Digital Communications ||

Third Year, 2ed Semester

Lecture No. 4

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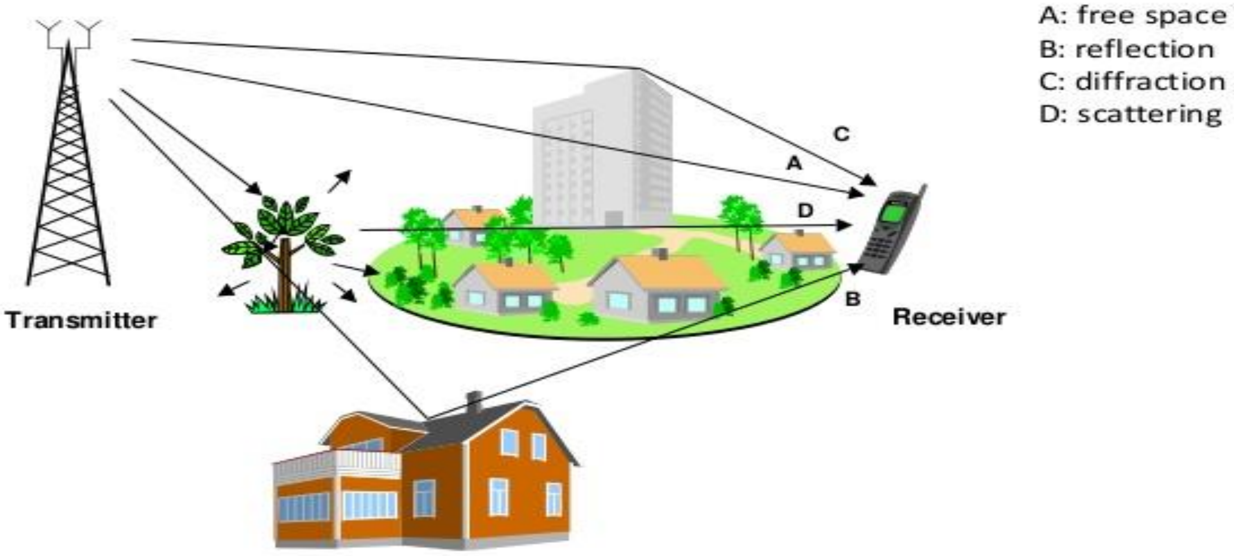
2021-2022

Multi path propagation effect



So, what are the challenges for a wireless communication system? let us say we have a typical wireless communication scenario with a base station mounted on the top of a tower. So, this is a base station or transmitter, also we have a mobile station or my mobile which is at the user. when the base station is transmitting typically the signal which propagates and reaches the mobile. So, this is the signal which is propagating from the base station of the signal path which is propagating in a straight line from the transmitter to the mobile.

However, in a wireless communication scenario unlike a wireline channel there is no guiding medium there is no wire between the transmitter and receiver. So, while there is a straight-line path between the transmitter and receiver there can also be multiple reflected components that arise from for instance objects such as trees. So, these are some trees in the wireless propagation environment and you can also have some other objects which deflect the signal for instance such as buildings. There are trees there are buildings and what these are doing is these are deflecting these are scattering the received wireless signal.

