OFDM FOR MOBILE COMMUNICATIONS

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ABSTRACT

- Definition of OFDM

The challenging conditions in wireless environment

How OFDM can overcome those factors

DEFINITION

Communication channel is divided into no. of equally spaced frequency bands.

Each sub carrier in each band is orthogonal to other.

It is used both in wired such as in DSL and in wireless communication such as in radio & television broadcast

A wireless system using OFDM can deliver broadband data at the data rates comparable to the wired services

A mobile system can be a rich user experience if it provides ubiquitous, fast, user-friendly connectivity.

OFDM has several unique properties that makes it well suitable for the mobile wireless applications.

OFDM FOR MOBILE COMMUNICATIONS

The different techniques used in the mobile communications are:

TDMA in which the segments are according to the time division.

CDMA in which the segments are according to the spreading codes.

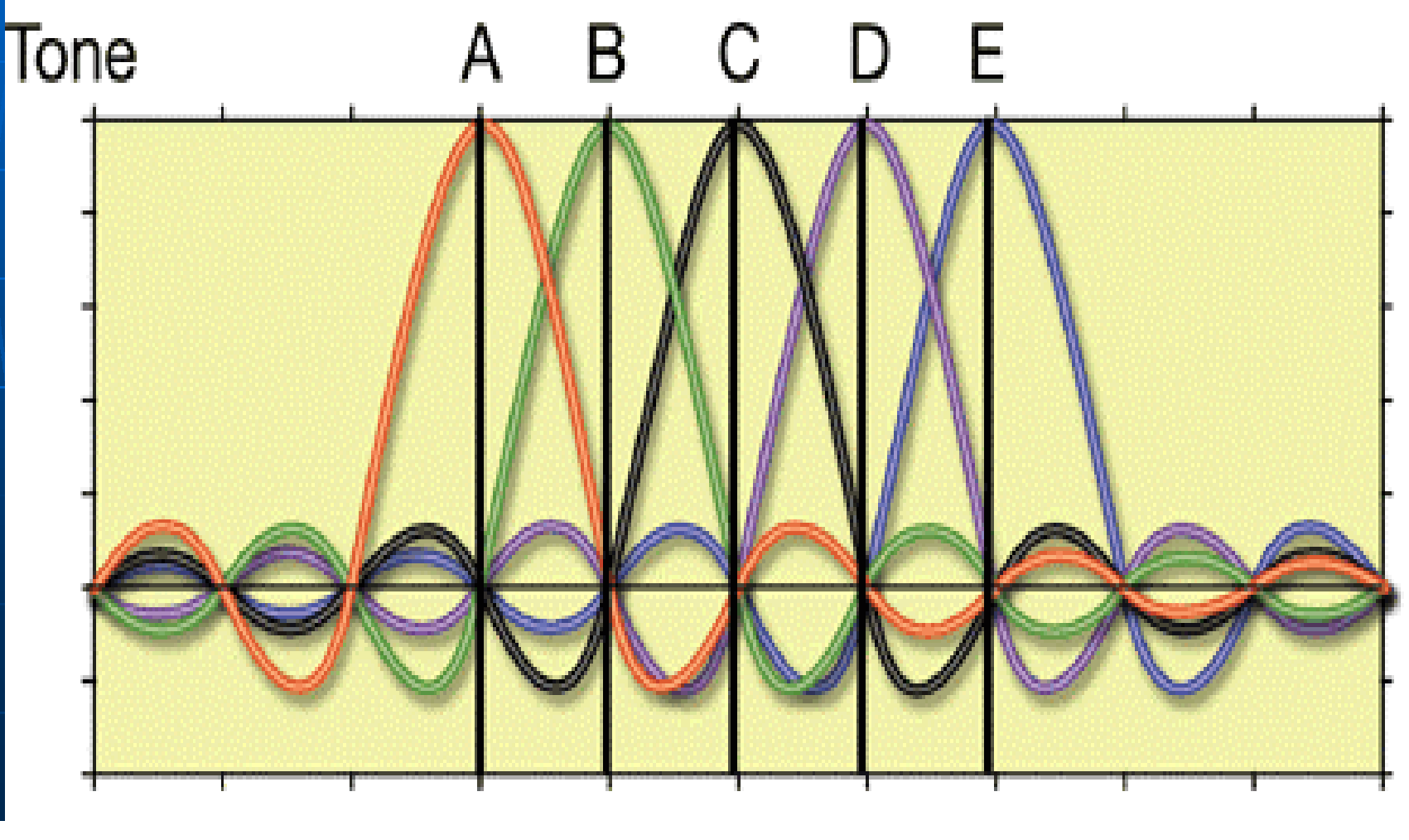
OFDM in which the spectrum is divided into a no. of equally spaced tones and carries a portion of user's information on each tone.

