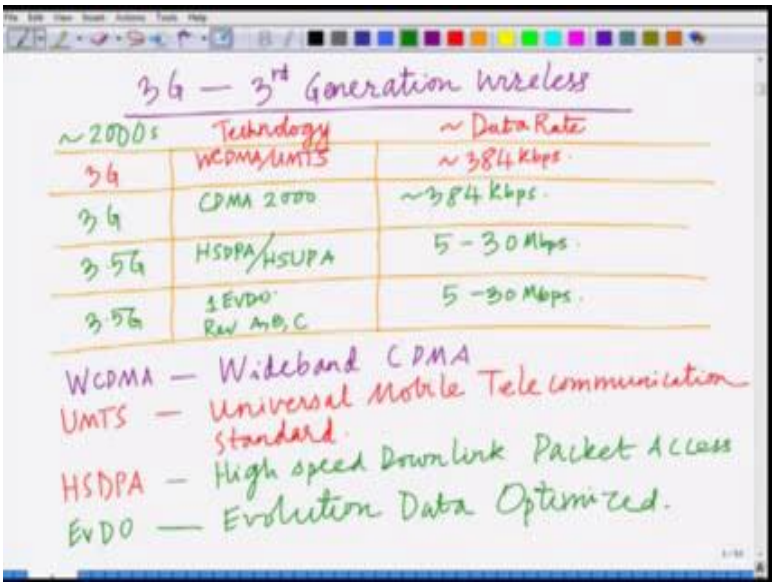

Similar to what we made for the 2G scenario and we have 3G - one of the fundamental standards for; 3G is WCDMA or UMTS, which has a data rate of approximately 384 kbps. So, this is our technology and this is the approximate the data rate capability. I have also 3G; another standard is CDMA 2000, which has a data rate of again approximately 384 kbps. And this evolved into 3.5G standard that is, HSDPA/HSUPA which has a data rate capability of around 5 to 30 Mbps and another 3.5G standard which was 1 x EVDO revision A, B, C; which has data rate around 5 to 30 Mbps. And if you look at the time line for 3G, these were around the early 2000 and fully evolved and deployed in various countries around the late 2000, that is expand the decade from 2000 to 2010.

If you look 3G, the life time of 3G was around the 2000. There is a 2000 to 2010 and of course, currently being also deployed in several countries and let us again. You can see that, these have a data rates from several 100s of kilo bit per second to a couple of 10s of mega bit per second. Again let us look at the different acronyms; we already seen CDMA stands for Code Division For Multiple Access and WCDMA, which is closely related to CDMA stands for Wideband CDMA or Wideband Code Division For Multiple Access. UMTS is the; Universal Mobile Telecommunication Standard. HSDPA is the High Speed Downlink Packet Access and our EVDO stands for Evolution Data Optimized alright.

So, we have these different standards, WCDMA which is Wideband CDMA; UMTS which is the Universal Mobile Telecommunication Standard. HSDPA, High Speed Downlink Packet Access and the corresponding uplinks standard is HSUPA, which is High Speed Uplink Packet Access. We have EVDO, which is Evolution Data Optimized. And as we said these have data range span roughly that decade of the 2000 and (Refer Time: 11:41) data rates around 100s of kilo bit per seconds to a couple of 10s of mega bit per second. And these further give way to the 4th generation of wireless communication system.

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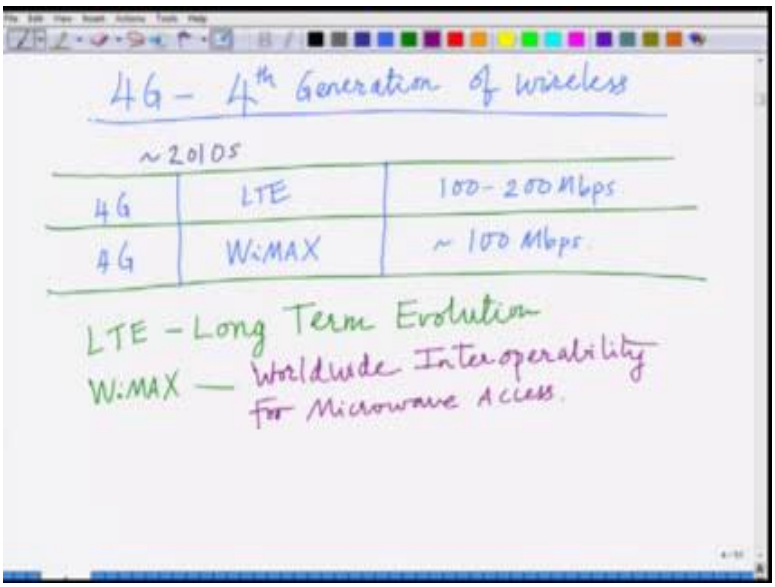

