The Evolution and Future of Mobile Communication Systems

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Chapter 4 : WCDMA (Wideband CDMA)

4.1 WCDMA

WCDMA of 3G potentially will offer the user significantly increased data throughput rates. Speeds of up to 2mbit/s and higher are being predicted but it will be sometime before these are achieved. New techniques such as voice over IP are being developed for use on the Transport Infrastructure and will bring significant advantages to the operator especially in terms of data compression techniques used in such transmission modes as ATM. Increased data throughput means greater capacity for a given amount of frequency spectrum and thus lower costs for both Infrastructure and spectrum licences. Potentially the benefits of WCDMA to the user and operator are massive with greater data rates for the user and reduced costs for the operator.

4.2 Carrier Spacing and Deployment Scenarios

The carrier spacing has a range of 200 kHz and can differ from 4.2 to 5.4 MHz, the different carrier spacing can be used to obtain suitable adjacent channel protections depending on the interference scenario. Figure 30 shows an example, where the bandwidth of 15 MHz with three cell layers. Larger carrier spacing can be applied between operators, than within one operators band in order to avoid inter-operator interference. Interfrequency measurements and handovers are supported by WCDMA to make use of three cell layers and carriers.

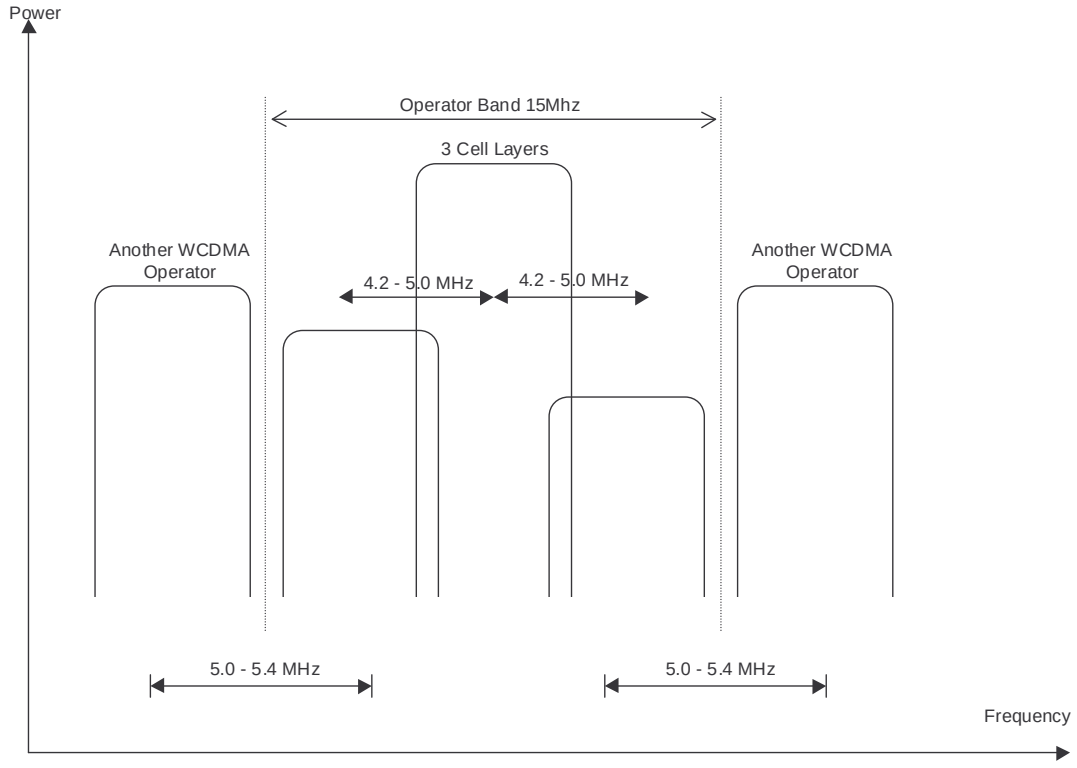


Figure 1 Frequency utilization with WCDMA

(Adapted from Holma, H. et al 2000)

4.3 Logical Channels

WCDMA mainly follows the ITU Recommendation M.1035 in the definitions of logical channels. The following logical channels are defined for WCDMA.

