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Title: Simulation Results for Parallel GSM Synchronisation

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1. Abstract

In this contribution we present simulation results for parallel GSM synchronisation from UTRA. The goal of the proposed strategy is that during slotted mode only halve as many idle time is required whereas the probability of incorrect synchronisation is slightly improved. This will be verified by computer simulations. The improvement is realised by parallel detection of the GSM synchronisation channel (SCH) and the GSM frequency correction channel (FCCH) as introduced in [1]. This principle is already included in [5]. Summarising our results lead to the following advantages:

- Only halve as many slotted frames are required
- Only halve the impact on the running connection is caused
- Slightly better probability of correct synchronisation is achieved

The paper is organised as follows:

In chapter 2 we give a short introduction. In chapter 3 we review the GSM frame structure and present a possible search procedure. In chapter 4 we investigate the synchronisation performance and present our simulation results. We will then give a conclusion and propose to use the parallel FCCH/SCH search scheme for the synchronisation form UTRA to GSM.

2. Introduction

Various schemes for synchronisation of UTRA with GSM neighbour cells are being evaluated. All schemes intent to optimise the impact on quality for the running UTRA connection, while still providing enough idle time for the mobile station to perform GSM synchronisation. For this study it is assumed but not essential, that slotted mode is used to allow UE to perform GSM synchronisation. The scheme is advantageous for all currently discussed slotted mode approaches, which are different e.g. in idle length and idle period.

3. Summary of Synchronisation from UTRA to GSM

In a GSM system the FCCH and the SCH channels are provided for synchronisation purposes of a mobile station. They are organised in a time division multiple access structure (TDMA). The GSM TDMA multiframe structure for a dedicated traffic channel consists of 26 consecutive GSM frames (26 frame multiframe). An idle period of one frame duration every multiframe is used for measurements. The FCCH and SCH is transmitted on the first two consecutive frames of the multiframe structure. The position within the frame is by definition GSM timeslot TN0. In contrast the multiframe structure contending FCCH/SCH bursts consists of 51 GSM TDMA frames (51 frame multiframe). FCCH bursts are scheduled at frame numbers 0,10,20,30 and 40 and SCH bursts are scheduled at frame numbers 1,11,21,31,41. Every two 26 frame multiframes the dedicated traffic channel idle measurement period is offset by one compared to the 51 frame multiframe structure.

This means during synchronisation of neighbour cells at least after 11 search frames one FCCH burst will be detected. Then the mobile is able to get a rough idea of the boundaries between slots and frames. Besides the mobile station is able to correct its local oscillator frequency. But this is not a point of our considerations since we assume a mobile station in connected mode. Therefor the local oscillator frequency will be roughly accurate to the serving cell oscillator.

After identifying a FCCH burst the SCH burst that follows 52 burst periods later (one frame mod 51) can be detected and the information about base station identification code BSIC and reduced frame number RFN can be evaluated.

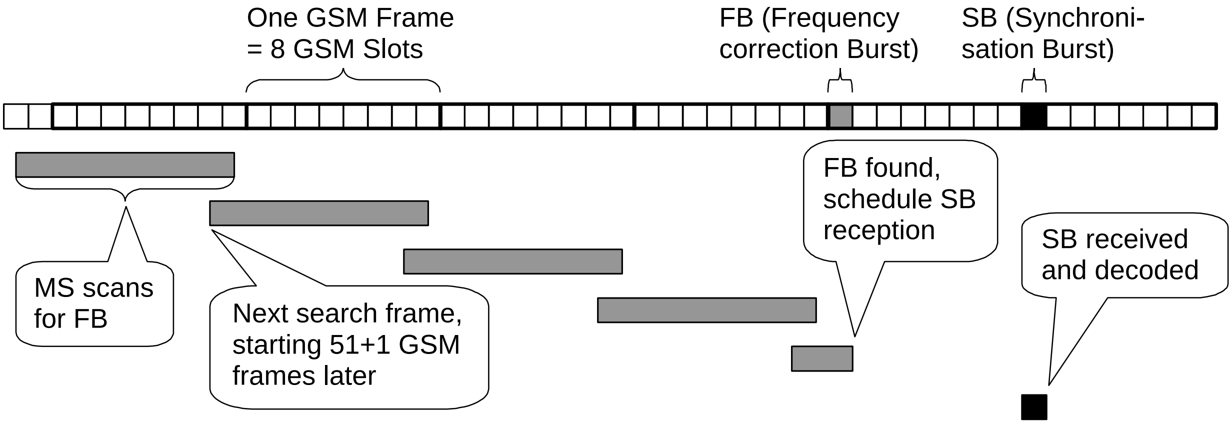

Figure 1: *GSM Synchronisation scheme*

This synchronisation scheme as used in GSM systems is intended to be used for the UTRA to GSM synchronisation, where GSM idle periods are substituted by compressed mode and suitable combinations of idle times and periods are currently under discussion. In fact we show, that detection of both GSM SCH and FCCH channel in parallel leads to reduced search time and enhances synchronisation performance.