OFDM has an important special property that each tone is orthogonal with every other tone.

This special property and a guard time incorporated made the OFDM to be more suitable for mobile communications.

The spectrum of each tone overlaps as shown in fig and because they are orthogonal, they do not interfere with each other.

By allowing to overlap the overall spectrum required is reduced.



WIRELESS ENVIRONMENT

The major challenging conditions in the wireless environment are:

Multipath: A phenomenon that occurs as transmitted signal is reflected by objects in environment between base station and a user.

This multipath causes the fading and degree of cancellation which will depend on the delay spread of the reflected signals.

Time dispersion occurs when the channel is band limited i.e. when the coherence bandwidth of the channel is smaller than the modulation bandwidth.

Time dispersion causes the ISI (intersymbol interference) and fading in the transmitted signal.

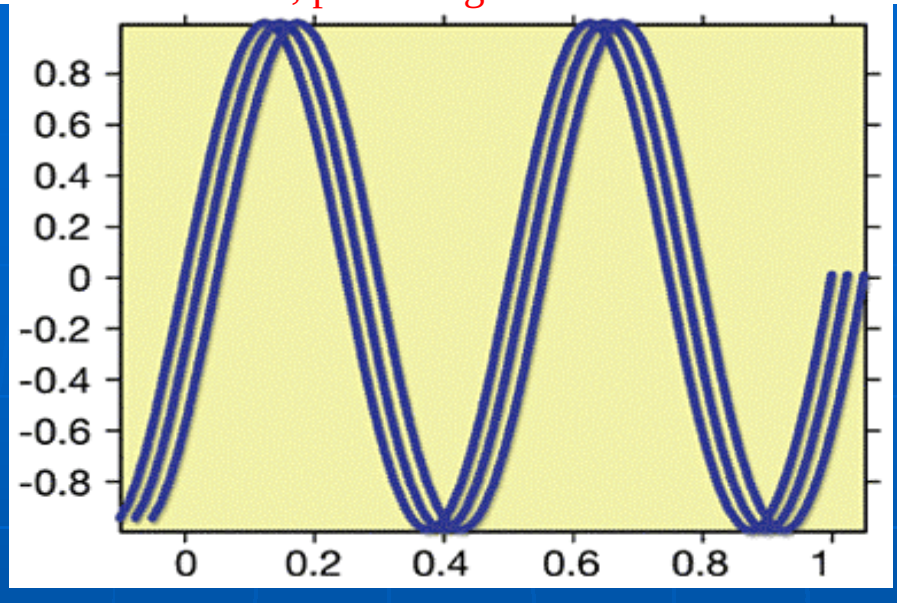


FIG2: EXAMPLE OF TIME DELAYED MULTI PATH SIGNALS

FIG 3: DEMONSTRATION OF MULTIPATH REFLECTIONS

The fading is again of two types:

Frequency selective which randomly affects only a portion of the overall spectrum.

This will be caused when the time dispersion is introduced by the channel and when delay spread exceeds the symbol period.

The other type of fading is a flat fading which may lead to deep fades of more than 30 dB affecting all frequencies in the signal equal.

This will be caused when there is no time dispersion in the channel and when delay spread does not exceed the symbol period.

