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Title: Time alignment of DL DCH data frames

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Title: **Time alignment of DL DCH data frames**

Date: **June 1-4, 1999**

Source: **Motorola**

Key Issue: **Iub/Iur - Timing adjustment information in UL DCH frames**

1. Introduction

This contribution discusses the process of establishing and adjusting the time reference in the RNC for scheduling downlink DCH data frames focussing on the requirements for exchange of information between the RNC and Node B.

2. Discussion

According to reference [2], section 8.2:

> *Upon reception of a DL DCH Transport channel frame, node B should evaluate the time difference between the optimal arrival time for the DL DCH Transport Channel frame to be transmitted in the indicated CFN and the actual measured arrival time of the DL DCH Transport channel frame.*
>
> *According to the measured time difference, node B should set a proper value for the Timing adjustment command in the UL DCH transport channel frame. If there is no UL data to be transmitted to the SRNC via the DCH transport bearer then a special UL DCH Control frame can be sent.*

The topics for discussion are:

- What range of timing difference is possible for Node B to detect
- What type of information is in the “timing adjustment command”
- When does Node B issue a “timing adjustment command”

2.1. Range of time difference detected at Node B

According to reference [2], CFN is the data element included in DL DCH data frame that tells Node B when to schedule transmission over the air. If the CFN value has an effective range of 0-720ms (assumption implied in reference [1] section 9.4.2), the range of the time difference that can be determined by Node B is likewise 0-720ms

An assumption is that Node B establishes a CFN reference clock for each connection to define the optimal arrival time of DCH frames. The CFN clock is set according to the frame number associated with the cell and the Td and OFF values associated with the connection. For a particular CFN value, the optimal arrival time occurs with a period of 720ms. A further assumption is that Node B associates an arriving DCH frame with the most recent CFN reference tick associated to the CFN value in the DCH frame. If the frame arrives more than zero up to 360ms after the reference tick it is assumed to have arrived late. If the frame arrives more than 360ms up to 720ms after the reference tick it is assumed to have arrived early with respect to the next tick. Obviously, if the time difference is zero, the frame is on-time.

Given these assumptions and the present definition of CFN, Node B can detect that a frame has apparently arrived late with a range of up to 360ms. Similarly, Node B can detect that a frame has apparently arrived early with a range up to 360ms.

2.2. Type of information in the "timing adjustment command"

The information conveyed to the SRNC in the timing adjustment data element might be:

- An "indication" that a downlink data frame arrived late and was discarded
- A "report" giving the amount of time a downlink data frame was late
- A "report" giving the amount of time a downlink control/data frame arrived with respect to the most recent CFN tick
- A "command" giving the amount of time (+/-) that the SRNC should adjust its scheduling point of downlink data frames

It is asserted that a minimum requirement of the Iub interface is that Node B inform the SRNC that a downlink data frame (or some data frames) have been discarded. Beyond that, it is assumed that it would be useful for Node B to give the SRNC some idea what amount of adjustment is necessary to have future downlink data frames arrive in time. Assuming that control frames are used initially to establish the scheduling of DCH data frames, it is asserted that the Node B must be able to report to the SRNC the arrival time (or to "command" a timing adjustment) over the entire range of 0-720ms. The reasoning behind the assertion is that no assumption can be made about the SRNC's knowledge of the timing at Node B, therefore a downlink control frame may arrive anywhere within the 720ms window.

The fourth bullet implies that Node B is performing an averaging process of the arrival times of several downlink frames. The outcome of the process is a "commanded" value for the SRNC to adjust its scheduling of downlink frames. It is recommended that Node B does not perform such a process. To do so would require that Node B be given parameters to perform the averaging algorithm. For the case of advancing the downlink schedule, the degenerate case is that a "command" is issued for each frame that arrives late at Node B (essentially the same as a "report"). For the case of retarding the downlink schedule, the problem of parameterisation is more acute. Node B would have to know what is the threshold for "too early." This threshold might be dependent on the user's QoS, the delay variation of the transport network, the delay differential between diversity radio links, etc.

The recommended solution is that Node B simply "report" the arrival of the downlink frame with respect to the optimal time (based on the CFN value in the frame). This approach supports initial synchronisation using control frames, and allows the SRNC to intelligently convert timing reports into timing adjustments.

2.3. When "timing adjustment command" is sent

If the timing adjustment data element can be accurately defined as a "report," the following principles are considered applicable (using the assumption that this data element is mandatory for each uplink control/data frame).

- Node B should send an uplink control/data frame in response to receiving any downlink data frame late.
- Node B should send an uplink control frame in response a downlink control frame
- Node B should send an uplink control frame periodically in the absence of uplink data frames

The reasoning behind the second bullet is to support initial synchronisation for a new radio link. The only problem is that downlink control frames may be used to update e.g. the outer loop power control parameter. In that case an uplink response may not be necessary. Some study should be given to whether or not it is worth including in the downlink control frame an element to solicit a response from Node B.

The purpose of the third bullet is to cover the case where downlink frames are arriving early and no data frames are being sent in the uplink. Not providing periodic reports may not cause significant problems (i.e. missed/deferred opportunity to reduce delay), but the overhead of providing this information seems to be acceptable.

The only issue that needs to be addressed is the value of the timing "report" that is inserted in uplink data frames and (periodic) uplink control frames when downlink frames are arriving on-time. Some possibilities are:

- Arrival time of the last downlink frame
- Average arrival time of the downlink frames received since issuance of the previous report
- Latest arrival time of the downlink frames received since issuance of the previous report

3. Proposals

It is proposed that:

1. The data element of the uplink data frame (e.g. ref [2], section 7.1.1) is changed from "timing adjustment command" to "timing adjustment report."
2. The data element "timing adjustment report" is a mandatory field of the uplink control frame.
3. Change the description of reference [2], section 8.2 to state that the time difference measurement is returned in the timing report.
4. Expand the description of reference [2], section 8.2 to include the principles presented in section 2.3 of this contribution.
5. RAN WG3 should study if 720ms range imposed by the present definition of CFN is sufficient for measuring the time of arrival of downlink DCH control/data frames.

4. References

[1] TS 25.401 (1.0.2) UTRAN Overall Description

[2] TS 25.427 (0.1.0) Iub/Iur Interface User Plane Protocol for DCH Data Streams