Principles of Modern CDMA/MIMO/OFDM Wireless Communications

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Lecture - 33
Near-Far Problem in CDMA

Hello, welcome to another module in this massive open online course in the principles of CDMA, MIMO, OFDM wireless communications systems. Let us look at another aspect of CDMA in this module which is termed as the Near-Far Problem.

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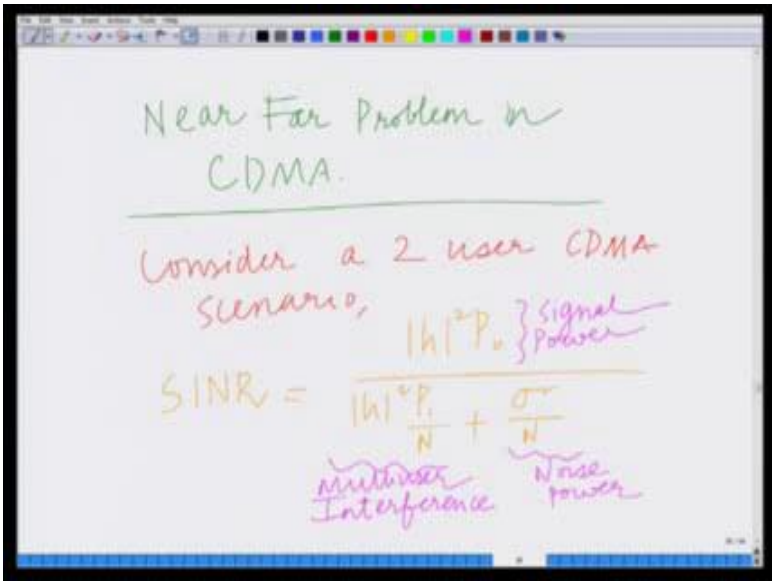

So, in this module let us look at another aspect the Near-Far Problem in CDMA system and this is the unique aspect of CDMA systems which is not seen before. So, to illustrate this consider a 2 user CDMA scenario and we have seen that the expression for the SINR in this 2 user CDMA scenario is given as

$$= \frac{|\bar{h}|^2 P_0}{\frac{\sigma^2}{N} + \frac{|\bar{h}|^2 P_1}{N}}$$

where this component is the numerator is the Signal Power, remember we said this is the Signal to Interference plus Noise Ratio, $\frac{|\bar{h}|^2 P_1}{N}$ is the Multi user Interference and $\frac{\sigma^2}{N}$ is

the Noise Power. This is the Signal to Interference plus Noise Ratio in a 2 user CDMA scenario with channel coefficient h power of user 0 given by P_0, power of user 1 given by P_1, N is the length of the spreading code and σ^2 is the variance of the noise at the receiver.

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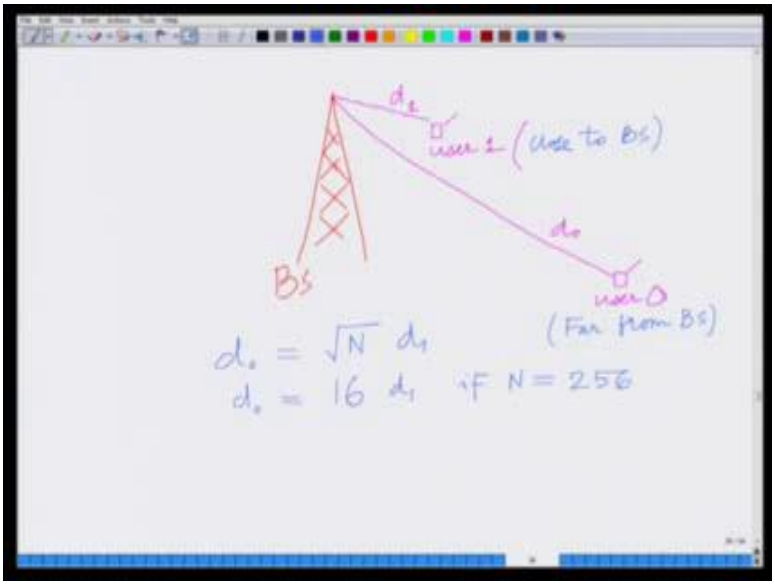