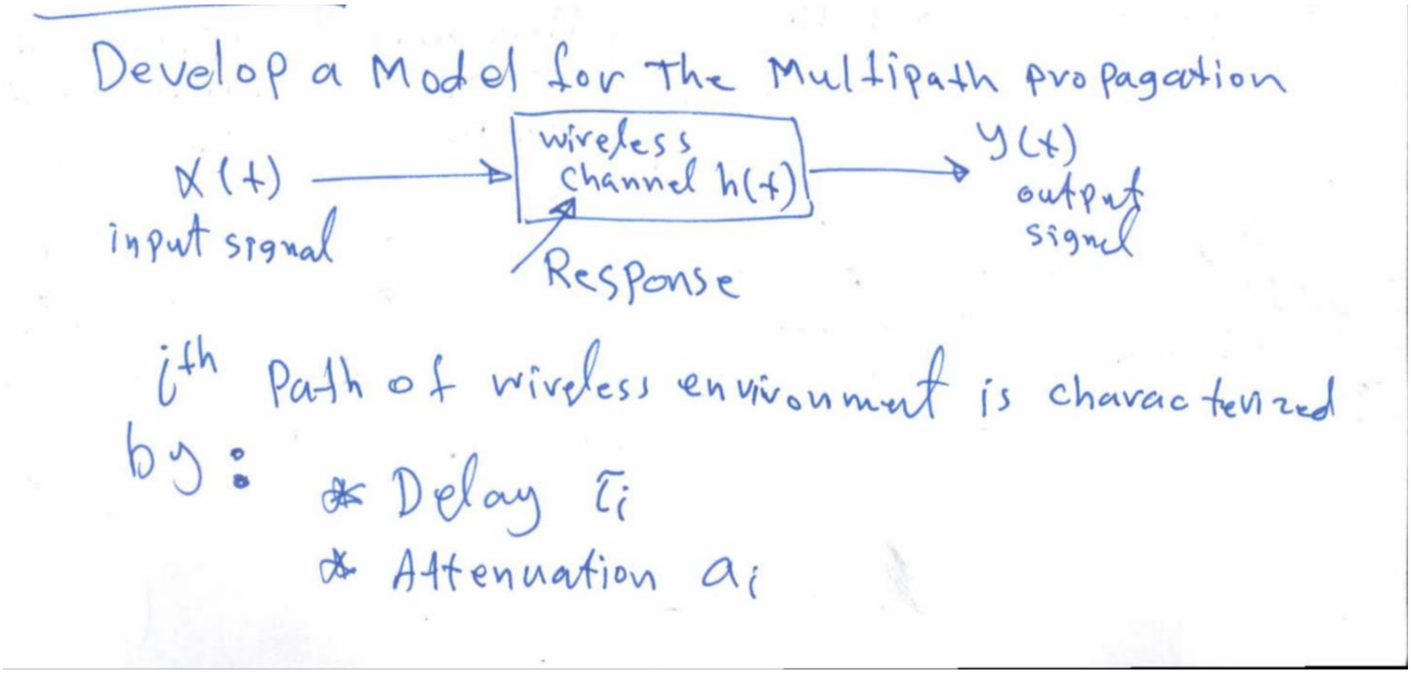
Therefore, these are also known as scatters. So, these trees and buildings are known as scatters scatter the wireless signal as a result of which you have not only the straight-line component, but you also have these multipath components this component which is arising from the scattering action of the scatters that is the trees and the buildings in the multi wireless propagation environment.

So, you have multiple signal components at the receiver this component which is the straight-line component is known as the line of **L O S** or the line-of-sight component. These components which arise from the scattering action and which are not are the deflected components these are known as **N L O S** for the non-line of sight, these are known as the non-line of sight components. We have a wireless propagation environment in which there is a line-of-sight path between the transmitter and receiver and there are also multiple non-line-of-sight components and together what we have is multiple signal components at the receiver. And therefore, this is also known as a multipath propagation environment the wireless communication environment the fundamental aspect of a wireless communication environment is that it is a multipath propagation environment.

These multiple electromagnetic signals interfere or superpose with each other they interfere and that can lead to interference which either constructive in nature or destructive in nature. So, this leads to first interference and this interference can either be constructive interference or this leads to interference that is either constructive or destructive.

If the interference is constructive that enhances the signal amplitude if the interference is destructive then that attenuates the signal. So, when we have constructive interference.

Develop a Model for the Multipath Propagation



let say we have a signal **x(t)** which is input to my signal to my wireless system and this is output signals. This is my input signal and this is the output signal and this is my wireless environment or my wireless channel between the transmitter and receiver, you would like to develop a model for the response of this system that is **h(t)** impulse response of the system, we would like to develop a model for the response of the system this is also known as the wireless channel.

This is **h(t)** that is what is the relation between the transmitted signal and the received signal that is transmitted signal **h(t)** and the received signal **y(t)** to know that it is important extremely important rather develop a model for this wireless channel, the intermediate wireless channel **h(t)** and once we develop a model for **h(t)** and then knowing the transmitted signal **h(t)** one can get an idea or one can derive the received signal **y(t)**.

