**TSG-RAN Working Group 1 meeting #11**
**San Diego, U.S.A.**

*TSGR1#11(00)*0305

February 29 - March 03, 2000

**Agenda Item:** **Ad Hoc 8/18**

**Source:** **Siemens**

**Title:** **Compressed Mode for seamless Hard Handover**

**Document for:** **Information and Discussion**

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# 1. Abstract

This paper proposes an enhanced method for a hard cell handover by using compressed mode in both the source and the target cell.

This enables a smooth and seamless transition from the source to the target cell avoiding data loss during the handover.

# 2. Introduction

The current Specifications of WG 1 do not describe the FDD UTRAN intrasystem hard intercell handover very explicitly. Spec. 25.331 of WG 2 depicts the HANDOVER COMMAND of layer 2/3 and its information contents referring the target cell. WG 3 ([2]) provides some information for the FDD Radio Interface Synchronisation, that means, that the downlink frame of the target cell is received subsequently to the downlink frame of the source cell including some small deviations.
The current hard handover specified up to now in WG 2 and WG 3 would usually cause an unavoidable loss of at least one TTI and therefore cause a loss of data at the receiving side.
This proposal aims to avoid this data loss by using compressed mode for the hard handover.
This paper is organised as follows: Section 3 depicts an conventional hard handover, whereas the occurring problems are summarised in section 4. Furthermore an enhanced method, which uses compressed mode during the hard handover, will be presented and evaluated in section 5.

# 3. Conventional Hard Handover Process

Layer 2/3 (UTRAN) sends a hard handover command, which contains the target Uplink DPCH info and Downlink DPCH info among other things. Layer 1 (UE) reacts and sets the adequate attitudes for the communication with the target cell. As described in [2] the FDD Radio Interface Synchronisation assures that UE receives the frame (with the CFN = n+1) of the target cell subsequently to the frame (CFN = n) of the source cell including small timing deviations. The UE, which still camps in the source cell, measures the timing between its current DPCH and SFN (p-CCPCH) in the target cell (typically using compressed mode) before doing a handover and reports it to SRNC (Serving Radio Network Controller). SRNC sends this time difference value in two parameters Frame_offset and Chip_offset over lub to the target Node B. This Node B rounds this offset value to the closest 256 chip boundary in order to get downlink orthogonality in the target cell (regardless of used spreading factor). The rounded value is used in the target Node B for the downlink's DPCH.

The propagation delay between the target cell and the UE can be measured and estimated, respectively. Therefore the UE measures the OTDOA (Observed Time Difference of Arrival), which is provided in [3] as the so called 'CFN-SFN observed time difference' or 'SFN-SFN observed time difference' measurement. Additionally the propagation delay prevailing in the serving target cell is well known, since this value can be derived from the RTT (Round Trip Time) measurement, provided in [3]. (RTT measurement described in [4] encloses some further supporting measurements like Doppler of received signal and Multipath Indicator). Furthermore the Inter Node B Node Synchronisation is reached via the RNC-Node B Node Synchronisation in order to determine inter Node B timing reference relations [2]. Using all these gained timing information the UTRAN can estimate the expected propagation delay in the target cell. Neglecting the rounding to the closest 256 chip boundary, the frame alignment according to the received downlink frames of the target and source cell can be reached at the UE. Moreover the uplink synchronisation at the Node B is facilitated, because the arrival of the first uplink in the target cell can be predicted using the knowledge of the target cell's propagation delay.

These synchronisation procedures will only be possible, if the target cell is within the monitored set. If not, an initial uplink and downlink synchronisation will be required.

