Wideband Code Division Multiple Access:

- W-CDMA was developed by NTT DoCoMo as the air interface for their 3G network.
- WCDMA is a wideband Direct-Sequence Code Division Multiple Access (DS-CDMA) system, i.e. user information bits are spread over a wide bandwidth by multiplying the user data with chips derived from CDMA spreading codes.
- The chip rate of 3.84 Mcps leads to a carrier bandwidth of approximately 5 MHz. DSCDMA systems with a bandwidth of about 1 MHz, such as IS-95, are commonly referred to as narrowband CDMA systems.
- WCDMA supports highly variable user data rates, in other words the concept of obtaining Bandwidth on Demand (BoD) is well supported. The user data rate is kept constant during each 10 ms frame. However, the data capacity among the users can change from frame to frame.
- WCDMA supports two basic modes of operation: Frequency Division Duplex (FDD) and Time Division Duplex (TDD).
- In the FDD mode, separate 5 MHz carrier frequencies are used for the uplink and downlink respectively, whereas in TDD only one 5 MHz is timeshared between the uplink and downlink.
- WCDMA employs coherent detection on uplink and downlink and will result in an overall increase of coverage and capacity.

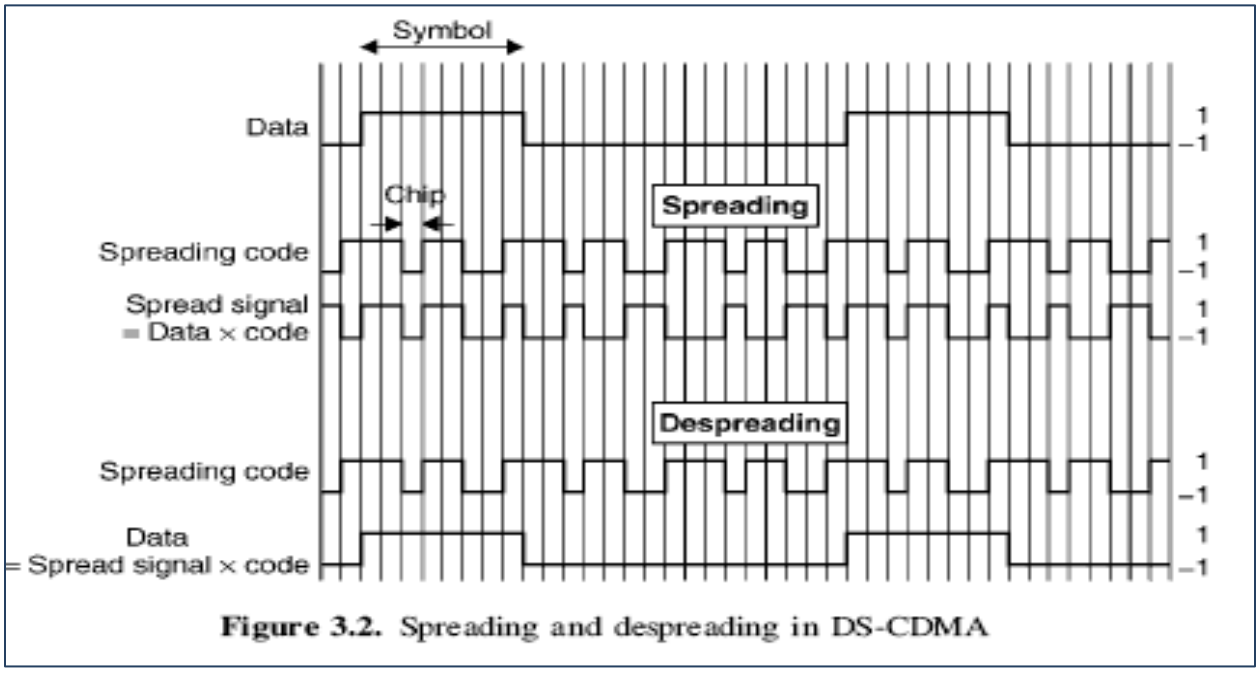


Figure 3.2. Spreading and despreading in DS-CDMA

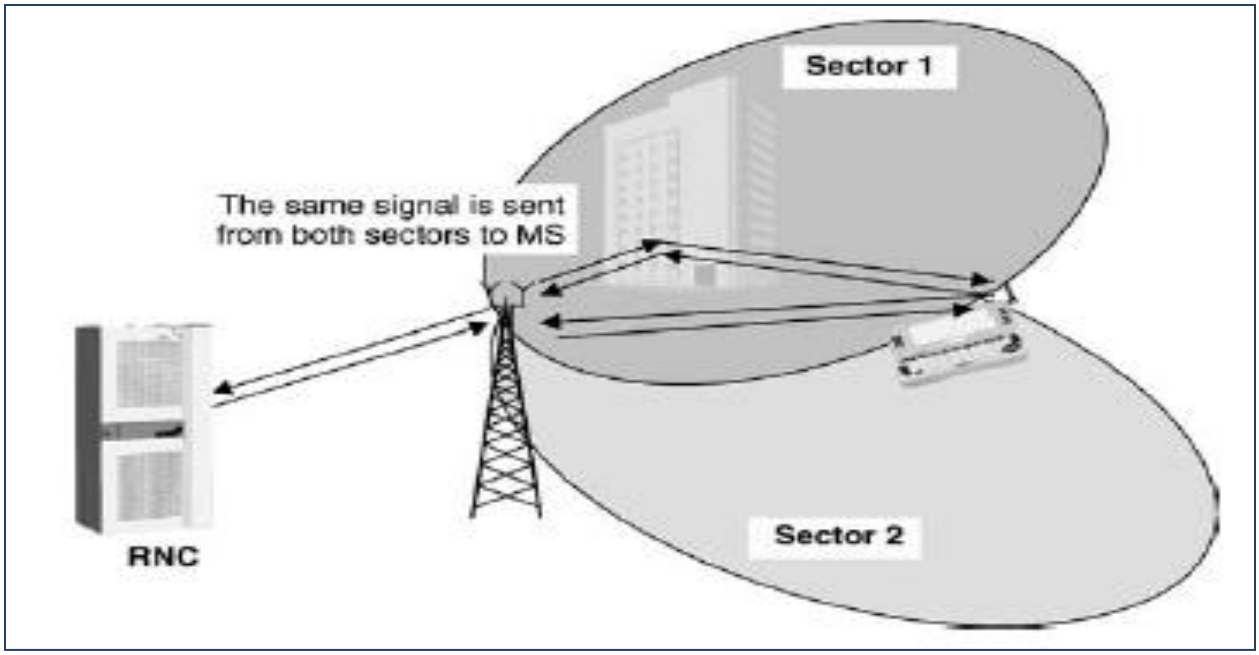