4.4 Control Channels

BCCH : Broadcast Control Channel carries system and cell specific channels;
PCH : Paging Channel for messages to the mobiles in the paging area;
FACH : Forward Access Channel for messages from the base station to the mobile in one cell.

In addition to the two Control Channels there are also two Dedicated Channels;

DCCH : Dedicated Control Channel, this covers two channels : stand-alone dedicated control channel (SDCCH), and the Associated Control Channel (ACCH);
DTCH : Dedicated Traffic Channel for point to point data transmission in the uplink and downlink.

4.5 Uplink Physical Channels

There are two dedicated channels and one common channel for the uplink. User data is transmitted on one of these channels, the Dedicated Physical Data Channel (DPDCH), as is the control information. The Random Access Channel is a common access channel.

The Dedicated Physical Control Channel (DPCCH) is needed to transmit pilot symbols for coherent reception, power signaling bits, and rate information for rate detection. The two basic solutions for multiplexing physical control and data channels are time multiplexing and code multiplexing. A combined IQ and code multiplexing solution (dual-channel QPSK) is used in the WCDMA uplink and to avoid Electromagnetic Compatibility (EMC) problems with Discontinuous Transmission (DTX).

There is a major drawback of a time multiplexed control channel, that is where there are EMC problems that arise when DTX is used for data transmission. Figure 31 shows an example of DTX during normal speech transmission. During periods when there is silence there is no need for information bits to be transmitted. This results in pulsed transmission of the of the control data that has to be transmitted.

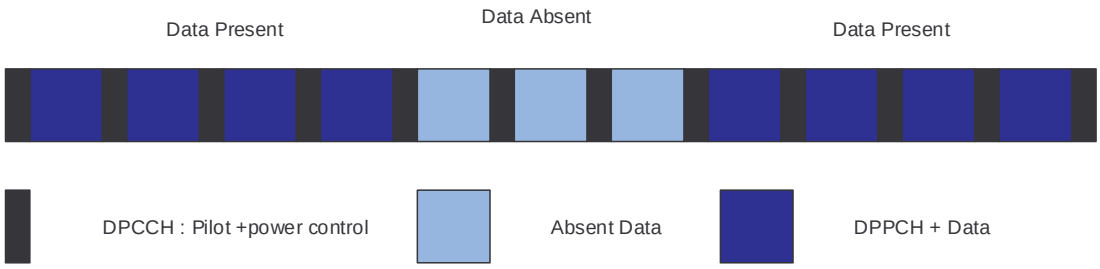


Figure 2 Pulsed Transmission when time multiplexed control channel

(Adapted from Holma, H. et al 2000)

The Random Access Burst is made up of two parts; a preamble which is made up of 16c256 chip (1ms) and a data part but data parts length is not a fixed length and this is what gives WCDMA its variable data rates.

The random access system is based on slotted ALOHA technique; Figure 32 shows the structure of the random access burst.

Before the transmission happens the Mobile Station (MS) has to carry out a number of tasks:

Achieve chip, slot, and frame synchronization to target BSS from the SCH;

Retrieve information from the BCCH about the random access code used in the target cell/sector;

Estimate the downlink path loss, which is used together with a signal strength target to calculate the required transmit power of the random access request.

