Wireless Medium Access Control and CDMA, 3G and 4G Communication

Lesson 12

OFDM (Orthogonal Frequency Division Medium Access)

OFDM

- Also called COFDM (code orthogonal frequency division multiplexing)
- Also called spread-spectrum based multi-carrier or discrete multi-tone modulation

OFDM

- Mobile multimedia services
- Number of carriers required increases

OFDM (orthogonal frequency division multiplexing in code-space)

- A new multi-carrier transmission technique for cellular mobile devices

OFDM

- A spread spectrum based technique for distribution (spreading) of data over large number of sub-carriers that are spaced at precise frequency intervals with a coding scheme
- Multi-carrier transmission in OFDM uses multiplexing in code-space

OFDM

- Multiple carriers use mutually orthogonal codes, which enables separation of carriers in case of multi-path transmissions and interference of signals
- All channel carriers (adjacent channel codes) using distinct but mutually orthogonal codes

OFDM

- Each channel carrier has distinct amplitude (power level) and may have a time guard
- Bandwidth remains equal to that in the single carrier case

Three most important characteristics of OFDM

- High spectral efficiency
- Strong resiliency to RF inter symbol interferences
- Lower multi-path distortions

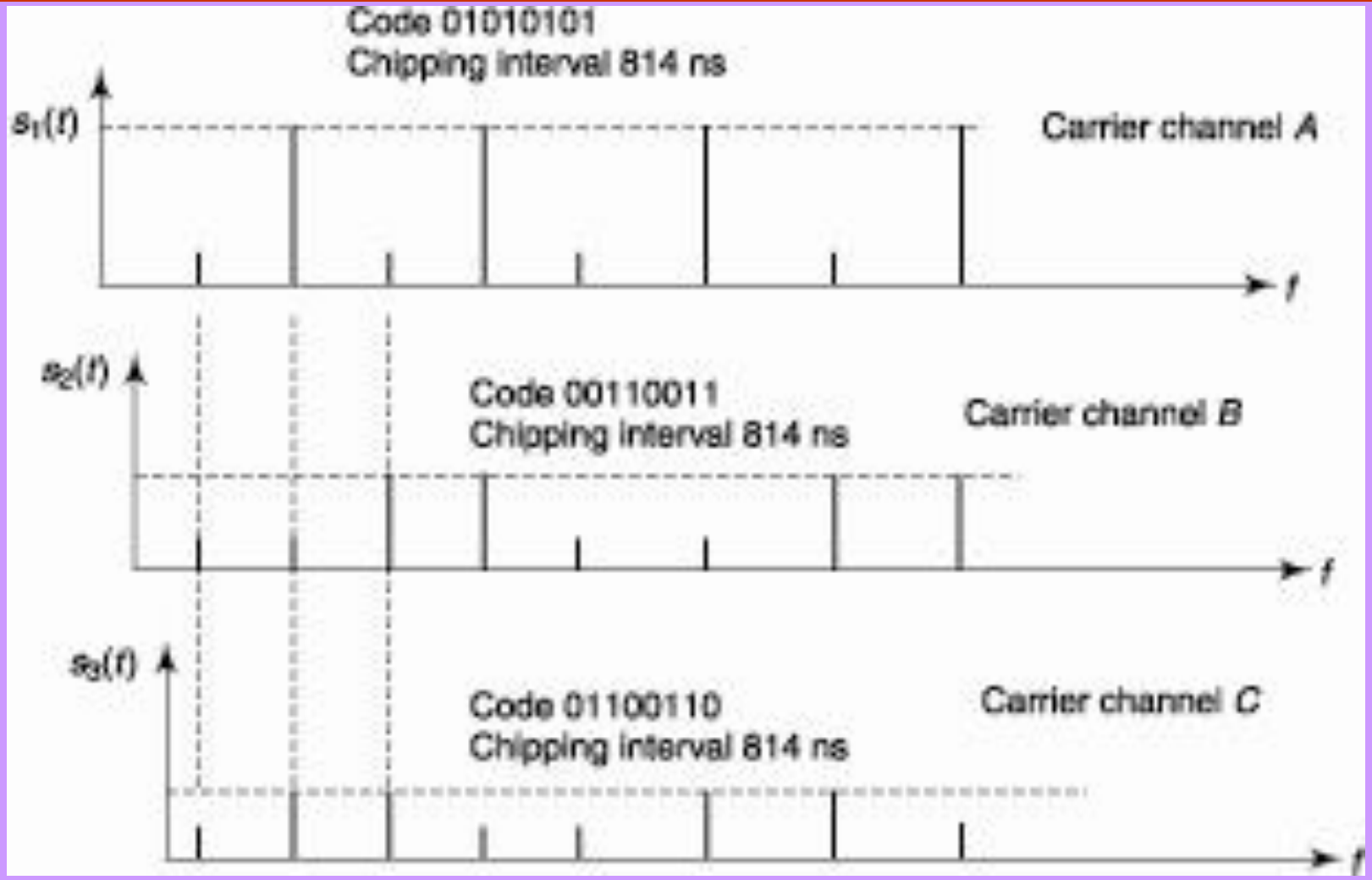
OFDM

- Peak to average power ratio (PAR) high in an OFDM system as compared to a single carrier system
- Gives a many carrier system with bandwidth equal to that of a single carrier system
- Digital video broadcasting OFDM system
- HyperLAN-2 OFDM system

OFDM

- COFDM distinct from quadrature modulation QPSK or OQPSK
- OQPSK also an orthogonal modulation in time-space, where different frequency carriers transmits in different time-space (at different phase angles)

Orthogonal code-shifted three-carrier transmission of channels by multiplexing in code-space



OFDM

- Each carrier has a different peak amplitude of signals $s1(t)$, $s2(t)$, and $s3(t)$
- There are three codes 01010101, 00110011, and 01100110
- These codes are Walsh codes of length 8, used here as examples

OFDM

- Actual code length may vary
- The codes themselves may be from a different set of orthogonal codes
- The only condition put on them is that they should all be orthogonal with no cross correlation
- Also, 0s are transmitted as + 1s and 1s are transmitted as –1s for signal mapping as per 3GPP specifications

OFDM Carrier chipping

- Each chipping using distinct orthogonal codes
- Scrambled using the same or distinct PN long codes
- Chipping instants of each carrier channel use a different code (code-space divides into *n* when using *n* distinct orthogonal codes)

OFDM Carrier chipping

