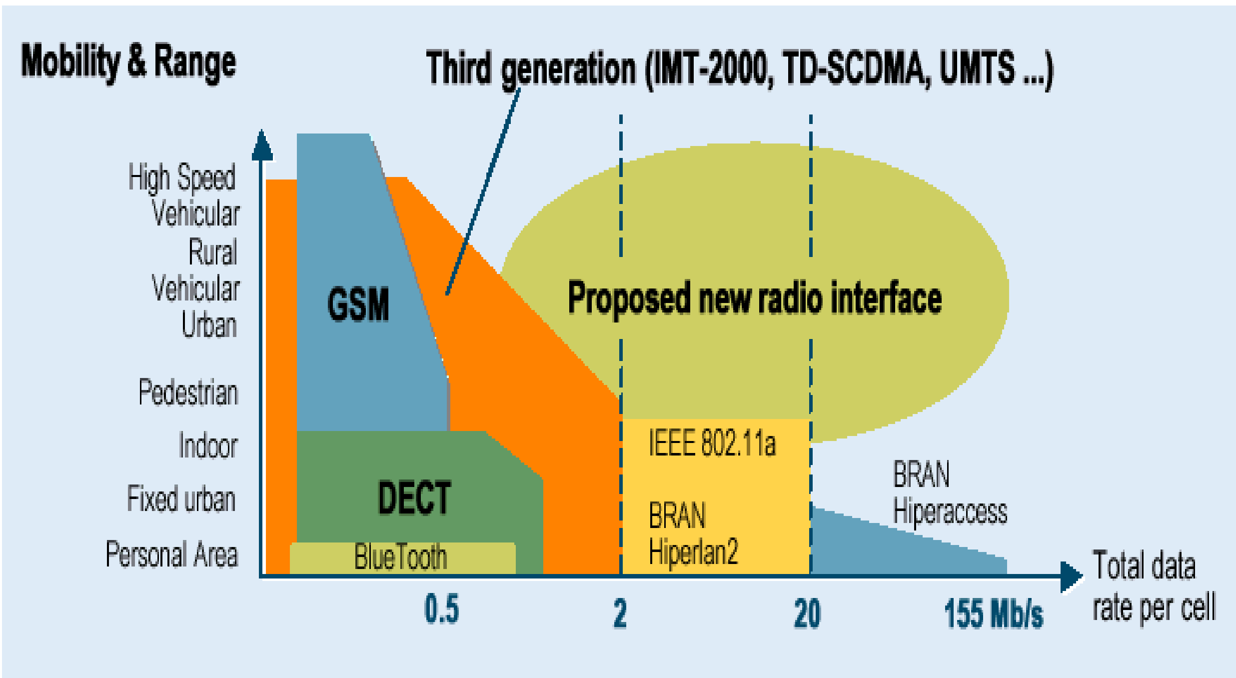
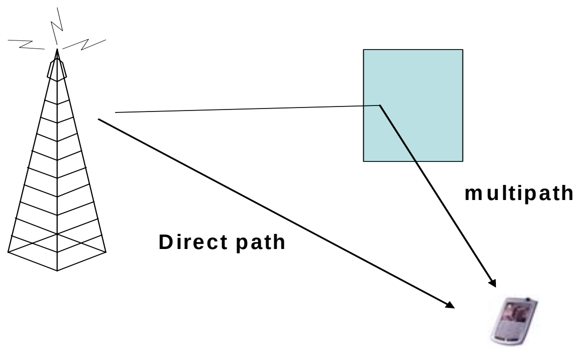
1 Wireless Systems and Channels

