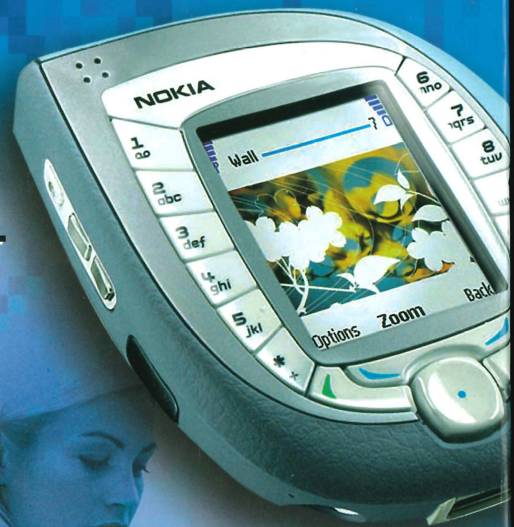


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WCDMA FOR UMTS

Radio Access For Third Generation
Mobile Communications

Third Edition



Edited by
Harri Holma and Antti Toskala

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West Sussex PO19 8SQ, England

Telephone (+44) 1243 779777

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Preface

Acknowledgements

Abbreviations

1 Introduction

Harri Ho

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2 UMTS

Harri Ho

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for common channels in general, as neither Primary nor Secondary CCPCH can use fast power control. Also, since they are often sent with full power to reach the cell edge, reducing the required transmission power level improves downlink system capacity.

6.5.5 Random Access Channel (RACH) for Signalling Transmission

The Random Access Channel (RACH) is typically used for signalling purposes, to register the terminal after power-on to the network or to perform location update after moving from one location area to another or to initiate a call. The structure of the physical RACH for signalling purposes is the same as when using the RACH for user data transmission, as described in connection with the user data transmission. With signalling use the major difference is that the data rate needs to be kept relatively low, otherwise the range achievable with RACH signalling starts to limit the system coverage. This is more critical the lower the data rates used as a basis for network coverage planning. The detailed RACH procedure will be covered in connection with the physical layer procedures.

The RACH that can be used for initial access has a relatively low payload size, since it needs to be usable by all terminals. The ability to support 16 kbps data rate on RACH is a mandatory requirement for all terminals regardless of what kind of services they provide.

6.5.6 Acquisition Indicator Channel (AICH)

In connection with the Random Access Channel, the Acquisition Indicator Channel (AICH) is used to indicate from the base station the reception of the random access channel signature sequence. The AICH uses an identical signature sequence as the RACH on one of the downlink channelisation codes of the base station to which the RACH belongs. Once the base station has detected the preamble with the random access attempt, then the same signature sequence that has been used on the preamble will be echoed back on AICH. As the structure of AICH is the same as with the RACH preamble, it also uses a spreading factor of 256 and 16 symbols as the signature sequence. There can be up to 16 signatures, acknowledged on the AICH at the same time. Both signature sets can be used with AICH. The procedure with AICH and RACH is described in the physical layer procedures section.

For the detection of AICH the terminal needs to obtain the phase reference from the common pilot channel. The AICH also needs to be heard by all terminals and needs to be sent typically at high power level without power control.

The AICH is not visible to higher layers but is controlled directly by the physical layer in the base station, as operation via a radio network controller would make the response time too slow for a RACH preamble. There are only a few timeslots to detect the RACH preamble and to transmit the response to the terminal on AICH. The AICH access slot structure is shown in Figure 6.22.

6.5.7 Paging Indicator Channel (PICH)

The Paging Channel (PCH) is operated together with the Paging Indicator Channel (PICH) to provide terminals with efficient sleep mode operation. The paging indicators use a channelisation code of length 256. The paging indicators occur once per slot on the corresponding physical channel, the Paging Indicator Channel (PICH). Each PICH frame carries 288 bits to be used by the paging indicator bit, and 12 bits are left idle. Depending on