- The WCDMA air interface has been crafted in such a way that advanced CDMA receiver concepts, such as multiuser detection and smart adaptive antennas, can be deployed by the network operator as a system option to increase capacity and coverage.
- WCDMA is designed to be deployed in conjunction with GSM. Therefore, handovers between GSM and WCDMA are supported.
- The wideband signal-to-interference ratio is also called the carrier-to-interference ratio C/I.
- Due to spreading and despreading , C/I can be lower in WCDMA than, for example, in GSM.
- Its detection is difficult without knowledge of the spreading sequence. For this reason, spread spectrum systems originated in military applications.

Handover:

- Softer Handover
- Soft Handover
- Inter-frequency hard handovers
- Inter-system hard handovers

Softer Handover:

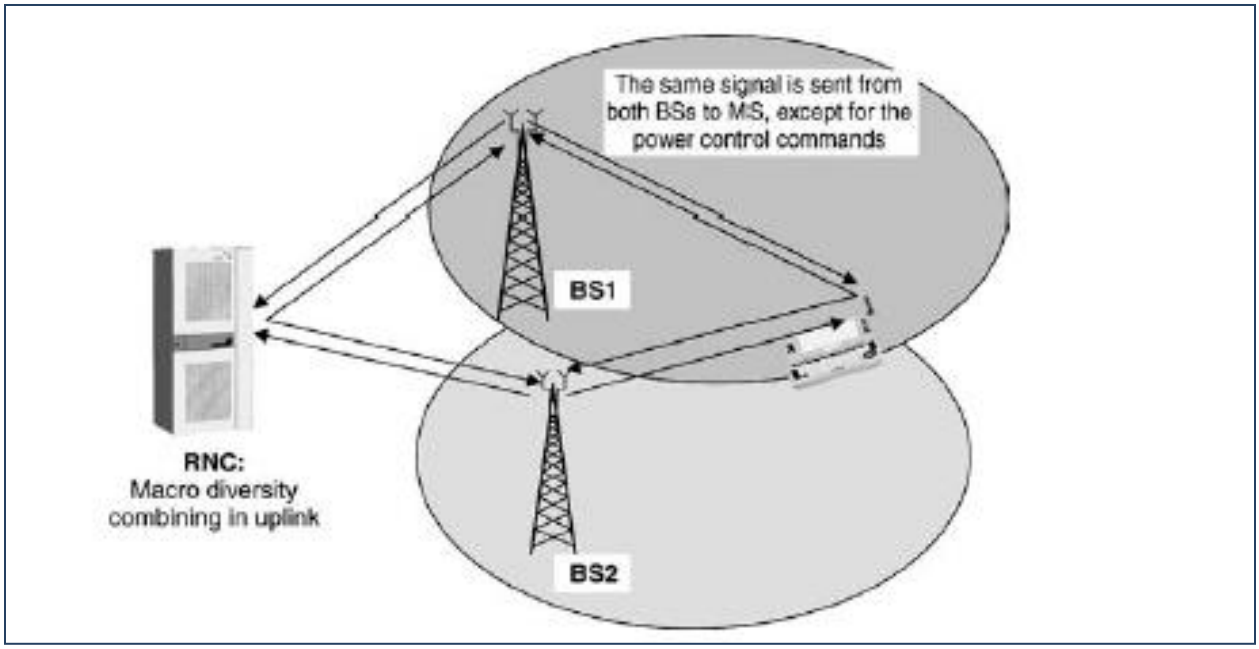
- During softer handover, a mobile station is in the overlapping cell coverage area of two adjacent sectors of a base station. The communications between mobile station and base station take place concurrently via two air interface channels, one for each sector separately.
- This requires the use of two separate codes in the downlink direction, so that the mobile station can distinguish the signals.
- The two signals are received in the mobile station by means of Rake processing.