1.1 Wireless Systems



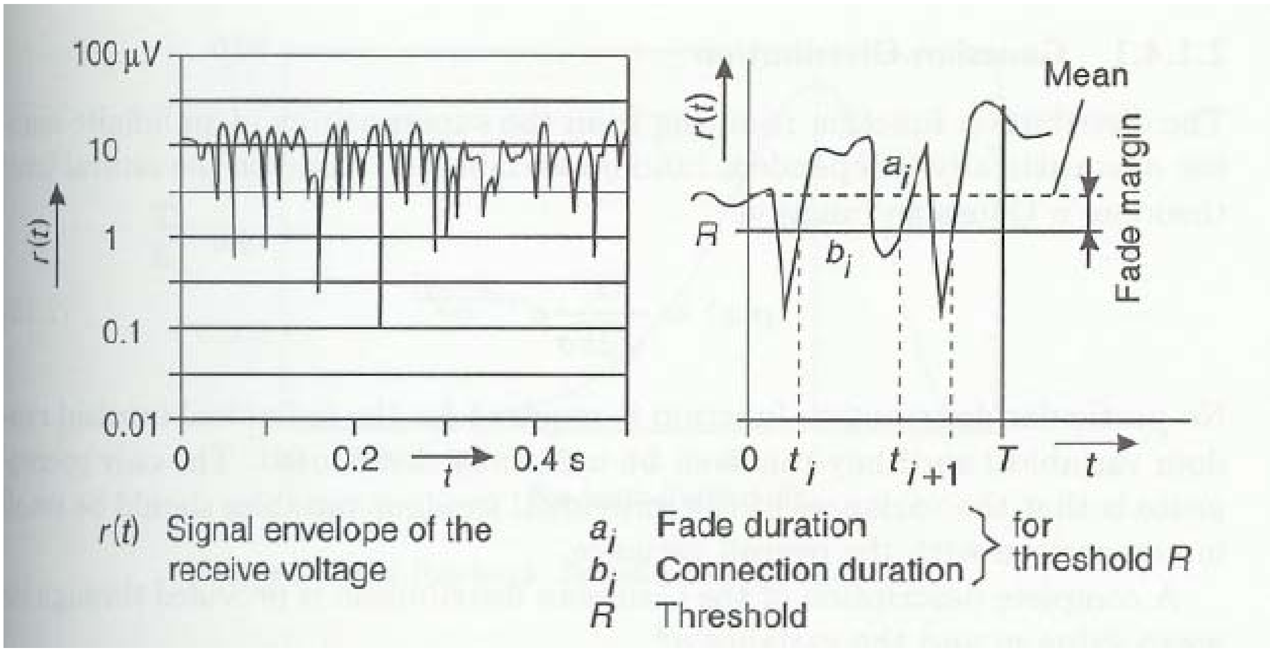
- 3G, WiFi, WiMAX, UWB, Bluetooth, Zigbee, etc...
- Data rate: 10kbps - 1Gbps
- Coverage: WPAN, WLAN, WMAN
- Applications: when, where, how?
- Spectrum: licensed, unlicensed
- Key technologies

1.2 Multipath Channels



- Channel disturbance can be a combination of additive noise, multiplicative fading and distortion due to time dispersion
- Scattering by randomly located scatters give rise to different paths with different path lengths
- Time dispersion causes intersymbol interference (ISI)
- Frequency dispersion introduces new frequency components other than those existing in the input signal
- Channel equalization techniques can be used to combat ISI

1.3 Channel Fading

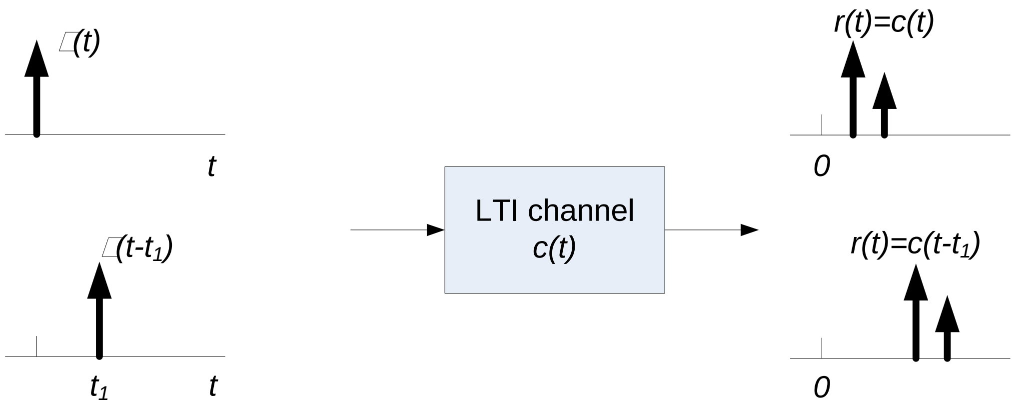


- Fading: fluctuations in amplitude of received signals
- cause: multipath reflections:

$$r(t) = b_1(t)s(t) + b_2(t)s(t - \tau_d)$$

- types: time-dispersive (frequency selective) and frequency-dispersive (time selective)

1.4 Channel Impulse Response

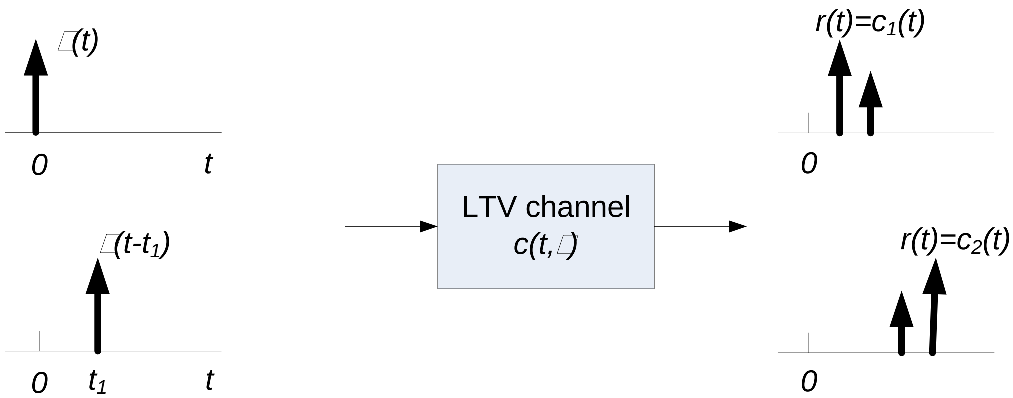


Let $c(t)$ denote the impulse response (i.e., the channel output when the channel input is an impulse applied at time $t = 0$, $\delta(t)$.