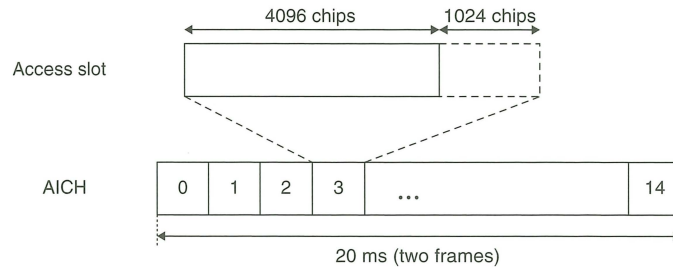


Figure 6.22. AICH access slot structure

the paging indicator repetition ratio, there can be 18, 36, 72 or 144 paging indicators per PICH frame. How often a terminal needs to listen to the PICH is parameterised, and the exact moment depends on running the system frame number (SFN).

For detection of the PICH the terminal needs to obtain the phase reference from the CPICH, and as with the AICH, the PICH needs to be heard by all terminals in the cell and thus needs to be sent at high power level without power control. The PICH frame structure with different PI repetition factors is illustrated in Figure 6.23.

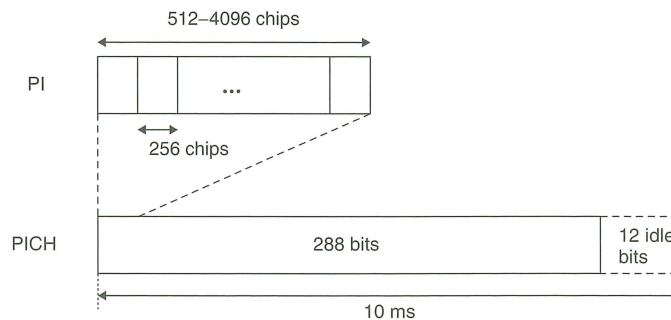


Figure 6.23. PICH structure with different PI repetition rates

6.5.8 Physical Channels for the CPCH Access Procedure

For the CPCH access procedure, a set of CPCH specific physical channels has been specified. These channels carry no transport channels, but only information needed in the CPCH access procedure. The channels are:

- CPCH Status Indication Channel (CSICH);
- CPCH Collision Detection Indicator Channel (CD-ICH);
- CPCH Channel Assignment Indicator Channel (CA-ICH);
- CPCH Access Preamble Acquisition Channel (AP-AICH).

The SIR target for closed loop power control is set by the outer loop power control. The latter power control is introduced in Section 3.5 and described in detail in Section 9.2.2.

On the terminal side, what is expected to be done inside a terminal in terms of (fast) power control operation is specified rather strictly. On the network side there is much greater freedom to decide how a base station should behave upon reception of a power control command, as well as the basis on which the base station should tell a terminal to increase or decrease the power.

6.6.2 Open Loop Power Control

In UTRA FDD there is also open loop power control, which is applied only prior to initiating the transmission on the RACH or CPCH. Open loop power control is not very accurate, since it is difficult to measure large power dynamics accurately in the terminal equipment. The mapping of the actual received absolute power to the absolute power to be transmitted shows large deviations, due to variation in the component properties as well as to the impact of environmental conditions, mainly temperature. Also, the transmission and reception occur at different frequencies, but the internal accuracy inside the terminal is the main source of uncertainty. The requirement for open loop power control accuracy is specified to be within ± 9 dB in normal conditions.

Open loop power control was used in earlier CDMA systems, such as IS-95, being active in parallel with closed loop power control. The motivation for such usage was to allow corner effects or other sudden environmental changes to be covered. As the UTRA fast power control has almost double the command rate, it was concluded that a 15 dB adjustment range does not need open loop power control to be operated simultaneously. Additionally, the fast power control step size can be increased from 1 dB to 2 dB, which would allow a 30 dB correction range during a 10 ms frame.

The use of open loop power control while in active mode also has some impact on link quality. The large inaccuracy of open loop power control can cause it to make adjustments to the transmitted power level even when they are not needed. As such, behaviour depends on terminal unit tolerances and on various environmental variables, running open loop power control makes it more difficult from the network side to predict how a terminal will behave in different conditions.

