Wireless Communication

概念：Wireless communication is transmitting voice and data using eletromagnetic waves in open space (atmosphere)

类型：point-to-point, multipoint, broadcast communication

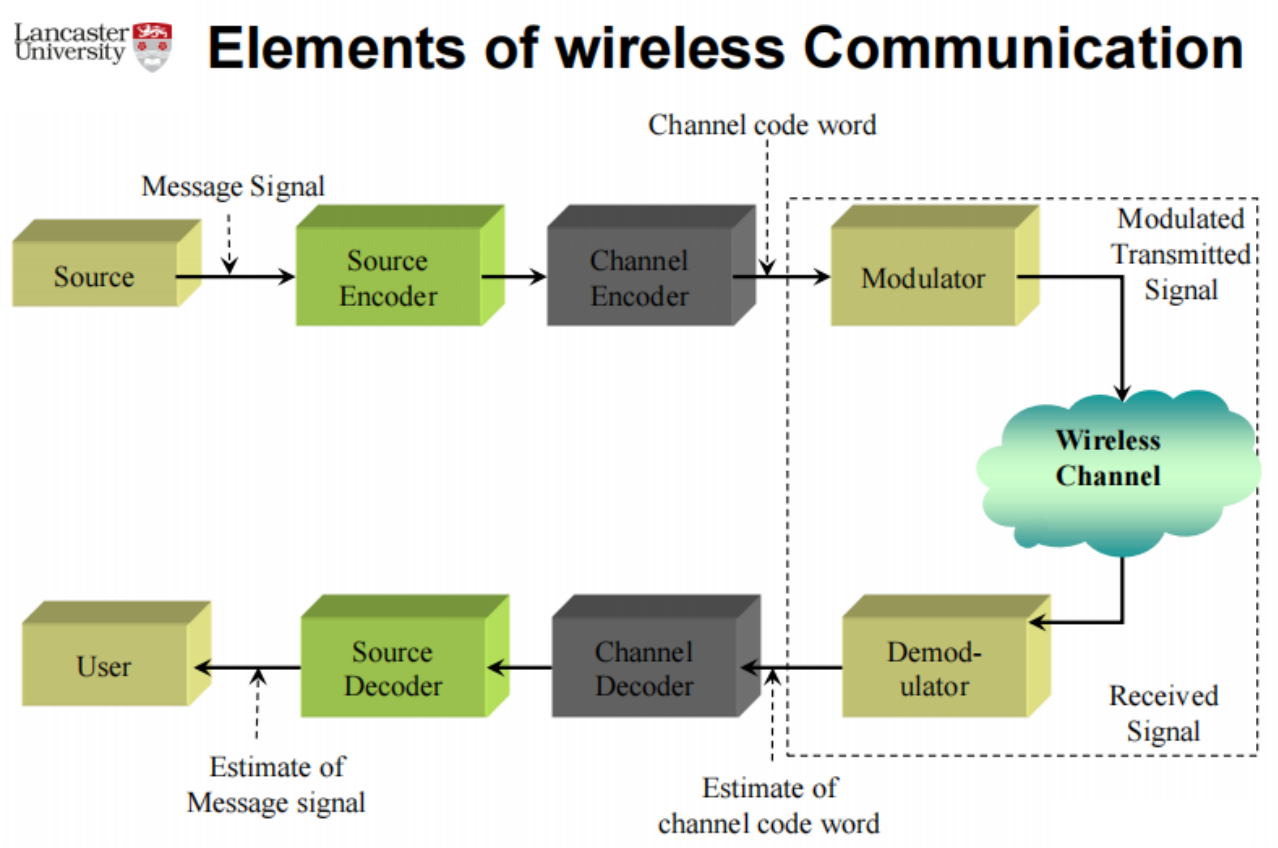
优点：1) freedom from wires

2) global coverage

3) stay connected (漫游roaming可以随时随地保持连接)

4) flexibility (可以同时simultaneously连接多个设备)

重大挑战：Security, secrecy, and privacy; Resource and spectrum utilizations; Communication infrastructure; coding and modulation; resource and inteference management.



wireless channel impairments

noise: thermal noise(AWGN)

path loss: the loss in power as the radio signal propagates

shadowing: due to the presence of fixed obstacles in the radio path

fading: combines the effect of multiple propagation path, rapid movement of units and reflectors.

Q: Explain what is mean path loss and shadowing and small-scale fading, and demonstrate their main difference.

- **the mean path loss is a deterministic factor that can be predicted with the distance between the transmitter and receiver.**
- **shadowing and small-scale fading are random phenomena, which means that their effects can only be predicted by their probabilistic distribution. for example, shadowing is typically modeled by a log-normal distribution.**