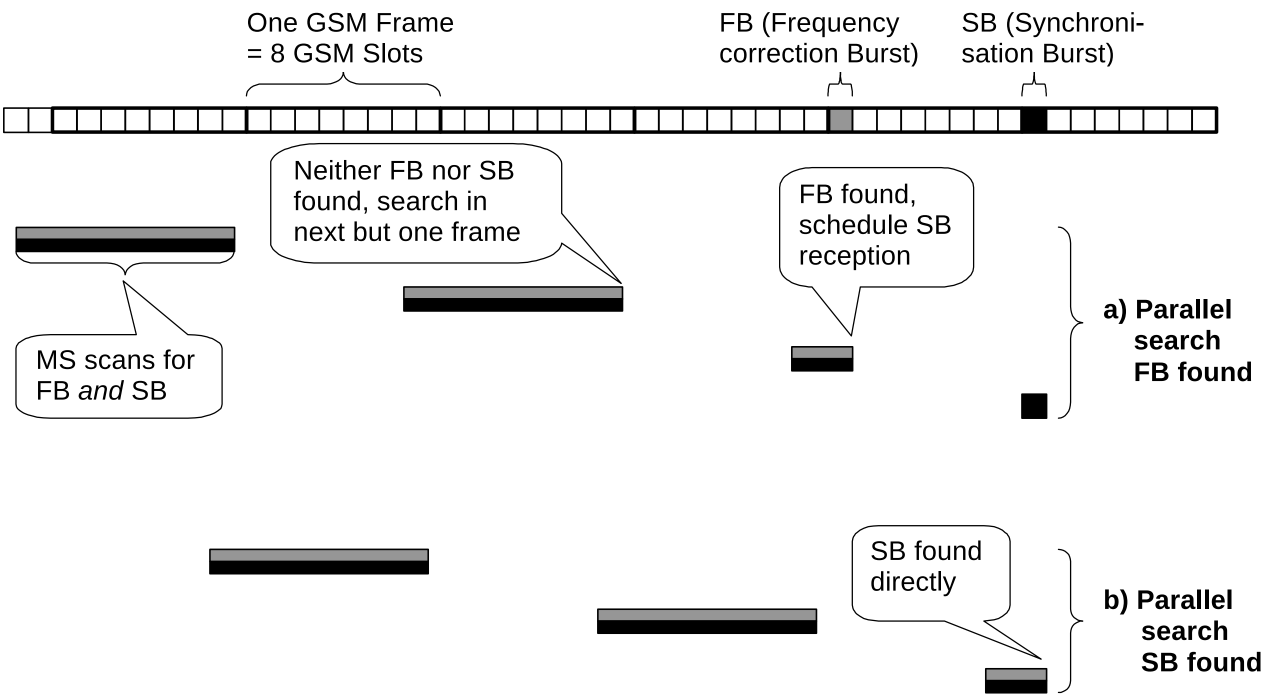

Figure 2: *Parallel search a) a FCCH burst is found first b) a SCH burst is found.*

The SCH burst has compared to the 142 fixed bits of the FCCH burst a similar but shorter recognisable structure of 64 fixed bits known as extended training sequence. In presence of a SCH burst the extended training sequence as well as in presence of a FCCH burst, the 142 fixed bits can be used to get an idea of the boundaries between slots and frames and therefore the position of the SCH 78 encrypted bits. Searching for FCCH burst in this case is not necessary and the decoding of information can be done immediately.

In presence of a frequency error the extended training sequence structure is not as easily recognisable as the FCCH fixed bit structure since the FCCH burst is in principle a sinusoidal signal of about 67 kHz. But when connected to UTRA the mobile station is frequency synchronised and frequency error between different base stations will be small.

In that case the parallel search scheme checking for FCCH and SCH simultaneous is significantly advantageous and synchronisation performance will be even better, because the autocorrelation properties of SCH are much better than FCCH all 1 bits.

4. Simulations

If the frequency error between transmitter and receiver is not too high, the detection of FCCH and SCH burst via correlation is very successful. Of course the FCCH burst correlation is somewhat easier to implement (e.g. running average) but the correlation over the extended training sequence of 64 bits leads to the improvement that only halve as many slotted frames are required for searching the TDMA position of the FCCH or SCH channel. And although the fixed bits of FCCH have 6.8 dB more energy than SCH extended training bits search and detection is advantageous, because of the good correlation properties of SCH known sequence and the single shot procedure.