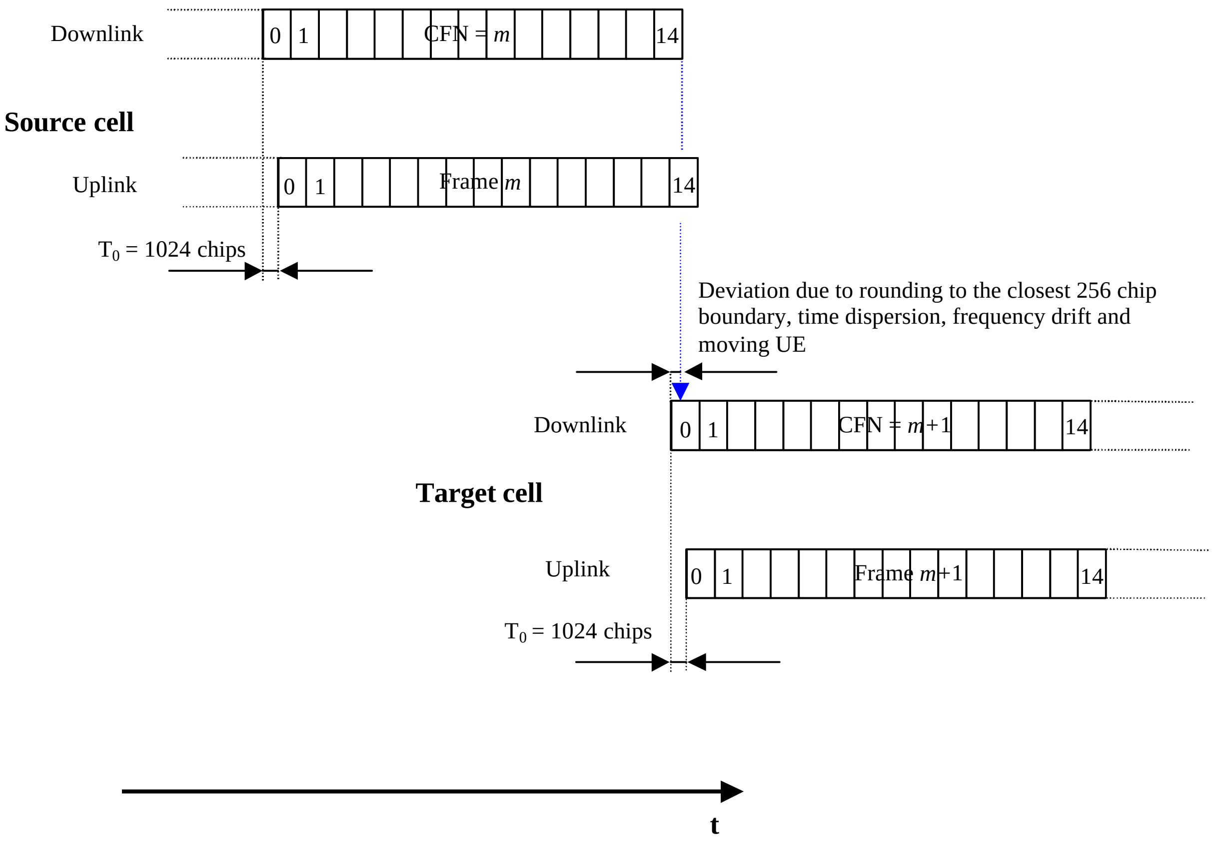


**Figure 1:** *Timing Diagram of conventional Hard Handover*

Figure 1 demonstrates an conventional hard handover. UTRAN commands the UE to switch from the serving cell to the target cell. UE should schedule the handover properly, that means UE should assure that one TTI will just be finished in the source cell and the consecutive TTI will start immediately in the target cell.

Even if the relative timings and propagation delays are exactly known, the reception of the two frames at the UE side will not be exactly seamless in most of the cases. This is due to the following facts: The CFN and chip timing of the target cell must be adopted to the closest 256 chip boundary in the target cell regardless of the used spreading factor. Time dispersion, frequency drifts and a moving UE must be also considered. Depending on the individual situation the deviation can cause a gap or an overlapping of the consecutive downlink frames (demonstrated in figure 1).

# 4. Disadvantages of an conventional Hard Handover

Given a necessary frequency switch for the handover and considering a single synthesiser UE or a fixed duplex UE, there would be no way of switching to the target downlink while sending the remaining 1024 bits to the source cell. The UE is restricted to stay on the source cell's frequencies until the uplink is completely sent; afterwards the UE can switch to the target cell. But at this moment the commencement of the target cell's downlink is already missing and as a result the detection probability of the whole TTI suffers.

In order to avoid and to counteract this problem, the consecutive downlink could be delayed theoretically by 1024 bits. Still the always occurring deviations described in section 3 and additional deviation due to uncertain timing information make a seamless hard handover always difficult or impossible without using compressed mode. Assuming a interfrequency handover, some additional time for the frequency switch must be considered.
All these circumstances prevent a seamless conventional hard handover without any data loss.

# 5. Hard Handover Method by using Compressed Mode

We propose to use compressed mode in both the source cell and the target cell for a seamless hard handover. As demonstrated in figure 2, the last frame of the source cell and the first frame in the target cell will be compressed. The compressed mode yields an idle time between the last uplink transmission in the source cell and the first downlink transmission in the target cell.

On one hand this idle time offers the possibility to compensate the maximum possible deviation from the ideal frame alignment and on the other hand gives a sufficient time margin for synthesiser frequency switching and for handling the time offset between the uplink and downlink.

The following bullets summarise the advantages of this gained idle time by using the compressed mode for the hard handover:

- Compensation of the deviations from the aimed frame alignment
- Considering an interfrequency handover the idle time offers enough time for a synthesiser frequency switch.
- Offset between uplink and downlink induces no problem for the handover anymore.
- This transmission gap can be used by the UE to collect more recent information of the downlink's timing in the target cell (update of rake finger placement). Therefore a more precise synchronisation is achieved.
- Possibly uplink synchronisation signals could be sent during the idle time. In this case the idle time does not maintain the original meaning, it would be more a kind of spare time between data transmission. For further information corresponding to the uplink synchronisation please refer to [5].

The HANDOVER COMMAND is scheduled by higher layers. So it would be up to higher layers to schedule the handover in a way, that the whole TTI will be accomplished in the source cell and the commencement of the consecutive TTI will be align with the beginning of the connection in the target cell.

Therefore the HANDOVER COMMAND currently specified in [1] needs further extensions. The point of time for the handover and the compressed mode parameters need to be incorporated in the HANDOVER COMMAND.