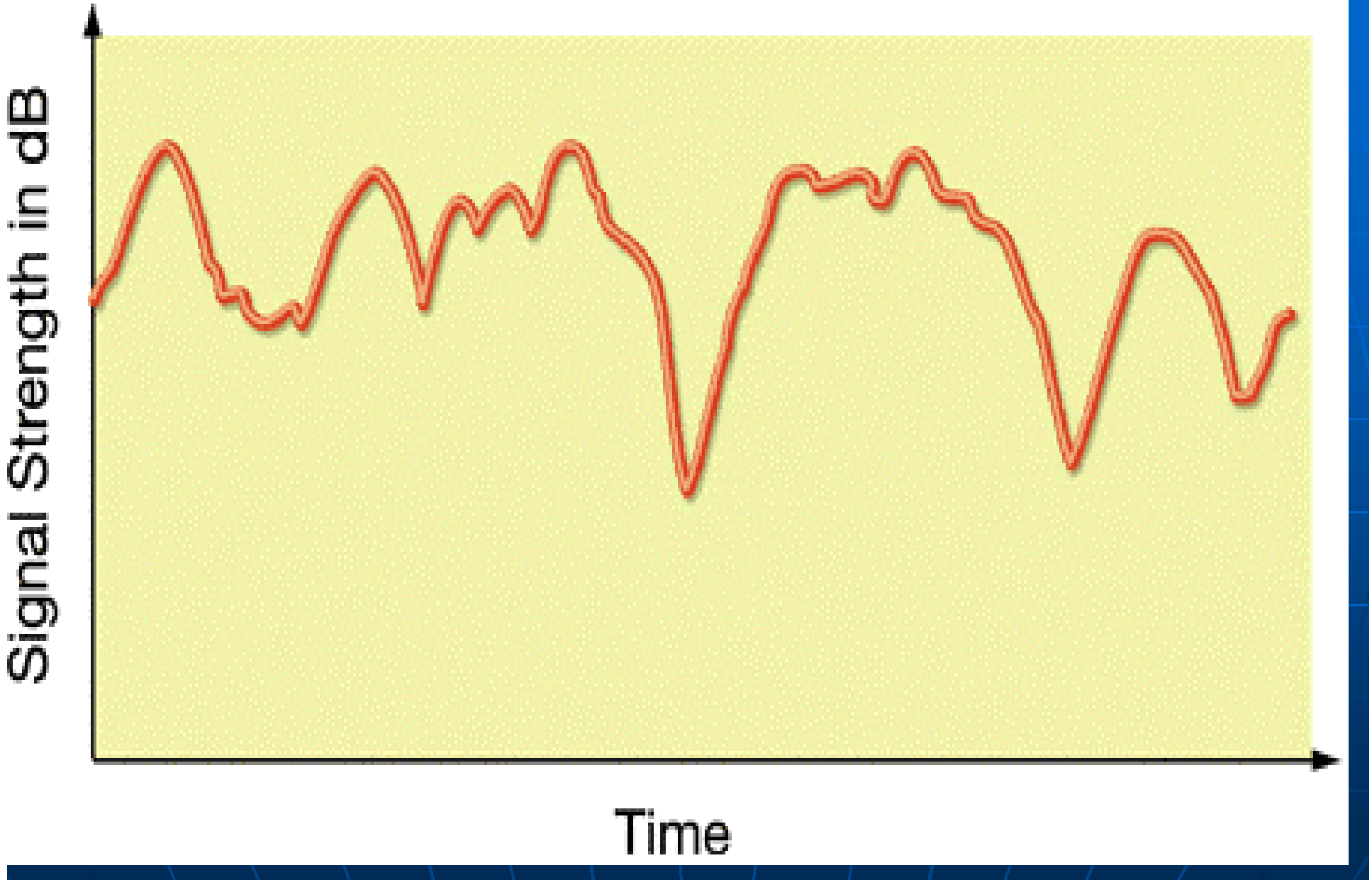


FIG4: DEMONSTRATION OF TIME VARYING FADING

Doppler spread describes the random changes in the channel.

It has effect of shifting frequency components of signal.

The chorence time of channel is inverse of Doppler.

It determines the rate at which fading occurs. If it is higher than modulated symbol rate fast fading and if lower slow fading occurs.

The fading signal amplitude are frequently characterized as either Rayleigh or Ricean.

Rayleigh fading occurs when there is no line of sight (LOS) component present in the received signal.