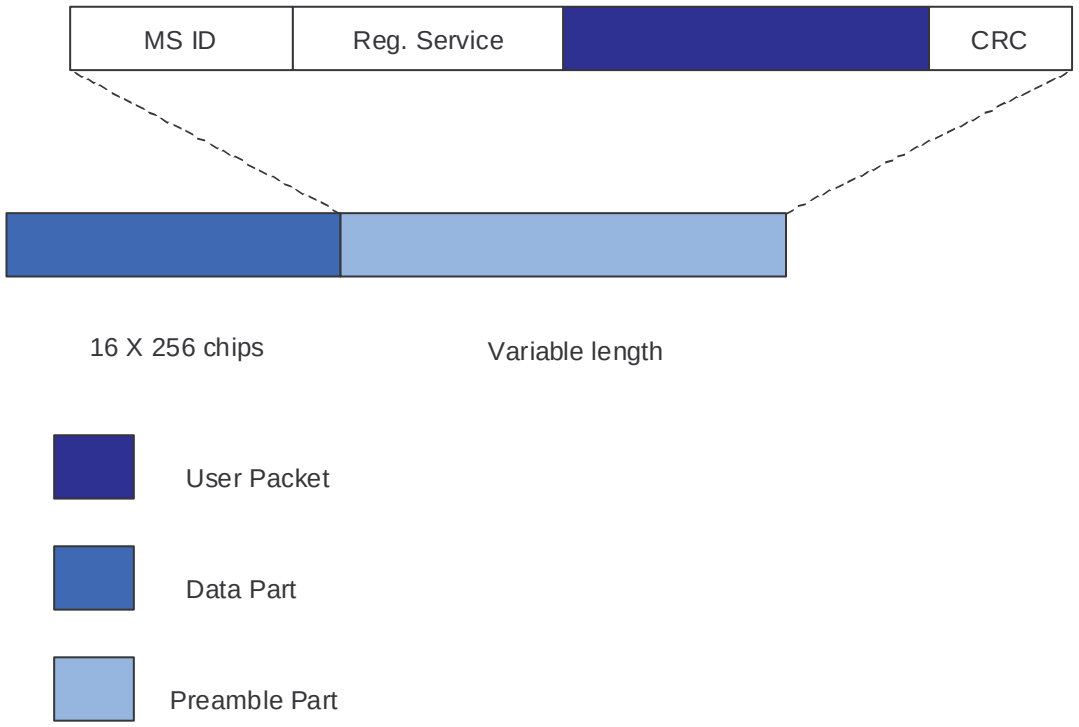


Figure 3 The structure of a Random Access Burst in a WCDMA System

4.6 Downlink Physical Channels

There are three physical channels in the downlink; the primary and secondary Common Control Physical Channels (CCPCH) carry the

downlink for the common control logical channels (BCCH, PCH and FACH); the SCH provides timing information and in WCDMA is used for handover measurements by the Mobile Station (MS).

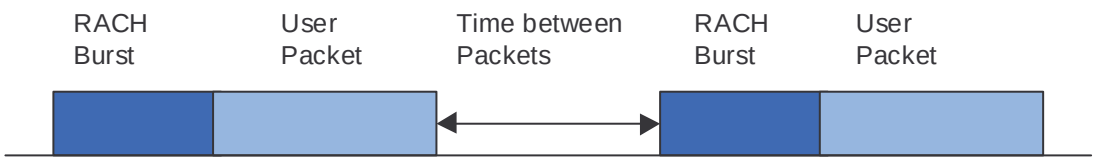
The dedicated channels (DPDCH and DPCCH) are multiplexed, however this means that there is an EMC problem caused by discontinuous transmission, but this is not considered a significant problem to the downlink, for two reasons :

There are signals to several users transmitted in parallel and at the same time.

Base Stations are not so close to other electrical equipment.

4.7 Packet Data

There are two very different types of packet data transmission within the WCDMA system. Short data packets can be added to the random access bursts and this method is called Common Channel Packet Transmission (CCPT). CCPT is most commonly used for short infrequent packets, where link maintenance needed for a dedicated channel would lead to an unacceptable overhead. Another factor for the use of CCPT cuts out the delay that can be associated with a dedicated channel. It should also be noted that for common channel packet transmission only open loop power control is in operation (Open Loop Power control measures the interference conditions from the channel, and adjusts the transmission power adoringly to meet the desired frame error rate (Ojanpera, T etal. 1998)). CCPT should therefore be limited to short packets that only use a limited capacity. This is shown in Figure 33.



Common Channel without fast power control

Figure 4 Packet Transmission on the Common Channel

For larger or more frequent packets transmitted on a dedicated channel, a large single packet is transmitted using a single packet system, where a dedicated channel is released immediately after the packet has been transmitted. In a multipacket system the dedicate channel is maintained by transmitting power control and synchronization information between subsequent packets.

4.8 Handovers

The WCDMA system's base stations do not need to be synchronized, and hence, there is no need for an external source of synchronization such as GPS. Asynchronous base stations have to be considered, especially when designing soft handover algorithms and when implementing position location services.

Before a soft handover happens, the MS measures observed timing differences of the downlink SCHs from the two base stations. The timing of a new downlink soft handover connection is adjusted with a resolution of one symbol. For example, dedicated downlink signals from the two base stations that are synchronized with an accuracy of one symbol. This enables the mobile RAKE receiver to collect the micro diversity energy from the two base stations. From this the timing adjustments of dedicated downlink channels can be carried out with a resolution of one symbol without losing orthogonality of downlink codes.