Table 1 demonstrates an example of possible compressed mode parameter for the hard handover. Corresponding to this example, figure 2 presents the hard handover by using compressed mode.

| | **Last frame in source cell** | **First frame in target cell** |
|---|---|---|
| **TGL** | 7 | 7 |
| **$N_{first}$** | 8 | 0 |
| **Used method** | SF/2 (arbitrary) | SF/2 (arbitrary) |

**Table 1:** *Compressed Mode parameter for the hard handover*

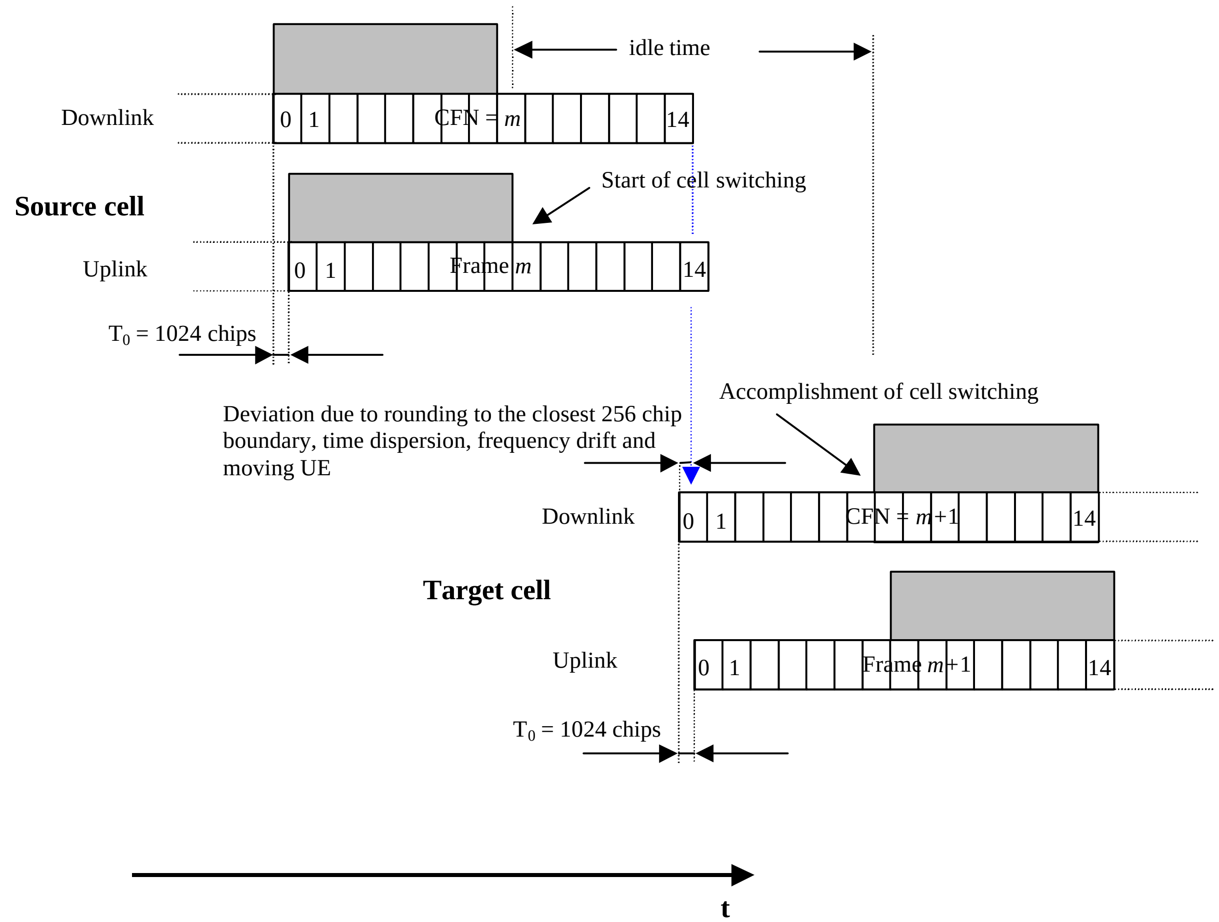


**Figure 2:** *Hard Handover by using compressed mode (parameters of table 1 used)*

# 6. Conclusions

During an hard handover a smooth and seamless transition from the source to the target cell without any data loss could be achieved by utilising the compressed mode.