For linear time-invariant (LTI) channel, the channel response to an input applied at time t_1, $\delta(t - t_1)$ is $c(t - t_1)$. In general, the channel output $r(t)$ is given by

$$r(t) = c(t) * s(t) = \int_{-\infty}^{\infty} s(t - \tau)c(\tau)d\tau$$

1.5 LTV channels



Most wireless channels are linear time-varying (LTV). Let $c_1(t)$ and $c_2(t)$ denote the channel response to the input $\delta(t)$ and $\delta(t-t_1)$. As the channel propagation environment changes over time, $c_2(t)$ is not simply $c_1(t)$ delayed by t_1 (i.e., $c_2(t) \neq c_1(t-t_1)$)

A LTV channel response can be described as $c(t,\tau)$, which is the channel output at t in response to an impulse applied to the channel at $t-\tau$.

In $c(t,\tau)$, τ represents the propagation delay, and

$$r(t) = c(t,\tau) * s(t) = \int_{-\infty}^{\infty} s(t-\tau)c(t,\tau)d\tau$$

1.6 A two-path channel (Page 239)

The channel impulse response for a channel with 2 distinct scatters is

$$r(t) = b_1(t)s(t) + b_2(t)s(t - \tau_d)$$

Accordingly, the impulse response may be expressed as

$$c(t, \tau) = b_1(t)\delta(t) + b_2(t)\delta(t - \tau_d)$$

where $b_1(t)$ and $b_2(t)$ are random processes that represent the time-varying propagation behavior of the two multipath components

- A multipath channel is *time dispersive* if the multipath delays are distinct
- The frequency response of a time dispersive channel will exhibit amplitude fluctuation
- ISI = time dispersive = frequency selective

1.7 Mathematical models

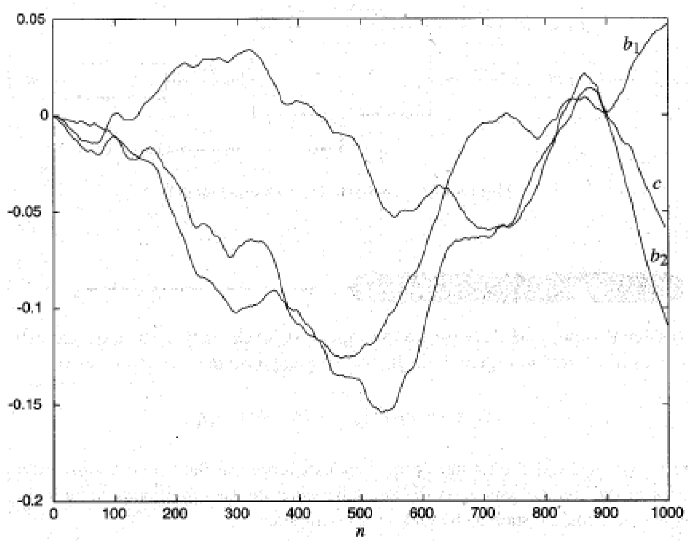
$b_1(t)$ and $b_2(t)$ can be generated by passing white Gaussian noise through lowpass filters.

The bandwidth of the filters decides the *coherent time* of the channel. When the bandwidth is wide (narrow), the channel experiences fast (slow) variation and a short (long) coherent time.

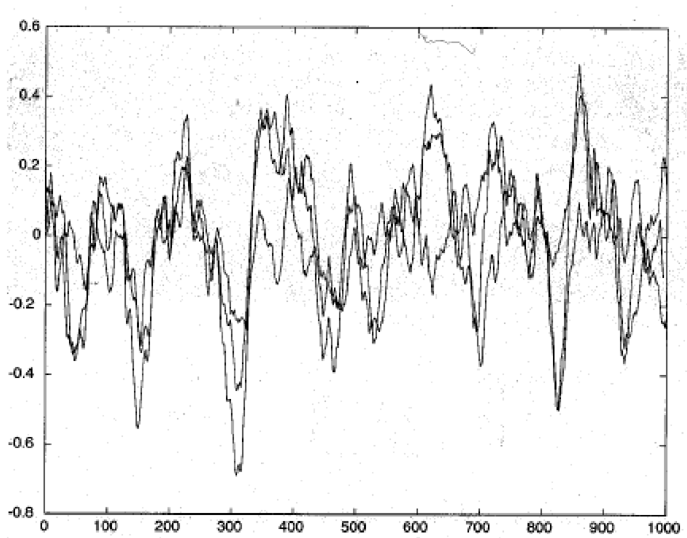
A simple two-pole IIR filter can used our simulations

$$H(z) = \frac{(1-p)^2}{(1-pz^{-1})^2}$$

When p is close to the unit circle, the filter bandwidth is narrow, whereas when p is close to zero. The bandwidth is wide.



1.Slow fading



2.Fast fading