Fading 的分类

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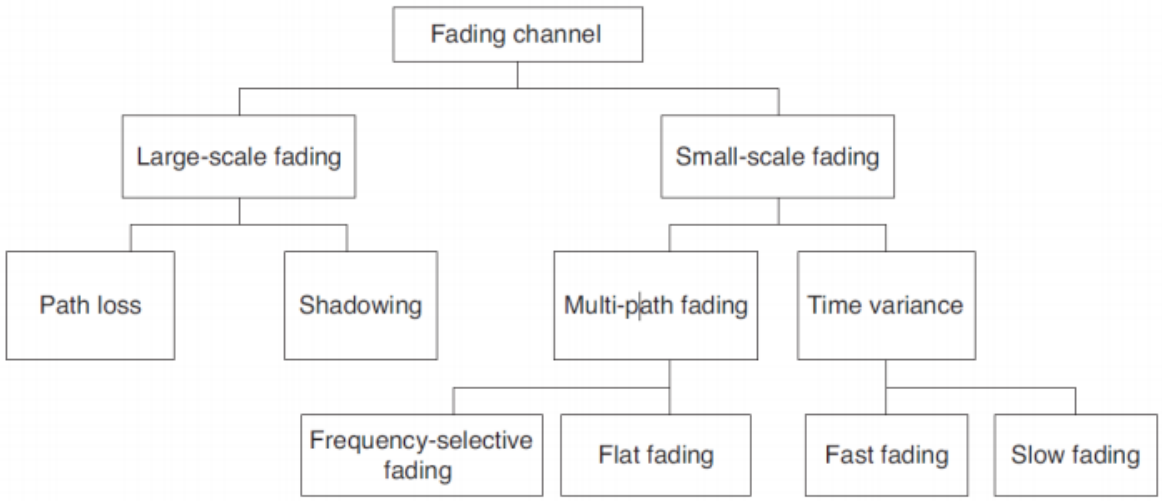
Classification of Fading Channels



General Path Loss Model

Free Space Propagation Model

Equation 1:

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

P_t : transmitted power
$P_r(d)$: received power
G_t : transmitter antenna gain
G_r : receiver antenna gain
d : T-R separation distance (m)
L : system loss
λ : wavelength in meters

Q: what is L?

A: L represents system loss, and are usually due to transmission line attenuation, filter losses, and antenna losses in the communication system. A value of L=1 indicates no loss in the system hardware.

Equation 2:

Effective isotropic radiated power (EIRP)=Pt*Gt

Equation 3: Assume that L=1

Path loss for the free space model with antenna gains

$$PL(dB) = 10\log\frac{P_t}{P_r} = -10\log\left(\frac{G_t G_r \lambda^2}{(4\pi)^2 d^2}\right)$$

When antenna gains are excluded

$$PL(dB) = 10\log\frac{P_t}{P_r} = -10\log\left(\frac{\lambda^2}{(4\pi)^2 d^2}\right)$$

注意：自由空间模型只适用于接接收端处于far-field region.

发送天线的far-field region就是超过far-field distance的区域。

Equation 4:

D is the largest physical linear dimension of the antanna.

Equation 5:

- 因为收到的信号随着距离d的n次方程度下降，所以这种方程可以修改为

$$P_r(d) = P_t \frac{G_t G_r \lambda^2}{(4\pi)^2 d^n L}$$

以适应各种环境。如下表所示：

Environment	Path Loss Exponent (n)
Free space	2
Urban area cellular radio	2.7 to 3.5
Shadowed urban cellular radio	3 to 5
Inside a building - line-of-sight	1.6 to 1.8
Obstructed in building	4 to 6
Obstructed in factory	2 to 3

Equation 6:

The ground reflected model:

$$P_r(d) = \frac{P_t G_t G_r h_t^2 h_r^2}{d^2}$$

Examples

1. Suppose a transmitter produces 50W of power.

a. Express the transmit power in units of dBm and dBW.

b. If the transmitter's power is applied to a unity gain antenna with a 900MHz carrier frequenc y, what is the received power in dBm at a free space distance of 100 m?

c. Repeat (b) for a distance of 10 km.

d. Repeat (b) (c) under ground reflected model with the height of the transmitter and receiver being 30 m and 1 m respectively.

2. Consider an indoor wireless LAN with fc=900MHz, cells of radius 100m, and nondirectional antennas. Under the free-space path loss model, what transmit power is required at the access point in order for all terminals within the cell to receive a minimum power of 10uW(微瓦) ? How does this change if the system frequency is 5GHz?

抵抗Fading的方法——分集

Q：为什么需要分集技术?

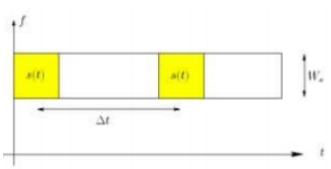
A：Diversity scheme is needed in wireless communication because if one path of radio signal undergoes a deep fading then another independent path may have a strong signal.

- 几种分集技术：Time diversity, Frequency diversity, Space diversity, Polarisation diversity

Space diversity

In space diversity, signal is propagated over various propagation paths. In urban areas, there is no clear line-of-sight between the receiver and the transmitter, so signal is reflected along multipath. So, space diversity is used to overcome this.

Time diversity



时间分集在不同的时间区间内传输相同的信号，并且相同信号之间的时间间隔不小于相干时间(coherence time)。

- Interleaving 可以用来实现时间分集，那什么是interleaving?

A：在陆地移动通信这种瑞利信道上，比特差错经常是成串发生的。这是由于持续时间较长的深衰落谷点会影响到相继一串的比特。但是，信道编码仅在检测和校正单个差错和不太长的差错串时才有效。为了解决这一问题，希望能找到把一条消息中的相继比特分散开的方法，即一条消息中的相继比特以非相继方式被发送。这样，在传输过程中即使发生成串差错，在接收端恢复成相继比特串的消息时，也就变成单个或长度很短的差错，再用信道编码所具有的纠错功能纠正差错，恢复原消息。这种将相继比特分散开的技术就是交织技术。

Frequency diversity

- 以多个不相关的载波传输相同的信息。为了使它们的相关性最小，这些载波频率之间的间隔超过了信道的相干带宽。OFDM modulation和access technique都利用了频率分集。

Polarization diversity

极化分集：使用不同极化方式的天线发射和接收多个版本的信号。天线可以是horizontal or vertically polarized.