# 7. References


[1] 3G TS 25.331 V3.0.0, RRC Protocol Specification

[2] 3G TS 25.402 V3.0.0, Synchronisation in UTRAN Stage 2

[3] 3G TS 25.215 V3.1.0, Physical layer – Measurements (FDD)

[4] 3G TS 25.305 V3.0.0, Stage 2 Functional Specification of Location Services in UTRAN

[5] TSGR1#11(00)0306; San Diego, U.S.A.; 02-2000; Siemens; Uplink Synchronisation for seamless Hard Handover

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| **25.215** | **CR** | **039** | Current Version: | 3.1.1 |

*GSM (AA.BB) or 3G (AA.BBB) specification number ↑* *↑ CR number as allocated by MCC support team*

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| **Proposed change affects:** *(at least one should be marked with an X)* | (U)SIM | | ME | X | UTRAN / Radio | X | Core Network | |

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|---|---|---|---|
| **Source:** | Siemens | **Date:** | 2000-02-21 |
| **Subject:** | Compressed Mode for seamless Hard Handover | | |
| **Work item:** | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Category:** | F Correction | X | **Release:** | Phase 2 | |
| | A Corresponds to a correction in an earlier release | | | Release 96 | |
| *(only one category* | B Addition of feature | | | Release 97 | |
| *shall be marked* | C Functional modification of feature | | | Release 98 | |
| *with an X)* | D Editorial modification | | | Release 99 | X |
| | | | | Release 00 | |

**Reason for change:**

**Clauses affected:** 6.1.1.1

| | | | | |
|---|---|---|---|---|
| **Other specs affected:** | Other 3G core specifications | | → List of CRs: | |
| | Other GSM core specifications | | → List of CRs: | |
| | MS test specifications | | → List of CRs: | |
| | BSS test specifications | | → List of CRs: | |
| | O&M specifications | | → List of CRs: | |

**Other comments:**

# 6 Measurements for UTRA FDD

## 6.1 UE measurements

### 6.1.1 Compressed mode

#### 6.1.1.1 Use of compressed mode/dual receiver for monitoring

A UE shall, on upper layers commands, monitor cells on other frequencies (FDD, TDD, GSM). To allow the UE to perform measurements, upper layers shall command that the UE enters in compressed mode, depending on the UE capabilities.

In case of compressed mode decision, UTRAN shall communicate to the UE the parameters of the compressed mode, described in reference [2], 25.212.

A UE with a single receiver shall support downlink compressed mode.

Every UE shall support uplink compressed mode, when monitoring frequencies which are close to the uplink transmission frequency (i.e. frequencies in the TDD or GSM 1800/1900 bands).

All fixed-duplex UE shall support both downlink and uplink compressed mode to allow inter-frequency handover within FDD and inter-mode handover from FDD to TDD. All fixed-duplex UE's shall support downlink and uplink compressed mode for a seamless hard handover within FDD. The gained transmission gap is used for frequency switching and for updating the timing measurements of the target cell for synchronisation establishment (refer to [4]).

*< WG1's note : the use of uplink compressed mode for single receiver UE when monitoring frequencies outside TDD and GSM 1800/1900 bands is for further study >*

UE with dual receivers can perform independent measurements, with the use of a "monitoring branch" receiver, that can operate independently from the UTRA FDD receiver branch. Such UE do not need to support downlink compressed mode.

The UE shall support one single measurement purpose within one compressed mode transmission gap. The measurement purpose of the gap is signalled by upper layers.

The following section provides rules to parameterise the compressed mode.

#### 6.1.1.2 Parameterisation of the compressed mode

In response to a request from upper layers, the UTRAN shall signal to the UE the compressed mode parameters.

The following parameters characterize a transmission gap :

- TGL: Transmission Gap Length is the duration of no transmission, expressed in number of slots.
- SFN: The system frame number when the transmission gap starts
- SN: The slot number when the transmission gap starts

With this definition, it is possible to have a flexible position of the transmission gap in the frame, as defined in [2].

The following parameters characterize a compressed mode pattern :

- TGP: Transmission Gap Period is the period of repetition of a set of consecutive frames containing up to 2 transmission gaps (*).
- TGL: As defined above

- TGD: Transmission Gap Distance is the duration of transmission between two consecutive transmission gaps within a transmission gap period, expressed in number of frames. In case there is only one transmission gap in the transmission gap period, this parameter shall be set to zero.

- PD: Pattern duration is the total time of all TGPs expressed in number of frames.

- SFN: The system frame number when the first transmission gap starts

- UL/DL compressed mode selection: This parameter specifies whether compressed mode is used in UL only, DL only or both UL and DL.

- Compressed mode method: The method for generating the downlink compressed mode gap can be puncturing, reducing the spreading factor or upper layer scheduling and is described in [2].

- Transmit gap position mode: The gap position can be fixed or adjustable. This is defined in [2].

- Downlink frame type: This parameter defines if frame structure type 'A' or 'B' shall be used in downlink compressed mode. This is defined in [2].

- Scrambling code change: This parameter indicates whether the alternative scrambling code is used for compressed mode method 'SF/2'. Alternative scrambling codes are described in [3].

- PCM: Power Control Mode specifies the uplink power control algorithm applied during recovery period after each transmission gap in compressed mode. PCM can take 2 values (0 or 1). The different power control modes are described in [4].

- PRM: Power Resume Mode selects the uplink power control method to calculate the initial transmit power after the gap. PRM can take two values (0 or 1) and is described in [4].

In a compressed mode pattern, the first transmission gap starts in the first frame of the pattern. The gaps have a fixed position in the frames, and start in the slot position defined in [2].