This is 4G or the 4th generation of what is also known, as the 4th generation of wireless communication standards and in this there are mainly 2, 4G standards. One is 4G is LTE, which has again 100 to 200 Mbps and another 4G standard is WiMAX, which has again a data rate of about 100 Mbps. And also we have some other standards such as LTE advanced, which have a significantly higher data rate of about half Gbps to 1 Gbps and LTE again is roughly spans the 2010s, the decade of 2010s that is roughly starting from 2000 years to 2010. It also currently in progress and its life cycle is expected to be a around, the year 2020. Even 5G is supposed to progressively take over that is fifth generation. And LTE stands for, Long Term Evolution. WiMAX stands for, the Worldwide Interoperability For Microwave Access. We have 2 dominant standards or technologies; that is LTE and WiMAX alright.

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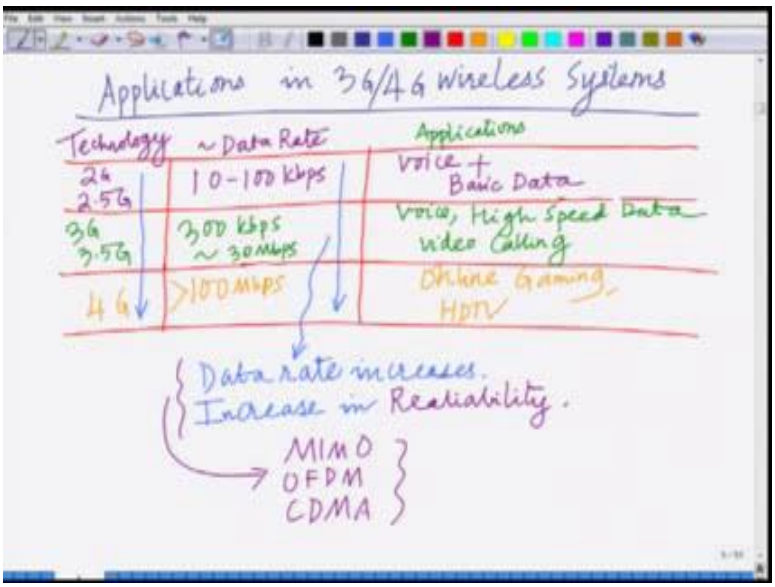

These are competing 4G wireless technologies. Therefore, let us now look at what are the different capabilities? Or what are the different applications? That are possible or how as the application scenario evolved across these different generation of wireless communication systems.

Let us briefly look at the applications or the evolution of the applications. Let us look at how the various applications have evolved; in this 3G from the 2nd generation, to the 3rd generation, to the 4th generation. So, if I have look at 2G to 2.5G systems, as I said I have a data rate, which is around 10 to 100 kbps roughly and therefore, this enables your voice telephone calls plus basic data access that is your basic internet access. This is the approximate. The first column is the technology or the generation of the technology, the second column the data rate, the 3rd column is the applications that are possible. And we are saying in 2G and 2.5G, which as a data rate around 10 to 100 kbps some voice and basic data access are possible. In 3G and 3.5G systems; we have data rates approximately, 300 kbps to approximately 30 Mbps.

And this enables a whole many more application, and then what are possible into 2G and 2.5G systems; such as voice, high speed data access plus video calling and so on. Further this has led to 4G and in 4G, we have data rates in access of 100 Mbps and this as lead to

plethora applications; such as online gaming which requires fast transmission of high definition video between multiple players were participating in the gaming application. Also high definition video conferencing, multi party video conferencing also HD TV transmission of high definition TV content; online gaming, video conferencing, high definition multiparty video conferencing, HD TV all these are applications, that are made possible by the 4th generation of wireless communication systems.

