Principles of Modern CDMA/MIMO/OFDM Wireless Communications

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Lecture - 11
Principle of Diversity

Hello, welcome to another module in this massive open online course in the principles of CDMA, MIMO and OFDM wireless communication systems. And what we have seen in the previous module is that the poor performance of the wireless communication system can be attributed to the deep fade events occurring because of the fading nature of the wireless channel, and what we have seen, what we are also seen or hinted at is that we are going to use this principle called term diversity to overcome this deep fade effect, overcome this degrading nature of the wireless channel. So, what we are going to talk about today is we are going to talk about an overview of this principle of diversity.

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So, I would like to talk a little bit more at a high level about the principle of diversity in a wireless communication system. So, what is the principle? We said diversity can be employed to overcome fading or to overcome to combat fading or to basically more precisely overcome effects of the deep fade that is because the deep fade events have significantly degrade the performance of the wireless communication system. So, this can be used overcome the effects of the deep fade or also basically another way it is

frequently stated is this can be employed to combat the fading nature of the wireless communication system.

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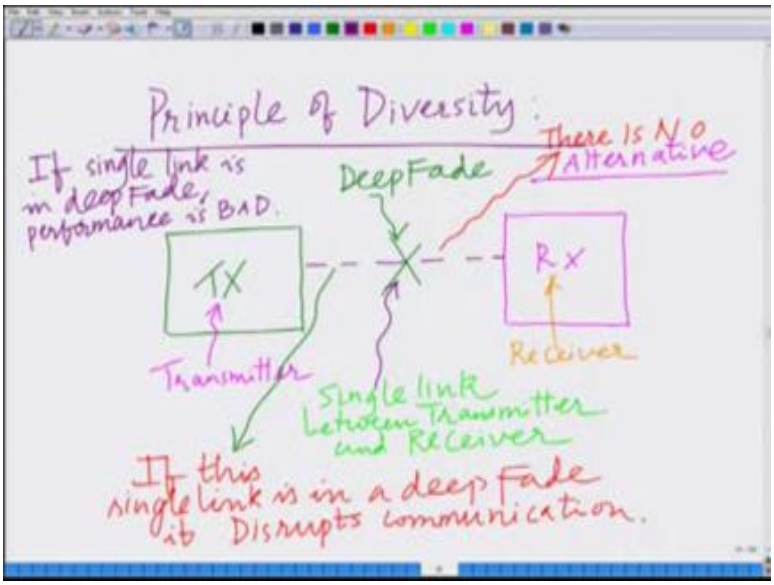

And the principle of diversity, what is the key behind diversity? The principle of diversity is very simple and it can be explained as follows. Consider a transmitter and now consider a receiver in a wireless communication system that this is my transmitter and basically this is my receiver and traditionally what we have is we have a single link between this transmitter and a receiver. So, what we have is we have a single link or a single propagate between a single fading path between transmitter and receiver.

Now, what happens if this link is in a deep fade let say this a deep fade event, if this single link is in a deep fade then there is no path or there is no link to transmit the signal over this wireless channel there is no link between the transmitter and receiver is disrupted and that results in the poor performance of the wireless communication system. Therefore if this single link is in a deep fade it disrupts communication right because there is a single link if this one link is in deep fade then there is no route to transmit the signal from the transmitter to the receiver and therefore, that disrupts communication.

In other words, basically there is no alternative link to transmit in the single link system; there is no alternative link which is not fading. So, there is no alternative link to transmit the signal from the transmitter to receiver. So, in this system the key is there is no alternative to transmit the signal between the transmitter and receiver therefore, if this

single link is in deep fade performance is bad. So, there is a single link if the single link is in deep fade then the link is broken that disrupts the communication the performance of the communication system de degrades and the performance is bad. That is the problem with our wireless communication system with a single link and therefore, how do we improve the performance of this wireless communication system? Naturally, one simple way is to introduce multiple links between the transmitter and the receiver.

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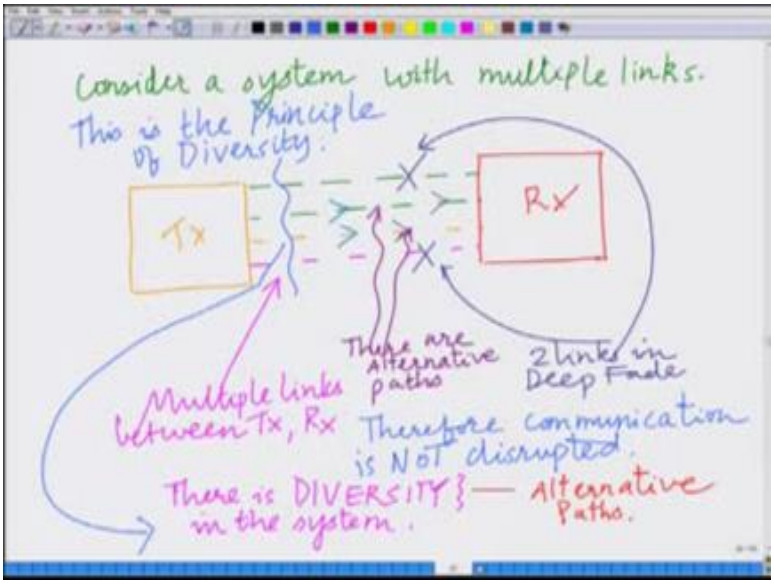

So, another simple idea is to consider a system with multiple links that is I have a transmitter I have a receiver as before. However, I do not have only a single link, but this time I have multiple links now observe that I basically have multiple links between the transmitter and receiver. Now let us say a few of these links are in the deep fade, let say two of these links are in deep fade. So, we have two links if two of the links are in a deep fade there are alternative paths, the important thing to notice here is that there are alternative paths right.