Now, let us consider the following scenario; let us consider a scenario in which there is a base station there is a CDMA; I have a CDMA base station and there are two users, but one is closer to the base station. So, I have user 1 who is very close to the base station; I have user 2 who is very far from the base station. So, basically my user 0 who is very far from the base station and let us say I have user 1 at distance of d_1 user 0 at a distance of d_0 which basically and user 0 is this is user 1 is close to the base station so user 0 is far from the base station; d_0 is the distance of user 0, d_1 is the distance of user 1. We have let us have the relation

$$d_0 = \sqrt{N}\ d_1$$

If N = 256; $d_0 = \sqrt{256}\ d_1 = 16\, d_1$

So, we have a CDMA multi user scenario in which we have two users; user 0 and user 1. User 0 is at the large distance d_0, user 1 is very close to the base station; we have the relation $d_0 = \sqrt{N}\ d_1$

For instance, if user 1 is at a distance of half a kilo meter that is 500 meters then user 0 is at So, these are fairly far that is 16 times half a kilo meter that is basically 8 kilo meters. So, if user 1, user 0 is at a distance of let us say one-fourth of a kilo meter then user 0 is at a distance of 16 times one-fourth that is 4 kilo meters and so on. So, basically now you can see that this creates of problem because the received Signal Power, the power at the receiver decreases with the inverse square of the decrease with the square of the distance proportional is inversely propositional to the square of the distance.

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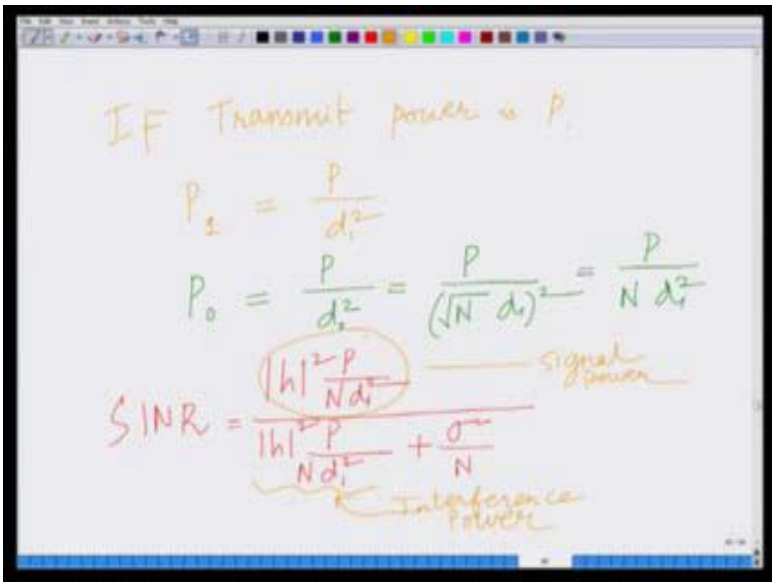

Therefore if the Transmit power is P then P_1 is equal to

$$P_1 = \frac{P}{{d_1}^2}$$

$$P_0 = \frac{P}{{d_0}^2} = \frac{P}{(\sqrt{N}\ d_1)^2} = \frac{P}{N\ {d_1}^2}$$

Now, if I substitute this in the expression for our SINR, I have SINR equals

SINR = = $\frac{|\bar{h}|^2 \frac{P}{N d_1{}^2}}{\frac{\sigma^2}{N} + \frac{|\bar{h}|^2 P}{N d_1{}^2}}$

Now you can clearly see that there is a problem because if you look at this numerator I have the Signal Power and on the denominator I have the Interference Power and there is clearly a problem because the Signal Power is equal to the Interference Power and therefore, this disrupts the communication because normally we assume that the Signal to Noise power Ratio is very high that is the Interference Power is much smaller than the signal power. But here we are observing something very interesting that is a user who is very close to the base station can swarm or can basically overwhelm the signal of user 0 who is very far from the base station; that is a Signal Power is becoming equal to the Interference Power.