In mobile no direct LOS path is used as they can be in building or behind one or other obstructions. This leads to Rayleigh fading but also results in shadow loss.

TRADITIONAL MOBILE WIRELESS SYSTEMS

In digital mobile systems, the techniques used to overcome the above described factors are:

Diversity used to help mitigate the multipath fading induced due to user's mobility.

The simplest diversity technique is the spatial diversity which involves the use of two or more receiving antennae.

The signal from the mobile will generally follow separate paths to each antenna.

Spread spectrum system employ frequency diversity where the signal is spread over larger bandwidth than coherence bandwidth.

This makes signal to be more resistant to the effect of frequency selective fading and only a small portion will be effected.

The two types of the spread spectrum are CDMA (code division multiple access) and FH (frequency hopping).

OPERATION OF OFDM

OFDM has the property that the sinusoidal waveforms of the tones are being the only Eigen functions of a linear channel.

This special property prevents adjacent tone interference and the multiple access interference which is present in CDMA.

Incorporation of a small amount of guard time to each symbol along with this property preserves the orthogonality in the presence of multipath.

The frequency domain representation of a number of tones, is as shown in figure and it highlights the orthogonal nature of the tones.

The orthogonality between tones can be maintained by ensuring symbol time contains one or multiple cycles of sinusoidal tone waveform.