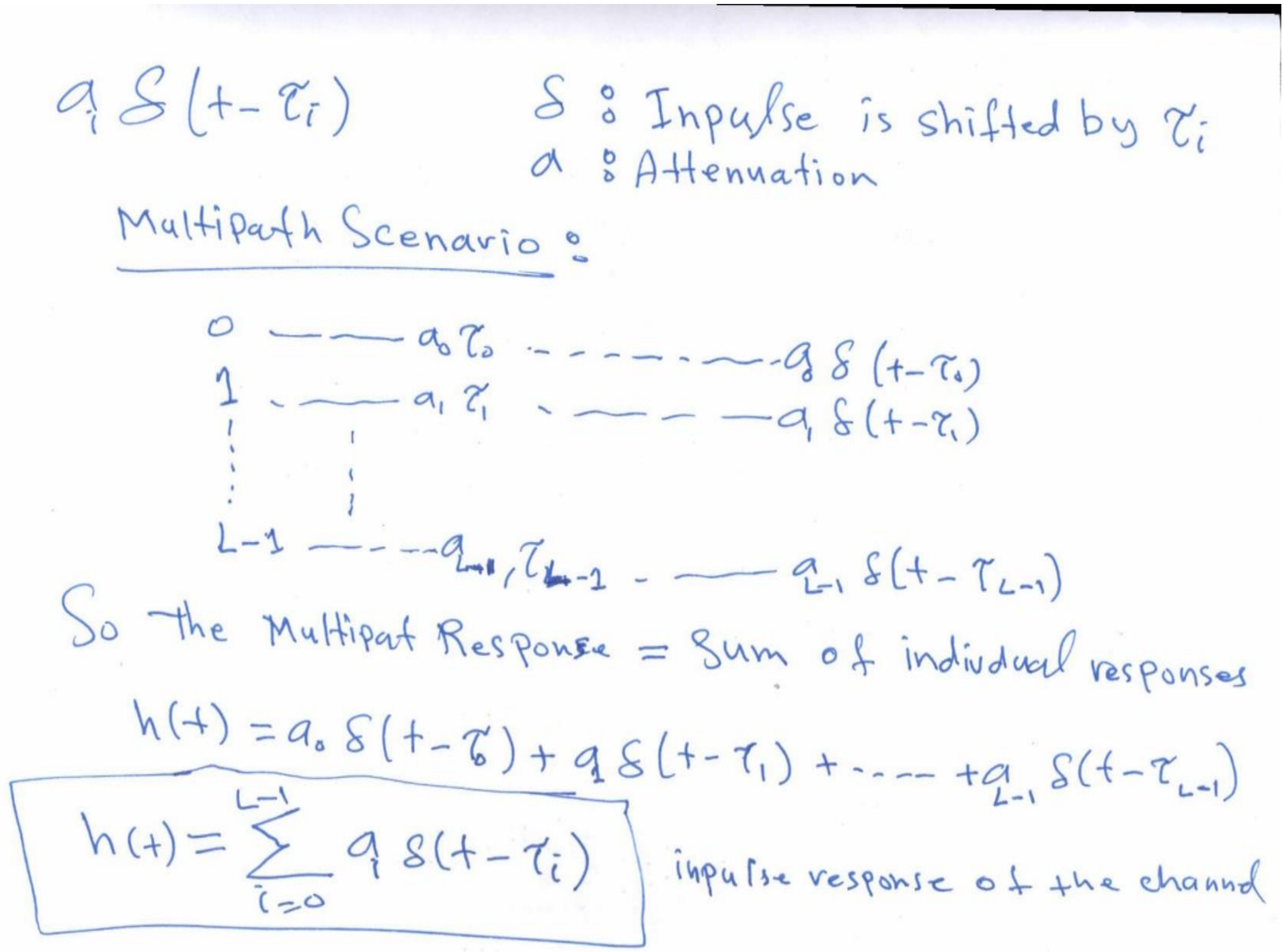
Let us say there are **L** paths, the **i-th** path of the wireless environment is characterized by a delay that is τ_i and then attenuation that is **a** of **i**. So, each **i-th** path in this wireless communication system is characterized by the delay of the signal which is τ_i, and **a** attenuation which is a_i.

can be model as the delta of the response of the signal which delays the signal by τi can be modeled as:

$a_i \, \delta \, (\tau - \tau_i)$

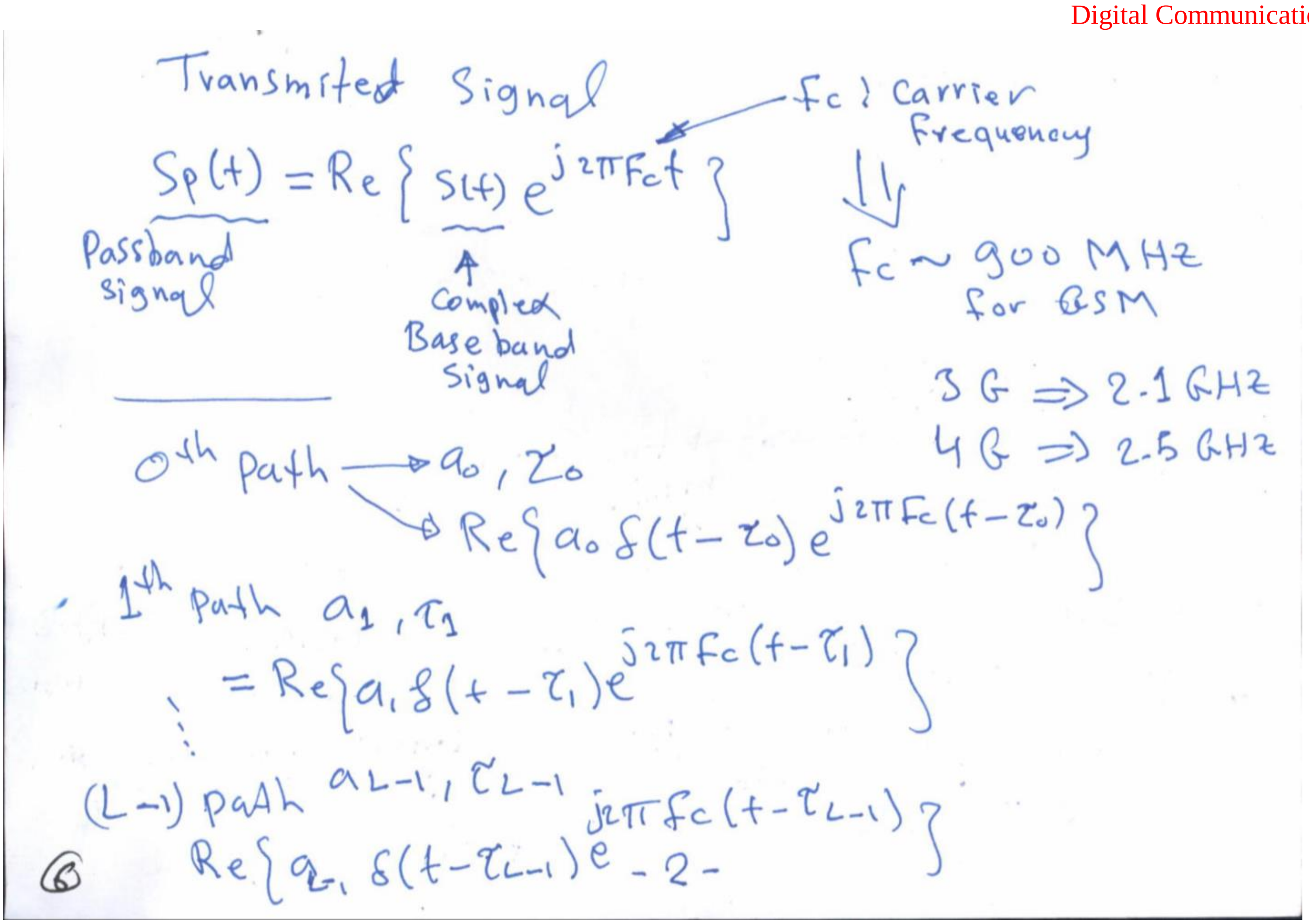
where **δ** is the direct delta function or this is the impulse, the impulse which is shifted by τ_i and this is, therefore, multiplied by a_i which is the attenuation.

This represents a system that is $a_i \, \delta \, (\tau - \tau_i)$ represents the system which attenuates the signal by ai and delays it by τ_i and therefore, now if we have a system which as **L** multipath components from 0 to **L-1**.



The impulse response of the channel

$$h(x) = \sum_{i=0}^{L-1} \mathrm{a_i} \delta(t - \tau_i)$$



This signal **S(t)** is complex this is termed as the complex baseband, this is upconverted to a carrier frequency **F_C** and this is transmitted over the air right this transmitted over the radio propagation channel. So, **F_C** is denoted the carrier and $e^{j2\pi f_c t}$ denotes the modulation with the carrier frequency.

Received signal

= sum of the various Multipath Components

$$y_p(t) = \sum_{i=0}^{L-1} \mathrm{Re}\left\{ a_i\, s(t-\tau_i)\, e^{j2\pi F_c (t-\tau_i)} \right\}$$

$$= \sum_{i=0}^{L-1} \mathrm{Re}\left\{ \left(a_i\, s(t-\tau_i)\, e^{-j2\pi F_c \tau_i}\right) e^{j2\pi F_c t} \right\}$$

$$= \mathrm{Re}\left\{ \left(\underbrace{\sum_{i=0}^{L-1} a_i\, s(t-\tau_i)\, e^{-j2\pi F_c \tau_i}}_{\text{Complex Baseband}} \right) \underbrace{e^{j2\pi F_c t}}_{\text{Carrier}} \right\}$$

Now

$$\underbrace{y(t)}_{\text{Complex Baseband Received Signal}} = \sum_{i=0}^{L-1} a_i\, s(t-\tau_i)\, \underbrace{e^{-j2\pi F_c \tau_i}}_{\text{complex phase factor}}$$

Narrowband assumption :-

$s(t-\tau_i) \sim s(t)$ → $F_m << F_c$

maximum Signal freq. — Carrier

So

$$y(t) = \left[\underbrace{\sum_{i=0}^{L-1} a_i\, e^{-j2\pi F_c \tau_i}}_{\text{complex Coefficient}} \right] s(t)$$

For Ex

GSM $F_m \sim 20\,kHz$

$F_c \sim 900\,MHz$

$$h = \sum_{i=0}^{L-1} a_i\, e^{-j2\pi F_c \tau_i}$$

Depends on the attenuation and Delay

$$y(t) = h \times s(t)$$

complex coefficient

$$h = \sum_{i=0}^{L-1} a_i e^{-j2\pi F_c \tau_i}$$