6.6.3 Paging Procedure

The Paging Channel (PCH) operation is organised as follows. A terminal, once registered to a network, has been allocated a paging group. For the paging group there are Paging Indicators (PI) which appear periodically on the Paging Indicator Channel (PICH) when there are paging messages for any of the terminals belonging to that paging group.

Once a PI has been detected, the terminal decodes the next PCH frame transmitted on the Secondary CCPCH to see whether there was a paging message intended for it. The terminal may also need to decode the PCH in case the PI reception indicates low reliability of the decision. The paging interval is illustrated in Figure 6.24.

The less often the PIs appear, the less often the terminal needs to wake up from the sleep mode and the longer the battery life becomes. The trade-off is obviously the response time to the network-originated call. An infinite paging indicator interval does not lead to infinite battery duration, as there are other tasks the terminal needs to perform during idle mode as well.

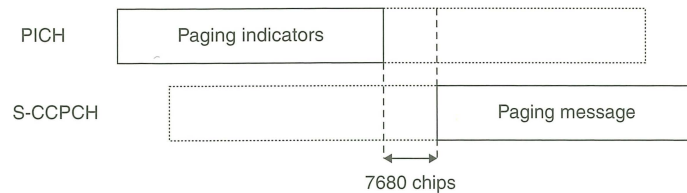


Figure 6.24. PICH relationship to PCH

6.6.4 RACH Procedure

The Random Access procedure in a CDMA system has to cope with the near-far problem, as when initiating the transmission there is no exact knowledge of the required transmission power. The open loop power control has a large uncertainty in terms of absolute power values from the received power measurement to the transmitter power level setting value, as stated in connection with the open loop description. In UTRA the RACH procedure has the following phases:

- The terminal decodes the BCH to find out the available RACH sub-channels and their scrambling codes and signatures.
- The terminal selects randomly one of the RACH sub-channels from the group its access class allows it to use. Furthermore, the signature is also selected randomly from among the available signatures.
- The downlink power level is measured and the initial RACH power level is set with the proper margin due to the open loop inaccuracy.
- A 1 ms RACH preamble is sent with the selected signature.
- The terminal decodes AICH to see whether the base station has detected the preamble.
- In case no AICH is detected, the terminal increases the preamble transmission power by a step given by the base station, as multiples of 1 dB. The preamble is retransmitted in the next available access slot.
- When an AICH transmission is detected from the base station, the terminal transmits the 10 ms or 20 ms message part of the RACH transmission.

The RACH procedure is illustrated in Figure 6.25, where the terminal transmits the preamble until acknowledgement is received on AICH, and then the message part follows.

In the case of data transmission on RACH, the spreading factor and thus the data rate may vary; this is indicated with the TFCI on the DPCCCH on PRACH. Spreading factors from 256 to 32 have been defined to be possible, thus a single frame on RACH may contain up to 1200 channel symbols which, depending on the channel coding, maps to around 600 or 400 bits. For the maximum number of bits the achievable range is naturally less than what can be achieved with the lowest rates, especially as RACH messages do not use methods such as macro-diversity as in the dedicated channel.

1. At core network-originated call or session set-up. In this case the request to start paging comes from the Core Network via the Iu interface.
2. To change the UE state from Cell_PCH or URA_PCH to Cell_FACH. This can be initiated, for example, by downlink packet data activity.
3. To indicate change in the system information. In this case RNC sends a paging message with no paging records but with information describing a new 'value tag' for the master information block. This type of paging is targeted to all UEs in a cell.

7.8.3.3 Initial Cell Selection and Reselection in Idle Mode

The most suitable cell is selected, based on idle mode measurements and cell selection criteria. The cell search procedure described in Chapter 6 is part of the cell selection process.

7.8.3.4 Establishment, Maintenance and Release of RRC Connection

The establishment of an RRC connection and Signalling Radio Bearers (SRB) between UE and UTRAN (RNC) is initiated by a request from higher layers (non-access stratum) on the UE side. In a network-originated case, the establishment is preceded by an RRC *Paging* message. The request from non-access stratum is actually a request to set up a Signalling Connection between UE and CN (Signalling Connection consists of an RRC connection and an Iu connection). Only if the UE is in idle mode, thus no RRC connection exists, does the UE initiate RRC Connection Establishment procedure. There can always be only zero or one RRC connections between one UE and UTRAN. If more than one signalling connection between UE and CN nodes exist, they all 'share' the same RRC connection.