(*): Optionally, the set of parameters may contain 2 values TGP1 and TGP2, where TGP1 is used for the 1st and the consecutive odd gap periods and TGP2 is used for the even ones. Note if TGP1=TGP2 this is equivalent to using only one TGP value.

In all cases, upper layers has control of individual UE parameters. The repetition of any pattern can be stopped on upper layers command.

The UE shall support [8] simultaneous compressed mode patterns which can be used for different measurements. Upper layers will ensure that the compressed mode gaps do not overlap and are not scheduled within the same frame. Patterns causing an overlap or too long gaps will not be processed by the UE and interpreted as a faulty message.

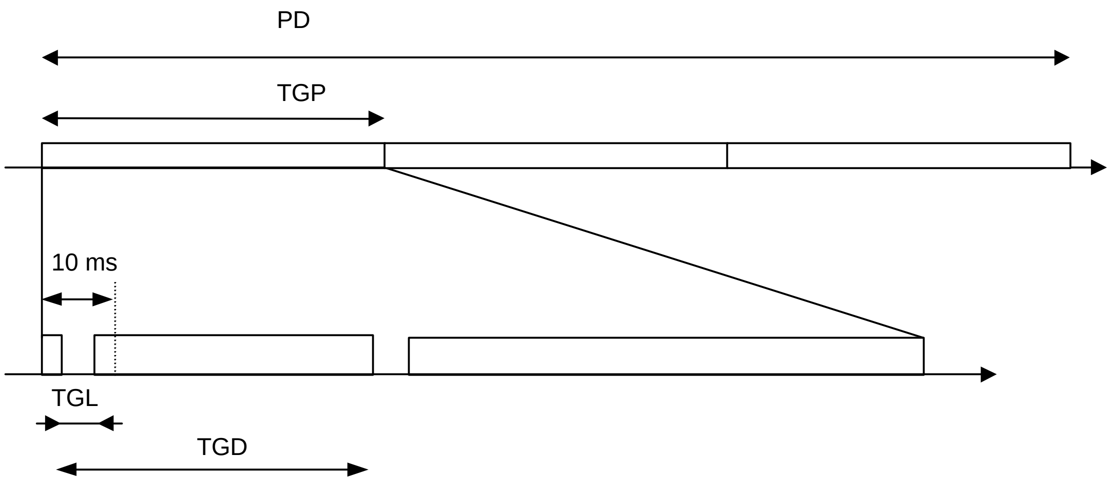


**Figure 1 : illustration of compressed mode pattern parameters**

#### 6.1.1.3 Parameterisation limitations

In the table below the supported values for the TGL parameter is shown.

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**25.214 CR 074** Current Version: 3.1.1

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**Proposed change affects:** (U)SIM [ ] ME [X] UTRAN / Radio [X] Core Network [ ]
*(at least one should be marked with an X)*

**Source:** Siemens **Date:** 2000-02-21

**Subject:** Uplink Synchronisation for seamless Hard Handover

**Work item:**

| **Category:** | | | | **Release:** | | |
|---|---|---|---|---|---|---|
| | F | Correction | X | | Phase 2 | |
| | A | Corresponds to a correction in an earlier release | | | Release 96 | |
| *(only one category* | B | Addition of feature | | | Release 97 | |
| *shall be marked* | C | Functional modification of feature | | | Release 98 | |
| *with an X)* | D | Editorial modification | | | Release 99 | X |
| | | | | | Release 00 | |

**Reason for change:**

**Clauses affected:** 4.3

| **Other specs affected:** | | | |
|---|---|---|---|
| | Other 3G core specifications | | → List of CRs: |
| | Other GSM core specifications | | → List of CRs: |
| | MS test specifications | | → List of CRs: |
| | BSS test specifications | | → List of CRs: |
| | O&M specifications | | → List of CRs: |

**Other comments:**

# 4 Synchronisation procedures

## 4.1 Cell search

During the cell search, the UE searches for a cell and determines the downlink scrambling code and common channel frame synchronisation of that cell. How cell search is typically done is described in Annex C.

## 4.2 Common physical channel synchronisation

The radio frame timing of all common physical channels can be determined after cell search. The P-CCPCH radio frame timing is found during cell search and the radio frame timing of all common physical channel are related to that timing as described in 25.211.

## 4.3 DPCCH/DPDCH synchronisation

### 4.3.1 General

The synchronisation of the dedicated physical channels can be divided into threetwo cases:

- when a downlink dedicated physical channel and uplink dedicated physical channel shall be set up in the serving cell at the same time;
- when a downlink and uplink dedicated physical channel shall be set up in the target cell at the same time during hard handover;
- or when a downlink dedicated physical channel shall be set up and there already exist an uplink dedicated physical channel.

The threetwo cases are described in subclauses 4.3.2, 4.3.3 and 4.3.43 respectively.

### 4.3.2 No existing uplink dedicated channel in the serving cell

The assumption for this case is that a DPCCH/DPDCH pair shall be set up in both uplink and downlink, and that there exist no uplink DPCCH/DPDCH already. This corresponds to the case when a dedicated physical channel is initially set up on a frequency.

