FACULTY OF EGINEERING AND TECHNOLOGY

WSN (MCS-033)

LECTURE -4

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OUTLINE

- **What are the characteristics of wireless channel?**
- **Statistical fading models**
- **Large Scale Fading**
- **Small Scale Fading**
- **MCQ**
- **Reference**

OUTLINE

What are the characteristics of wireless channel?

1. The most important characteristics of wireless channel are −
2. Path loss
3. Fading
4. Interference
5. Doppler shift

Statistical fading models

The physical causes of fading of a transmitted signal wave can be modeled statistically. These statistical mathematical models are very useful to characterize the probability to receive messages transmitted over the wireless channels. The availability of these statistical models allow to tie the probability to successful message reception with the characteristics of the wireless channel, the transmit radio power, and many other parameters such as modulation, coding, etc.

Large Scale Fading

1. Path Los

Path loss is the attenuation in signal power (strength) of the signal wave as it propagates through air. Path loss is proportional to the distance between the transmitter and the receiver. The causes for path loss are free space loss, refraction, reflection, diffraction, absorption and others. The signal strength decreases with distance and when it is below threshold (receiver sensitivity) the distance is called maximum communication range of the transmitter. In the received power expression shows the path loss is

$$\mathrm{PL} = \frac{(4\pi r)^2}{\lambda^2}\overline{\mathrm{PL}}.$$

2. Shadowing

Radio signals are often shadowed while transmitted by buildings or other large obstacles resulting in an Non Line Of Sight (NLOS) path between the transmitter and the receiver. Shadow fading is a phenomenon that occurs when a node moves behind an obstruction (sized hundreds times of wavelength λ) and experiences a significant reduction in signal power. The received signal power can be modeled by a random variable that depends on the number and the characteristics of the obstructing objects that are located in the propagation area and participate in the process of signal propagation. Therefore, the value of the received power may differ substantially from the path loss model (Pantos et al., 2008). The path loss can be seen as the statistical mean value of the received power.

Small Scale Fading

1. Multipath Fading

Multipath is defined as the propagation phenomenon that results in radio signals reaching the receiving node by multiple paths. Multipath propagation occurs because of the presence of physical objects that lead signals to be reflected and scattered.

2. Rayleigh Fading

Rayleigh fading is a statistical model that is often used to describe the effect of a propagation environment on a radio signal due to scattering. It is most applicable when there is no dominant propagation along a line of sight between the transmitting and receiving node. Because there is no direct ray component, Rayleigh fading is often classified as the worst case fading type . Rayleigh fading models assume that the complex envelope c(t) of the received signal is the sum of many random complex components arriving from different paths. Its amplitude r(t) follows the Rayleigh distribution (Pantos et al., 2008),

Namely

$$c(t) = x(t)e^{\theta(t)}, \tag{2.7}$$

where, recalling z in (2.1),

$$x(t) \triangleq \sqrt{z(t)} = \sqrt{[I(t)]^2 + [Q(t)]^2},$$

$$\theta(t) = \arctan\left(\frac{Q(t)}{I(t)}\right),$$

and $I(t), Q(t)$ are the baseband orthogonal components of the received pass-band signal which are given by

$$I(t) = \sum_{i=1}^{N} a_i \cos(\omega_i(t) + \psi_i), \tag{2.8}$$

$$Q(t) = \sum_{i=1}^{N} a_i \sin(\omega_i(t) + \psi_i), \tag{2.9}$$

3. Rician Fading

In case there is a strong component (usually an LOS component or a strong reflection) in addition to the other multipath components, then the amplitude and phase distributions of the complex envelope are different from the previous case. The complex envelope has now the following form

$$c(z) = c_0 + \sum_{i=1}^{N} c_i(z) .$$

Real and imaginary part of c(z) remain Gaussian with the same variance but now their mean values are not equal to zero (Pantos et al., 2008). Recalling z in (2.1), and letting x 2 = z, the amplitude of the complex envelope follows Rician distribution whose probability density function is given by

$$p_r(x) = \frac{r}{\sigma^2} e^{-\frac{x^2+|c_0|^2}{2\sigma^2}} I_0\left(\frac{x|c_0|}{\sigma^2}\right) .$$

4. Nakagami Fading

Another useful type of distribution is Nakagami-m which has similar behavior to the Rician one. If the Central Limit Theorem is not satisfied, then Nakagami-m is an approximate distribution for the amplitude of the complex envelope (Pantos et al., 2008). This distribution has more general application since it is used in order to describe either better or worse fading conditions than Rayleigh and Rician distribution by choosing properly the value of parameter m. More specifically, the Nakagami-m distribution models very well the distribution of signal envelopes in a variety of fading environments, ranging from a strong line-of-sight environment to a highly diffuse scattering environment. The degree of fading in this distribution is characterized by the shape parameter m, which takes a value greater than or equal to half, where m = 1/2 corresponds to one-sided Gaussian fading (it represents the maximum amount of fading that the Nakagami-m distribution can characterize), m = 1 and 1 < m < ∞ corresponds to Rayleigh and Rician fading respectively. An infinite m corresponds to a deterministic envelope (it represents the case of no fading) (Kallik, 2010). Thus the degree of fading decreases with increase of the parameter m. Recalling that $x = \sqrt{z}$, the probability density function of Nakagami-m is given by

$$p_r(x) = \frac{2}{\Gamma(m)} \left(\frac{m}{\Omega}\right)^m x^{2m-1} e^{-\frac{m}{\Omega}x^2}, \qquad x \geq 0, m \geq \frac{1}{2}.$$

REFERENCES

- https://www.kth.se/social/files/5431a388f276540a05ad2514/An_Introduction_WSNS_V1.8.pdf

MCQ

5. Ethernet in metropolitan area network (MAN) can be used as ___________

a) pure Ethernet

b) Ethernet over SDH

c) Ethernet over MPLS

d) all of the mentioned

6. A point-to-point protocol over Ethernet is a network protocol for ___________

a) encapsulating PPP frames inside Ethernet frames

b) encapsulating Ethernet framse inside PPP frames

c) for security of Ethernet frames

d) for security of PPP frames

7. High speed Ethernet works on _________

a) coaxial cable

b) twisted pair cable

c) optical fiber

d) unshielded twisted pair cable

8. The maximum size of payload field in Ethernet frame is __________

a) 1000 bytes

b) 1200 bytes

c) 1300 bytes

d) 1500 bytes

9. What is interface gap?

a) idle time between frames

b) idle time between frame bits

c) idle time between packets

d) idle time between networks

10. An Ethernet frame that is less than the IEEE 802.3 minimum length of 64 octets is called _______

a) short frame

b) runt frame

c) mini frame

d) man frame