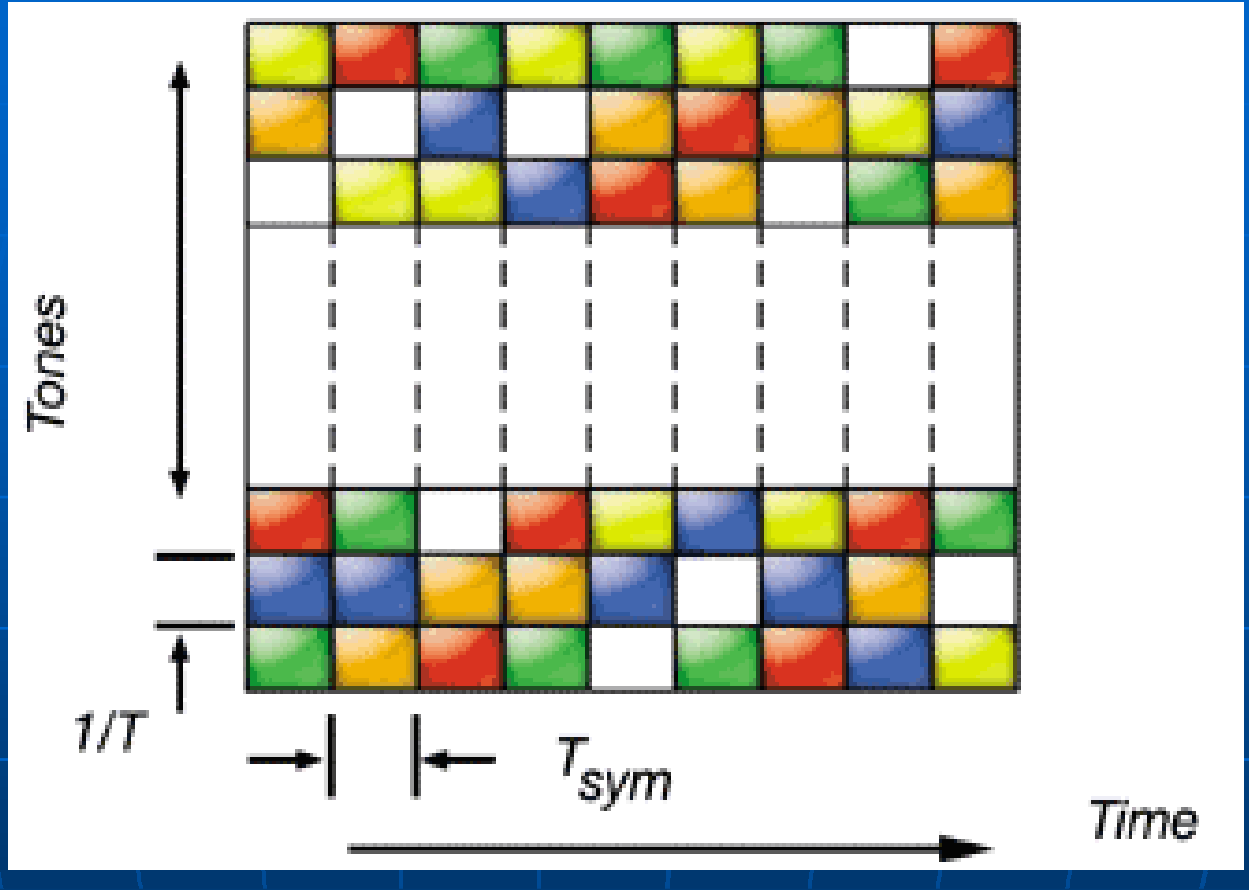


FIG5: TWO DIMENTIONAL ILLUSTRATION OF OFDM CHANNEL RESOURCE

The below figure shows three tones over a single symbol period, where each tone has an integer number of cycles during the symbol.

In order to generate the pure sinusoidal tone the signal requires to start at time minus infinity.

This is important as tones are the only waveforms that can ensure orthogonality.

This can be achieved by adding a guard time called cyclic prefix through which the orthogonality is ensured and also prevents the ICI (intercarrier interference).

The alignment of the delayed replicas of the tones due to multipath can also be done by the cyclic prefix.