The synchronization establishment procedures of the dedicated physical channel are described below. The synchronization establishment flow is shown in figure 1.

a) UTRAN starts the transmission of downlink DPCCH/DPDCHs. The DPDCH is transmitted only when there is data to be transmitted to the UE.

b) The UE establishes downlink chip synchronization and frame synchronization based on the CPICH timing and timing offset information notified from UTRAN. Frame synchronization can be confirmed using the Frame Synchronization Word. Successful frame synchronization is confirmed and reported to the higher layers when $S_R$ successive frames have been confirmed to be frame synchronized. Otherwise, frame synchronization failure is reported to the higher layers.

c) The UE starts the transmission of the uplink DPCCH/DPDCHs at a frame timing exactly $T_0$ chips after the frame timing of the received downlink DPCCH/DPDCH. The DPDCH is transmitted only when there is data to be transmitted. The UE immediately starts inner-loop power control as described in sections 5.1.2 and 5.2.1, i.e. the transmission power of the uplink DPCCH/DPDCH follows the TPC commands generated by UTRAN, and the UE performs SIR estimation to generate TPC commands transmitted to UTRAN.

d) UTRAN establishes uplink channel chip synchronization and frame synchronization. Frame synchronization can be confirmed using the Frame Synchronization Word. Successful frame synchronization is confirmed and reported to the higher layers when $S_R$ successive frames have been confirmed to be frame synchronized. Otherwise, frame synchronization failure is reported to the higher layers.

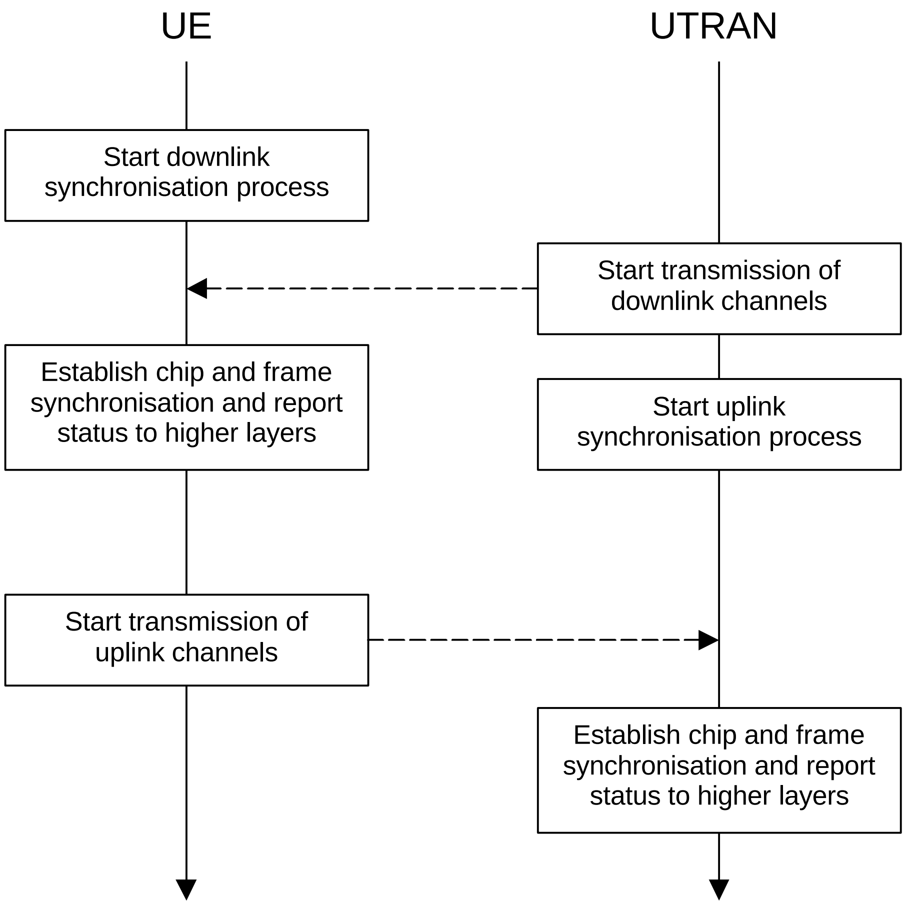


**Figure 1: Synchronisation establishment flow for dedicated channels: uplink dedicated channel not existing**

### 4.3.3 No existing uplink dedicated channel in the target cell (hard handover)

The assumption for this case is that a DPCCH/DPDCH pair shall be set up in both uplink and downlink in the target cell, and that there exist no uplink DPCCH/DPDCH already in the target cell.

The synchronisation establishment procedures of the dedicated physical channel are described below. The synchronisation establishment flow is shown in figure 2.

a) UTRAN sends a HANDOVER COMMAND to UE.

b) UE accomplishes the current transmission of uplink DPCCH/DPDCH by using compressed mode.

c) The UE establishes downlink chip and slot synchronisation.

d) The UE starts the transmission of the uplink DPCCH/DPDCH at a frame timing exactly $T_0$ chips after the frame timing of the received downlink DPCCH/DPDCH (using compressed mode).

e) UTRAN establishes uplink channel chip synchronisation and frame synchronisation. Frame synchronisation can be confirmed using the Frame Synchronisation Word. Successful frame synchronisation is confirmed and reported to the higher layers when $S_R$ successive frames have been confirmed to be frame synchronised. Otherwise, frame synchronisation failure is reported to the higher layers.