- Combined chipping rate remains 1.2288 Mchip/s with a bandwidth of 1.25 MHz as an example
- Actual chipping rate may be higher
- Spread spectrum frequency is 1.2288 MHz only when the bandwidth used is 1.25 MHz
- For $n = 12$, twelve carrier channels transmit with n codes

OFDM Carriers

- Each carrier uses different power levels (amplitudes)
- To enable separation of carriers at the receiver
- A guard space in time between different OFDM carriers may also be used
- This will affect the effective data transmission rates

OFDM Carriers

- The wireless LAN (HyperLAN-2) IEEE 802.11a standard 0.800 μs guard time
- Some carriers may be used by pilot channels for synchronizing and some may be redundant

Use of Digital signal processors

- Perform modulation and demodulation in OFDM systems
- Processing expressions for COFDM modulation based on fast Fourier transforms and inverse Fourier transforms

Wireless LAN Applications

- For point-to-point transmission and for multicasting
- OFDM 5.8 GHz band
- 802.11a prescribes a chipping rate of 0.250 Mchip/s, 4 pilot carriers, 48 data carriers, and 12 virtual carriers

802.11a Applications

- 64-QAM method for modulation
- This entails a shift in time as well as in peak amplitude space
- A set of six symbols is transmitted through a single carrier

802.11a Applications

- Each set of symbols has a distinct phase angle or amplitude
- Bit transmission rate is 6× 0.250 Mchip/s = 1.5 Mchip/s
- When using convolution encoding to reduce bit error rates, the rate achieved is 1.125 Mbps (3/4th of the rate without convolution encoding)

Applications

- Digital audio broadcasting (DAB)
- Digital video broadcasting (DVB)
- DVB-H (DVB for handheld devices) to enable users to watch TV on their mobile devices

Wideband OFDM (WOFDM)

- A technique in which spacing between multi-carrier channels is made large
- Therefore, any frequency errors between the transmitter and the receiver do not affect system performance

Flash-OFDM (fast low-latency access with seamless handoff OFDM)

- Based on the FHSS spectrum
- Fast-hopped OFDM

MIMO-OFDM (multiple input, multiple output OFDM)

- A technique in which multiple antennae are used for inputs and outputs
- Provides broadband wireless access (BWA) and performs well in multiple non-line-of-sight multiple-path environments

VOFDM (vector OFDM)

- Technique based on MIMO-OFDM
- Developed by Cisco Systems, Inc

3G and 4G

- File transfer at 10 Mbps
- High resolution 1024 × 1920 pixel hi-vision picture transfer at 24 Mb/s
- High resolution video transfer
- High speeds of data transfer, the three to twelve carriers of CDMA2000 phase shifted in time-space do not suffice

Summary

- COFDM
- Spread-spectrum based multi-carrier or discrete multi-tone modulation

End of Lesson 12

OFDM (Orthogonal Frequency Division Medium Access)