- In the uplink direction a similar process takes place at the base station: the code channel of the mobile station is received in each sector, then routed to the same baseband Rake receiver and the maximal ratio combined there in the usual way.
- During softer handover only one power control loop per connection is active. Softer handover typically occurs in about 5–15% of connections.

Soft Handover:

- During soft handover, a mobile station is in the overlapping cell coverage area of two sectors belonging to different base stations.
- The communication between mobile station and base station take place concurrently via two air interface channels from each base station separately.
- Both channels (signals) are received at the mobile station by maximal ratio combining Rake processing.



- The code channel of the mobile station is received from both base stations, but the received data is then routed to the RNC for combining.
- This is typically done so that the same frame reliability indicator as provided for outer loop power control is used to select the better frame between the two possible candidates within the RNC. This selection takes place after each interleaving period, i.e. every 10–80 ms.
- During soft handover two power control loops per connection are active, one for each base station. Soft handover occurs in about 20–40% of connections.

WCDMA : Parameters:

- Channel bandwidth --- 5 MHz
- Duplex mode --- FDD and TDD
- Data modulation ----- QPSK (downlink)
- Data modulation ------BPSK (uplink)
- Power control frequency --- 1500Hz
- Frequency reuse factor --- 1
- Chip rate ----- 3.84 Mbps
- Frame duration --- 10ms
- Channel coding --- Convolution and turbo codes

- Handover ---- Soft and softer handover

Main differences between WCDMA and GSM air interfaces:

	WCDMA	GSM
Carrier spacing	5 MHz	200 kHz
Frequency reuse factor	1	1–18
Power control frequency	1500 Hz	2 Hz or lower
Quality control	Radio resource management algorithms	Network planning (frequency planning)
Frequency diversity	5 MHz bandwidth gives multipath diversity with Rake receiver	Frequency hopping
Packet data	Load-based packet scheduling	Time slot based scheduling with GPRS
Downlink transmit diversity	Supported for improving downlink capacity	Not supported by the standard, but can be applied

	WCDMA	IS-95
Carrier spacing	5 MHz	1.25 MHz
Chip rate	3.84 Mcps	1.2288 Mcps
Power control frequency	1500 Hz, both uplink and downlink	Uplink: 800 Hz, downlink: slow power control
Base station synchronisation	Not needed	Yes, typically obtained via GPS
Inter-frequency handovers	Yes, measurements with slotted mode	Possible, but measurement method not specified
Efficient radio resource management algorithms	Yes, provides required quality of service	Not needed for speech only networks
Packet data	Load-based packet scheduling	Packet data transmitted as short circuit switched calls
Downlink transmit diversity	Supported for improving downlink capacity	Not supported by the standard

WCDMA : Band Structure:

- Downlink band -----2110-2200 MHz
- Uplink band -------1885 -2025 MHz

OFDM : Need

- A wireless network should be designed to minimize adverse effects.
- To create broadband multimedia mobile communication systems, it is necessary to use high-bit-rate transmission of at least several megabits per second.
- To overcome such a multipath-fading environment with low complexity and to achieve WBMCS, orthogonal frequency division multiplexing (OFDM) transmission scheme is used.
- OFDM is one of the applications of a parallel-data-transmission scheme, which reduces the influence of multipath fading and makes complex equalizers unnecessary.
- Modulation : a mapping of the information on changes in carrier phase ,freq. ,amplitude or combination.
- Multiplexing : method of sharing of bandwidth with other independent channels.
- OFDM is combination of modulation and multiplexing.
- In OFDM signal itself is first split into independent channels ,modulated by data and re-multiplexed to the create OFDM carrier.
- OFDM is special case of FDM.
- FDM channel is like water flow out of faucet where OFDM signal is like a shower.
- OFDM is a special case of multicarrier transmission, where a single data stream is transmitted over a number of lower-rate subcarriers (SCs).
- In a classical parallel-data system, the total signal frequency band is divided into *N* nonoverlapping frequency subchannels. Each subchannel is modulated with a separate symbol, and then the *N* subchannels are frequency multiplexed.
- However, this leads to inefficient use of the available spectrum. To cope with the inefficiency, the ideas proposed in the mid-1960s were to use parallel data and FDM with overlapping sub channels,

Benefits of OFDM:

- One challenge in today's wireless systems is an effect called 'multipath.' Multipath results from reflections between a transmitter and receiver whereby the reflections arrive at the receiver at different times.
- The time span separating the reflection is referred to as delay spread. This type of interference tends to be problematic when the delay spread is on the order of the transmitted symbol time. Typical delay spreads are microseconds in length, which are close to CDMA symbol times.
- OFDMA symbol times tend to be on the order of 100 microseconds, making multipath less of a problem. In order to mitigate the effect of multipath, a guard band of about 10 microseconds, called the cyclic pre x, is inserted after each symbol
- Achieving higher data rates requires OFDM systems to make more efficient use of the bandwidth than CDMA systems. The number of bits per unit hertz is referred to as the spectral efficiency.
- Achieving higher data rates requires OFDM systems to make more efficient use of the bandwidth than CDMA systems. The number of bits per unit hertz is referred to as the spectral efficiency.
- One method of achieving this higher efficiency is through the use of higher order modulation. Modulation refers to the number of bits that each subcarrier transmits.
- For example, in a quaternary amplitude modulation (QAM) there are 2 bits transmitted per tone.
- Another benefit of OFDM is the use of advanced multiantenna signal processing techniques.
- The two most common techniques are called multiple input multiple output (MIMO) processing and beam forming.

OFDM :Application:

- In the 1960s, the OFDM technique was used in several high-frequency military systems.
- In the 1980s, OFDM was studied for high-speed modems, digital mobile communications.
- In the 1990s, OFDM was exploited for wideband data communications over mobile radio FM channels, high-bit-rate digital subscriber lines **(HDSL; 1.6 Mbps),** asymmetric digital subscriber lines **(ADSL; up to 6 Mbps),** very-high-speed digital subscriber lines **(VDSL; 100 Mbps),** digital audio broadcasting **(DAB),** and high definition television **(HDTV)** terrestrial broadcasting .

OFDM :Advantages & Disadvantages:

- **Advantages**
    - ❖ High spectral efficiency
    - ❖ Simple implementation: the use of FFT and IFFT in OFDM reduces the modem complexity, especially at the receiver.
    - ❖ Resistance to fading and interference.
- **Disadvantages**
    - ❖ High peak-to-average power ratio: The high peak-to-average power ratio (PAPR) imposes stringent requirements on the A/Ds and D/As, and more importantly, on the linearity of the power amplifier (PA).
- OFDMA was developed to move OFDM technology from a fixed-access wireless system to a true cellular system with mobility.
- In OFDMA, sub carriers are grouped into larger units, referred to as sub channels, and these sub channels are further grouped into bursts which can be allocated to wireless users.
- Each burst allocation can be changed from frame to frame as well as within the modulation order.
- This allows the base station to dynamically adjust the bandwidth usage according to the current system requirements.
- In addition, since each user consumes only a portion of the total bandwidth, the power of each user can also be modulated according to the current system requirements.
- Quality of service (QoS) is another feature that can be adapted for different users depending on their specific application, such as voice, streaming video, or internet access for example.
- The use of IFFT/FFT allows terminals to arbitrarily combine multiple frequencies (subcarriers), leading to orthogonal frequency division multiple access (OFDMA).
- *An OFDMA system is defined as one in which each terminal occupies a subset of subcarriers (termed an OFDMA traffic channel), and each traffic channel is assigned exclusively to one user at any time.*

OFDMA symbol description and parameters:

- Frequency domain description:

- An OFDMA symbol is made up of subcarriers:

- Data subcarriers : for data transmission

- Pilot subcarriers : for various estimation purposes.

- Null subcarriers : no transmission at all ,for guard bands and DC carrier.