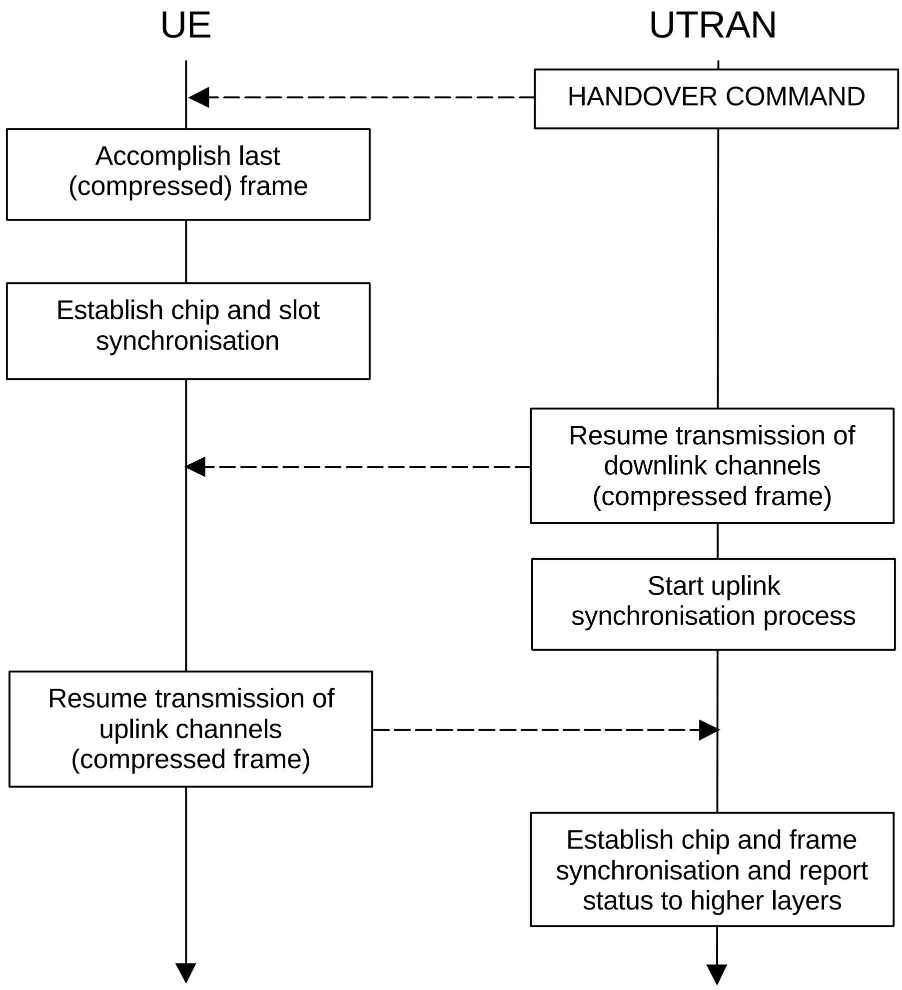


**Figure 2: Synchronisation establishment flow for dedicated channels in the target cell: uplink dedicated channel not existing**

Figure 3 depicts an example of an hard handover by utilising compressed mode.