4.8.1 Soft Handovers

Soft handovers with WCDMA are very different to the handovers used in the GSM system and this basic principle stems from the US system CDMA. Basically the MS is connected to more than one BTS (Base Station Transceiver) at a time. The reason for this is to reduce interference into other cells (BTSs). It also has the advantage of improving performance through macro diversity.

Figure 34 illustrates a soft handover principle. The uplink signal fro the MS is received by both BTSs, which, after demodulation and combining, pass the signal forward to the combining point, typically this is the BSC. From a downlink point of view the same information is transmitted via both BTSs, and the MS receives the information from both of the BTSs as a separate multipath signals and can therefore combine them.

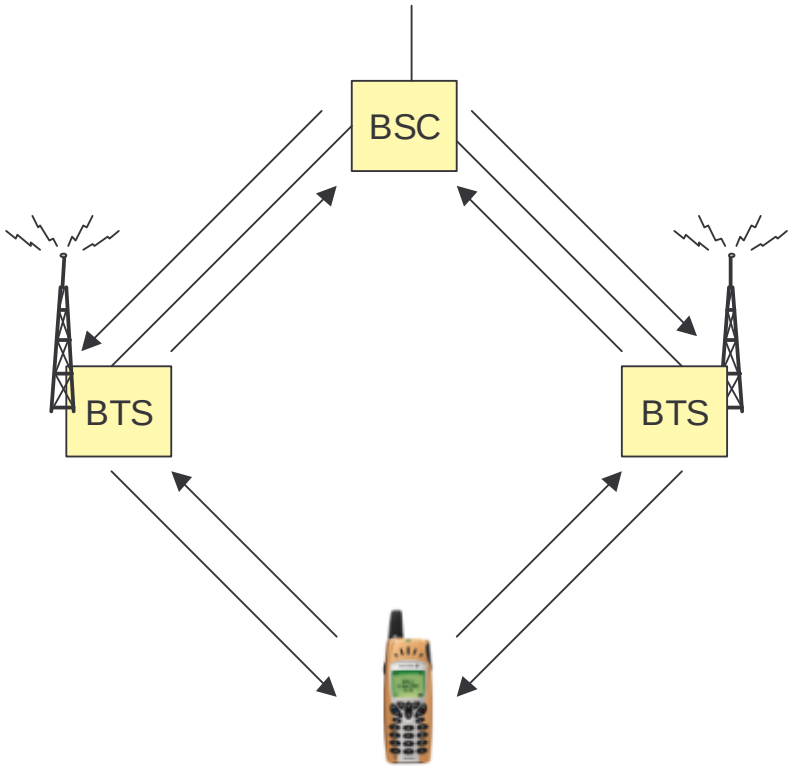


Figure 5 Principle of soft handover with two base station transceivers (BTS)

Infrequent handovers are needed for utilizations of a hierarchical call structures; macro, micro and indoor cells. Several carriers and inter-frequency handovers may also be used for taking care of high capacity needs in hot spots. Infrequent Handovers will be needed also for handovers to the 2G systems (See UMTS). There are two methods that are being considered for WCDMA, (1) Dual Receiver and, (2) Slotted Mode.

Chapter Summary and Key points

GPRS saw the realization of the maximum data rate that can be attained using the GSM system. So there was a need for Wideband CDMA (WCDMA), this is an enhanced version of the mobile communication system that is used in the United States. The main use for WCDMA in the UK will be for mobile data communications, this is because the UK already has an effective voice system in the GSM system.

It should be noted that WCDMA has several major drawbacks, the biggest being that with WCDMA used a form of DTX, this DTX causes EMC (Electromagnetic Compatibility) problems. The DTX is used in both Voice and Data transmission, but the problem only occurs when the MS is in Data transmission mode.

WCDMA is not envisaged to by applied in the UK for the next 3-4 years, this will probably be around the same time that UMTS is made available, however the potential benefits of WCDMA to the user and operator are massive with greater data rates for the user and reduced costs for the operator.

WCDMA is an integral part of UMTS (Universal Mobile Telecommunications System). UMTS is an integration of communications systems, and will hopefully provide a solid base for mobile communications in the future.