So, basically the communication is not disrupted in this scenario because there are multiple links even if one or a few links are in a deep fade there are alternative paths for the signal to propagate from the transmitter to receiver hence communication is not disrupted. Therefore, communication is not disrupted when there are multiple links and having this multiple links or this alternate path means that there is diversity in the system. What is the meaning of diversity? Diversity means that there are alternatives

right means there is not one, but there are many. Diversity by the very term means that there are many therefore, there are many alternative paths or there is diversity in the system. So, when you have multiple paths there is basically there is diversity in a system or basically what it means is there are alternative paths.

Therefore, if a few of them are in deep fade not everything is lost you can still transmit the signal or the signal can still reach from the transmitter to the receiver where the non fading paths because it is possible because there are multiple paths, it is possible because there is diversity in the system and this principle where you have multiple links, multiple paths to allow propagation of the signal from the transmitter to receiver that multiple links this is called as the diversity. This principle where you have multiple modes between the transmitter and receiver this is the principle and this is an important principle of diversity.

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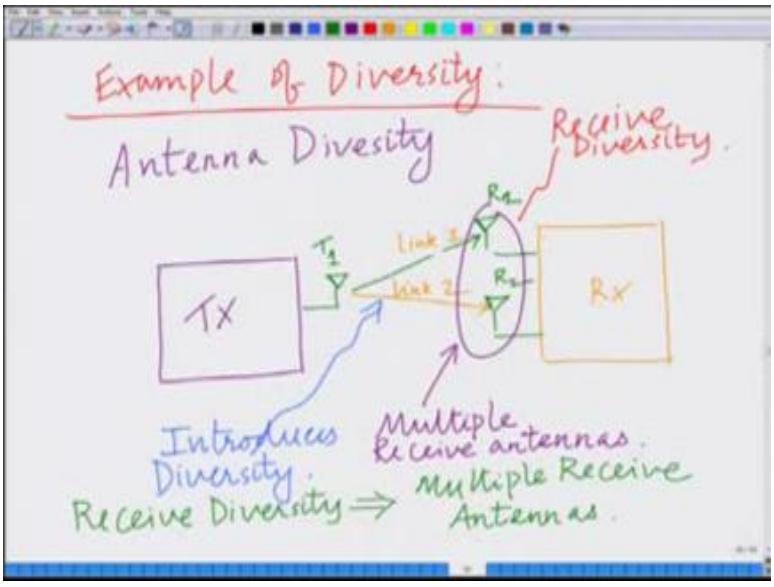

For an example, an example of diversity consider antenna diversity - one form of diversity is antenna diversity, where let say you have a transmitter this is our transmitter as before and this is our receiver. Now you have let say a transmit antenna, instead of having a single received antenna you have two received antennas. So, now you have one link between let us call this transmit antenna T_1, let us call this received antenna R_1, let us call this received antenna R_2. Now you have one link between transmit and T_1 and R_1 and you have another link between T_1 and R_2, so now because you have multiple

received antennas. So, what you have is you have multiple received antennas because you have multiple received antennas what you have is now you have multiple path your multiple links between the transmit antenna and these multiple received antennas and this is now how you are introducing diversity. So, that even one of this link fails that is for instance let say the link between T_1 and R_1 fails you still have the link between T_1 and R_2.

Similarly, the link between T_1 and R_2 fails you have the link between T_1 and R_1 and thus you are introducing by these multiple links, you are introducing diversity in the system and specifically where you have this multiple received antennas this is termed as receive diversity, receive diversity implies multiple received antennas. Now because of this multiple receive antennas your multiple links and therefore, you have diversity and this is termed as a receive diversity.

Similarly you can have transmit diversity where you have multiple transmit antennas, there is if you have multiple transmit antennas instead of receive antennas you have transmit diversity and why not both you can have multiple transmit antennas as well as multiple receive antennas that is even better and therefore, you have both transmit as well as receive diversity. And it is not just antennas, we will discover later in this course that you can also have diversity in time - that is you can transmit the signal across different time slots and this will give us different channels across different times slots this is known as temporal diversity.

Even transmit the single across different frequency bins this is known as frequency diversity you can transmit the signal to different users this is termed as multi user diversity. So, there are basically diversity is a very important, very key concept, there are many different forms of diversity and one can exploit diversity to improve the performance of the wireless communication system and diversity therefore, plays key role a significant role and also we are going to discuss it in our discussion in this course it is going to play an important role when you discuss the performance of several wireless communication system. So, diversity is one of the most important principles, one of the most important aspects that can be employed in a wireless communication system to overcome combat the effect of fading and therefore, decrease the bit error rate and hence improve the performance of a wireless communication system.

So, we will stop this module here and we will continue with this diversity and discussion of different aspects of diversity in the subsequent module.

Thank you very much.