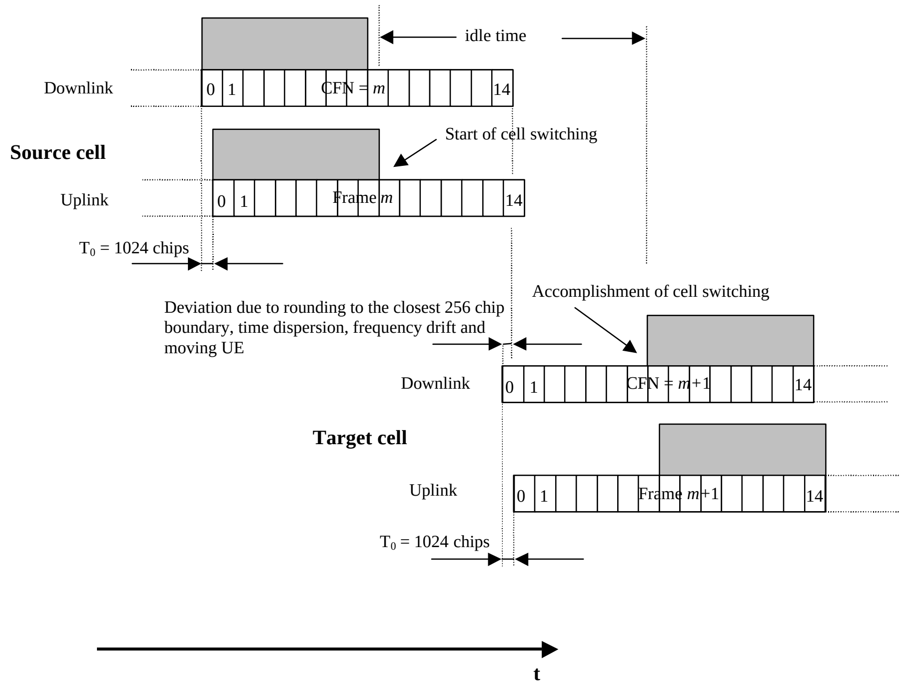


Figure 3: Example of a Hard handover by utilising compressed mode

## 4.3.4~~3~~ With existing uplink dedicated channel

The assumption for this case is that there already exist DPCCH/DPDCHs in the uplink, and a corresponding dedicated physical channel shall be set up in the downlink. This corresponds to the case when a new cell has been added to the active set in soft handover and shall begin its downlink transmission.

At the start of soft handover, the uplink dedicated physical channel transmitted by the UE, and the downlink dedicated physical channel transmitted by the soft handover source cell continues transmitting as usual.

The synchronisation establishment flow is described in figure 2.

a) The UE starts the chip synchronisation establishment process of downlink channels from the handover destination. The uplink channels being transmitted shall continue transmission as before.

b) UTRAN starts the transmission of the downlink DPCCH/DPDCH at a frame timing such that the frame timing received at the UE will be within $T_0 \pm 148$ chips prior to the frame timing of the uplink DPCCH/DPDCH at the UE. UTRAN then starts the synchronization establishment process of the uplink DPCCH/DPDCH transmitted by the UE. Frame synchronization can be confirmed using the Frame Synchronization Word. Successful frame synchronization is confirmed and reported to the higher layers when $S_R$ successive frames have been confirmed to be frame synchronized. Otherwise, frame synchronization failure is reported to the higher layers.

c) Based on the handover destination CPICH reception timing, the UE establishes chip synchronisation of downlink channels from handover destination cell. Frame synchronization can be confirmed using the Frame Synchronization Word. Successful frame synchronization is confirmed and reported to the higher layers when $S_R$ successive frames have been confirmed to be frame synchronized. Otherwise, frame synchronization failure is reported to the higher layers.

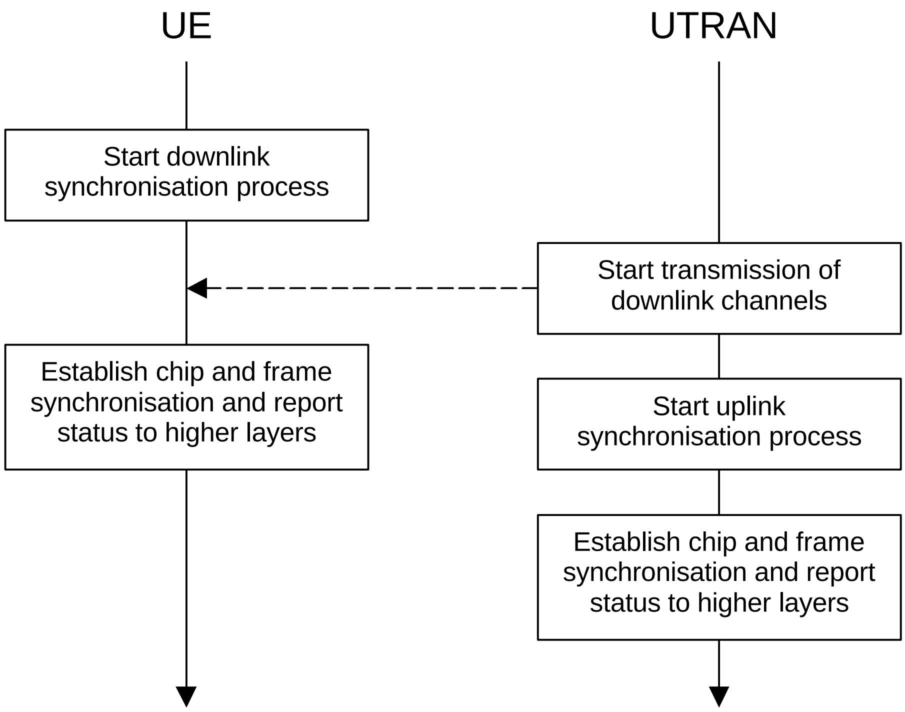


**Figure 2: Synchronisation establishment flow for dedicated channels: uplink dedicated channel already existing**

## 4.3.4 Transmission timing adjustments

During a connection the UE may adjust its DPDCH/DPCCH transmission time instant.

If the receive timing for any downlink DPCCH/DPDCH in the current active set has drifted, so the time between reception of the downlink DPCCH/DPDCH in question and transmission of uplink DPCCH/DPDCH lies outside the valid range, L1 shall inform higher layers of this, so that the network can be informed of this and downlink timing can be adjusted by the network.

NOTE: The maximum rate of uplink TX time adjustment, and the valid range for the time between downlink DPCCH/DPDCH reception and uplink DPCCH/DPDCH transmission in the UE is to be specified by RAN WG4.