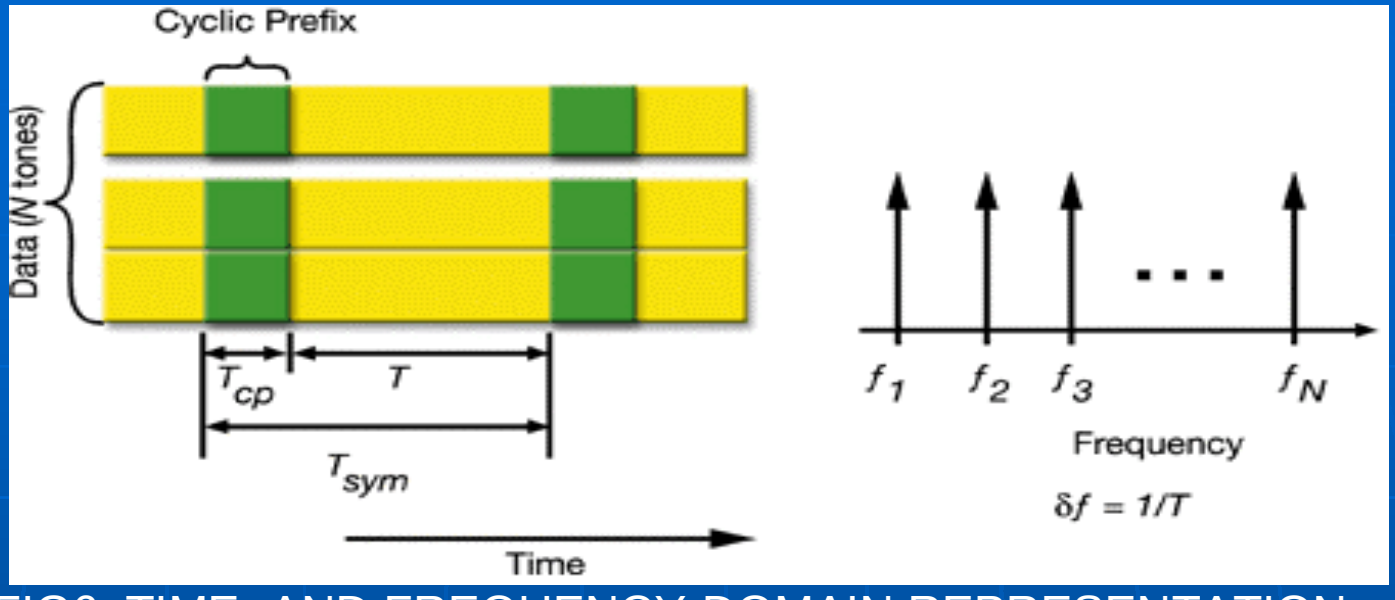


FIG6: TIME- AND FREQUENCY-DOMAIN REPRESENTATION

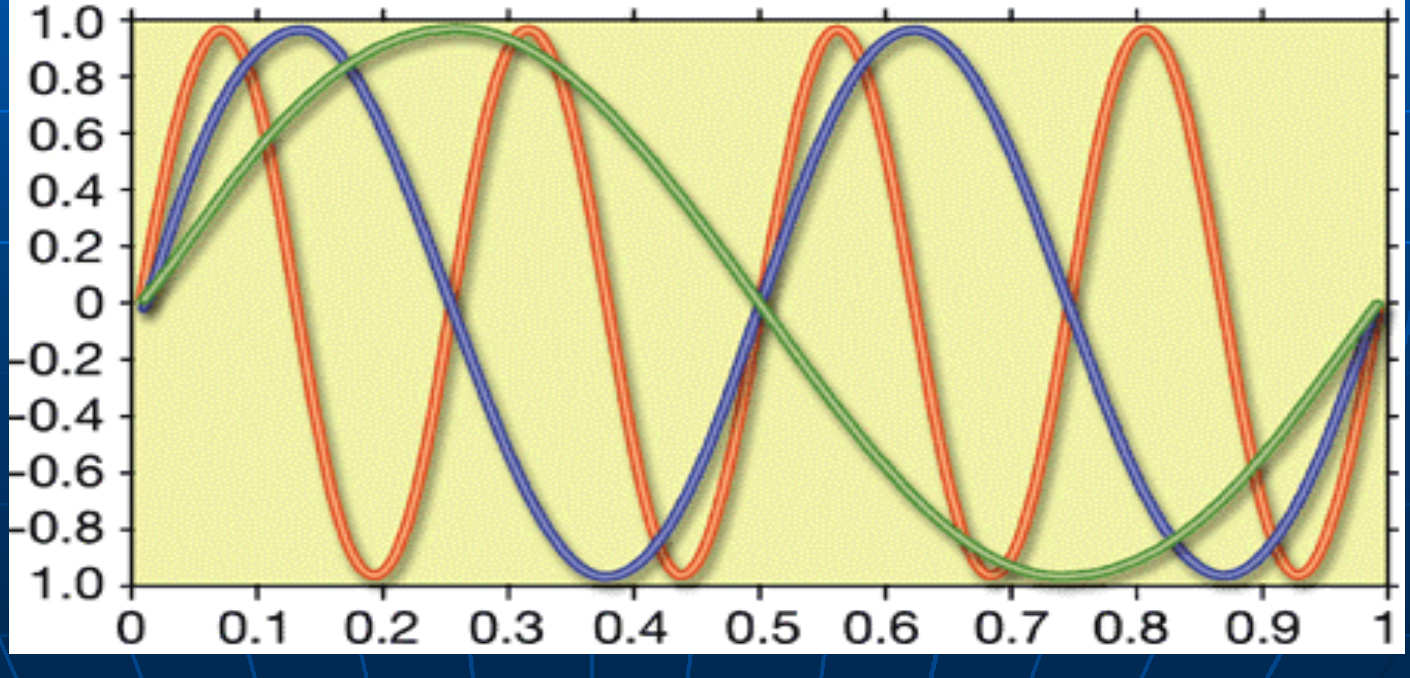


FIG 7: INTEGER NUMBER OF SINUSOID PERIODS

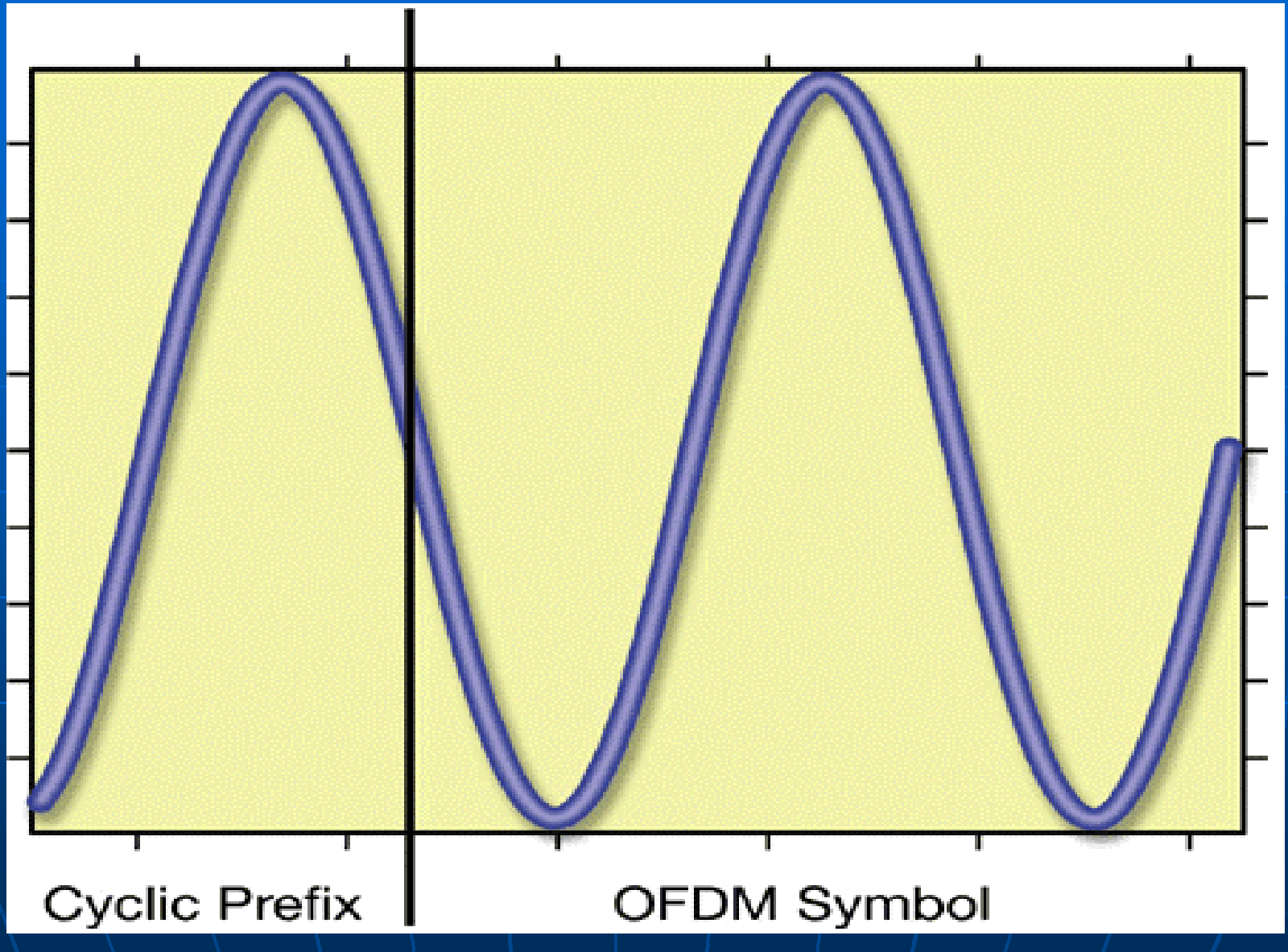


FIG8: CYCLIC EXTENSION OF SINUSOID

The cyclic prefix is also used to serve as a guard time to eliminate ISI (intersymbol interference).

This is because the amount of time dispersion from the channel is smaller than duration of cyclic prefix.

The cyclic prefix must also be long enough to account for the anticipated multipath delay spread.

The sizing of the cyclic prefix is a compromise between the amount of delay spread that is acceptable and the amount of Doppler shift that is acceptable.

CONCLUSION

OFDM can overcome the unique design challenges in the mobile data systems and can provide high performance mobile data communications.

OFDM is well positioned to meet the unique demands of mobile packet data traffic.

OFDM will unwire all the IP applications inherent in the wired Internet and intranets (including interactive data applications and peer-to-peer applications.

All layers of the OFDM air interface need to be jointly designed and optimized from the ground up for the IP data world.

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THANK YOU