The 'maintenance' of RRC connection refers to the RRC Connection Re-establishment functionality, which can be used to re-establish a connection after radio link failure. Timers are used to control the allowed time for a UE to return to 'in-service-area' and to execute the re-establishment. The re-establishment functionality is included in the Cell Update procedure (7.8.3.9).

The RRC connection establishment procedure is shown in Figure 7.17. There is no need for a contention resolution step such as in GSM [13], since the UE identifier used in the connection request and set-up messages is a unique UE identity (for GSM-based core network P-TMSI+RAI, TMSI+LAI or IMSI). In the RRC connection establishment procedure this initial UE identifier is used only for the purpose of uniqueness and can be discarded by UTRAN after the procedure ends. Thus, when these UE identities are later needed for the higher layer (non-access stratum) signalling, they must be resent (in the higher layer messages). The RRC *Connection Set-up* message may include a dedicated physical channel assignment for the UE (move to Cell_DCH state), or it can command the UE to use common channels (move to Cell_FACH state). In the latter case, a radio network temporary identity (U-RNTI and possibly C-RNTI) to be used as UE identity on common transport channels is allocated to the UE.

The channel names in Figure 7.17 indicate either the logical channel or logical/transport channel used for each message.

The RRC connection establishment procedure creates three (optionally four) Signalling Radio Bearers (SRBs) designated by the RB identities #1 ... #4 (RB identity #0 is reserved for signalling using CCCH). The SRBs can later be created, reconfigured or even deleted

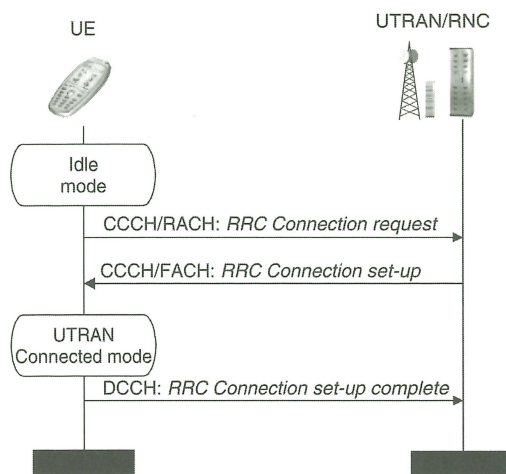


Figure 7.17. RRC connection establishment procedure

with the normal Radio Bearer control procedures. The SRBs are used for RRC signalling according to the following rules:

1. RB#1 is used for all messages sent on the DCCH and RLC-UM.
2. RB#2 is used for all messages sent on the DCCH and RLC-AM, except for the *Direct Transfer* messages.
3. RB#3 is used for the *Direct Transfer* messages (using DCCH and RLC-AM), which carries higher layer signalling. The reason for reserving a dedicated signalling radio bearer for the *Direct Transfer* is to enable prioritisation of UE-UTRAN signalling over the UE-CN signalling by using the RLC services (no need for extra RRC functionality).
4. RB#4 is optional and, if it exists, is also used for the *Direct Transfer* messages (using DCCH and RLC-AM). With two SRBs carrying higher layer signalling, UTRAN can handle prioritisation on signalling, RB#4 being used for 'low priority' and RB#3 for 'high priority' NAS signalling. The priority level is indicated to RRC with the actual NAS message to be carried over the radio. An example of low priority signalling could be the SMS.
5. For RRC messages utilising transparent mode RLC and CCCH logical channel (e.g. Cell Update, URA Update), RB identity #0 is used. A special function required in the RRC layer for these messages is padding, because RLC in transparent mode neither imposes size requirements nor performs padding, but the message size must still be equal to a Transport Block size.

7.8.3.5 Control of Radio Bearers, Transport Channels and Physical Channels

On request from higher layers, RRC performs the establishment, reconfiguration and release of Radio Bearers. At establishment and reconfiguration, UTRAN (RNC) performs admission

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