If you look at these different generation of wireless communication systems, if (Refer Time: 17:51) you look at, the behaviour across this different generations; you can see that as the generations are evolving the data rate progressively evolving. It is easy to see that, as the data rate across the generation; the data rate is progressively increases. Also the reliability, which information can be transmitted is progressively increasing, because when we talk about the transmission of video content; such as required in for instance gaming or video quality.

In that requires a significant amount of reliability not just data rate, but assurance on the quality with which the data or the bytes transmitted across the channel. The reason increase in data rate, at the same time there is an also increase in the reliability or the quality of service of transmission of this information across the channel. The data rate increases also there is importantly; there is an increase in the reliability through these different generations. And these and this data rate increase and this increase in reliability is made fundamentally possible because of various technologies, reduce radical revolutionary technologies in the area of wireless communication.

This is made possible by fundamentally 3 different technologies; one is MIMO, the other is OFDM and CDMA. These are the 3 technologies; which make this phenomenal increase data rate and reliability across the different generation of wireless communication system possible.

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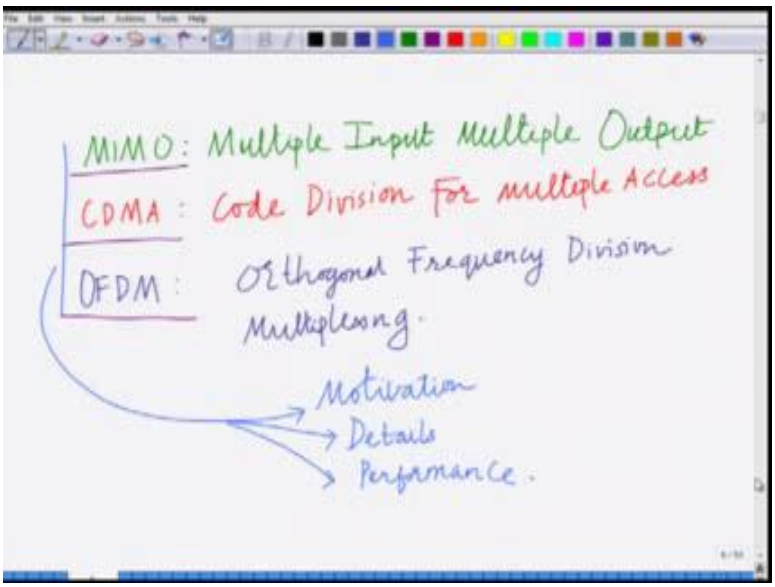

Let me explain this MIMO and these are the technologies; which we are going to talk about in detail in this course stands for Multiple Input Multiple Output. MIMO stands for Multiple Input Multiple Output wireless technology. CDMA as we already seen stands for Code Division For Multiple Access and another important technology, which is OFDM stands for Orthogonal Frequency Division Multiplexing. So, 3 fundamental technologies MIMO, CDMA and OFDM, and these technologies have lead to an increase in the data rate and reliability.

Significant increase in the data rate and reliability across the various generations of wireless communication systems, as we go from 2G to 3G; 3G is dominated by CDMA and also multiple antenna systems, Multiple Input Multiple Output systems and of course, 4G makes extensively use of MIMO technology and also OFDM which is Orthogonal Frequency Division Multiplexing. These have totally changed the landscape of the wireless communication systems and tremendously increased both their capabilities and their performance making them; what they are today in terms of making possible wide array of applications in both wireless seller networks and also wireless LAN applications.

We will be studying in this course; we will primarily be focusing on these 3 technologies that are MIMO, CDMA and OFDM. We will be studying various aspects of these technologies, such as the motivation first what is the motivation. We will studying various aspects, such as the motivation, the details of these schemes how are these and also the performance which is the most important thing that is how to analyse the performance. That is what is the motivation for each of this what are the details; how was each of this technologies is implemented and an idea about the performance how can one get idea of the different possible schemes, what is the performance, how much and how far they enhance the performance. This is what this course about we are going to focus this aspects of MIMO, OFDM and CDMA technologies which form the backbone for the evolution of current wireless communication systems. We will stop this module here.

Thank you very much.