We have run simulations to examine GSM synchronisation properties from UTRA in connected mode using the propagation profile for the typical urban environment as defined in GSM recommendations 05.05 (TU50). We distinguish between the search for FCCH bursts, the detection of SCH bursts and the search and detection of SCH bursts. Search for FCCH bursts is passed, if the position of the SCH channel within the 51 frame multiframe structure is found within a range of some ten bits. For the Simulations we have assumed the FCCH search gives a perfect estimation of the position. This assures, that SCH detection will be executed at the right position. The detection and therefor the synchronisation is successful if the SCH CRC check is passed and the information of BSIC and RFN is read correctly. In conventional GSM synchronisation schemes the two procedures are executed one after the other. We propose additionally a new search and detection scheme. It can be named “Search and Detection of SCH bursts” and is described further on. As mentioned above in GSM systems both the FCCH and the SCH are provided to help the mobile station acquiring slot synchronisation. The two synchronisation steps to read the SCCH channel information are:

- Search for TDMA position of FCCH burst within an interval of for example about one GSM frame
- Detection of BSIC and RFN by reading SCH information under knowledge of TDMA position of SCH burst (knowledge from first step)

The probability of correct synchronisation is given by the product of the probability of correct execution of both steps and the synchronisation error can be calculated complementary. For the parallel scheme, in 50% of the cases i.e. when synchronisation is achieved via SCH only we eliminate the first step of searching for FC burst and try to search and detect information out of the SCH channel in one shot. We search for the TDMA position of the SCH burst and get the information about BSIC and RFN. This is possible because of the relatively long known 64 bit sequence of the extended training sequence. We also assume a search time of one GSM frame and get a result for synchronisation error using SCH channel only in order to compare the results with the conventional GSM synchronisation scheme. Figure 3 shows simulation results for the search for FCCH bursts, the detection of SCH bursts and the search and detection of SCH bursts.

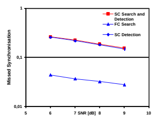

Figure 3: *Simulation results for the search for FCCH bursts, the detection of SCH bursts and the search and detection of SCH bursts*

By calculation the probability of missed synchronisation in case of conventional synchronisation and SCH only synchronisation we verified, that SCH only search and detection is slightly better in performance than the conventional approach. In this case we have chosen a frequency error of 500 Hz assuming the mobile station is in connected mode, the error then comes from doppler shift and base station frequency inaccuracy. We examined the synchronisation for signal to noise rations in a range between 6 to 9 dB.

SNR [dB]	Conventional GSM synchronisation	SCH only Search and Detection
6	29.1 %	26.4 %
7	24.7 %	22.5 %
8	20.7 %	18.7 %
9	17.3 %	15.5 %

Table 1: *Comparison of conventional GSM Synchronisation and SCH only synchronisation*

Figure 4 shows the performance enhancement of the SCH only synchronisation is 0.5 dB compared to the conventional approach. Because the proposed parallel search uses FCCH and SCH scanning in 50% of the cases each, we calculate a 0.25 dB performance advantage for the parallel scheme compared to the conventional search. We propose therefor to use parallel search because it uses halve as many slotted frames at slightly improved performance. The complexity of calculation increases but should not be a problem for UTRA mobiles which anyhow have powerful correlation hardware. For a MS with separate UTRA and GSM parts, it can even be performed by a conventional GSM part, if buffering is applied and the calculation can be done "off line" in between successive slotted frames. Note that the GSM part is idling during UTRA connection. The synchronisation time decreases by 50% and the total performance will be about 0.25 dB better.

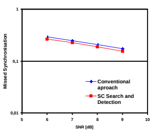

Figure 4: *Comparison between conventional GSM search and SCH only search*

5. Conclusion

Simulation results show that search and detection of SCH bursts is slightly better in case of low frequency error using conventional and SCH only synchronisation in parallel. Our simulations confirm that the parallel search scheme leads to the following advantages:

- Only halve as many slotted frames are required
- Only halve the impact on the running connection is caused
- Slightly better probability of correct synchronisation is achieved

6. Proposal

We propose to use the parallel FCCH/SCH search scheme for the synchronisation form UTRA to GSM in order to allow to reduce the impact of slotted mode on the running connection and thus to increase the overall system performance. The scheduling of slotted frames as to be specified in [5] should be optimised for the parallel detection scheme.

References

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[2] Digital cellular telecommunications system (Phase 2); Multiplexing and multiple access on the radio path (GSM 05.02 version 4.9.0)
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[5] 3GPP FDD, Physical layer - Measurements, 3GPP (S1.31) V0.1.0 1999-3