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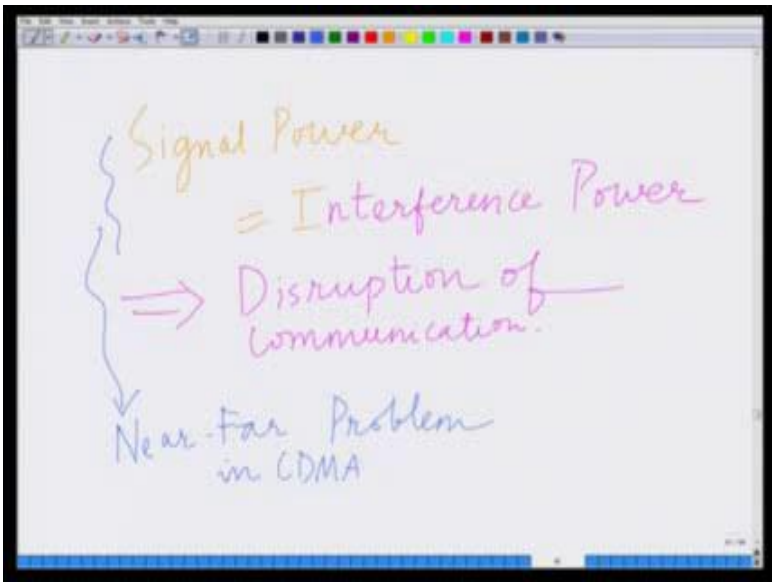

So, we see that the Signal Power is equal to our Interference Power and this leads to disruption of communication because of the high Interference Power, therefore what we are seeing is that a close interfering user can basically suppress the signal of the desired user by creating by large Interference Power this is known as the Near-Far Problem in CDMA system. So, this problem, this is known as the Near-Far; so this problem whereby a close user or close interference overwhelms or basically suppresses the signal of the desired user.

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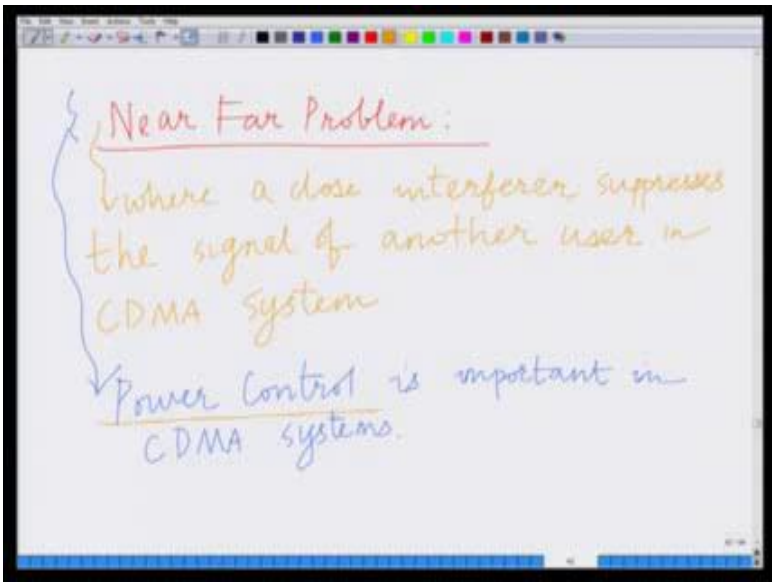

So, what is the Near-Far Problem? A Near-Far Problem in CDMA systems where a close interferer suppresses the signal of another user in the CDMA system and clearly you can see this leads to disruption and communication and therefore, in this context it is very important to control the power of the various users in the CDMA system. Therefore, what is this means it is important to power control is the very important aspect of CDMA systems so that the users who were close to base station transmit with the smaller power compared to the users who are very far from the base station thereby all the users signals are received with more or less equal power at the base station thereby one user causing a large amount of interference to another user is avoided. Therefore, power control is a very important aspect of CDMA system and this is to avoid the Near-Far Problem whereby a close interfering user can suppress the signal of the other users who are much farther from the base station. So, this explains the Near-Far Problem and how to solve the Near-Far Problem in a CDMA system.

So, we will conclude this module here and we will look at other modules, other aspects of wireless communication in the subsequent modules.

Thank you very much.